



JAKARTA EE

Jakarta Persistence

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3.3-SNAPSHOT, July 02, 2024: DRAFT

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Specification: Jakarta Persistence

Version: 3.3-SNAPSHOT

Status: DRAFT

Release: July 02, 2024

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Chapter 1. Introduction

This document is the specification of the Jakarta API for the management of persistence and object/relational mapping in the Jakarta EE and Java SE platforms. The technical objective of this work is to provide a standard object/relational mapping facility for the Java application developer using a Java domain model to manage data held in a relational database.

- The Jakarta Persistence 3.1 specification is the first release with new features and enhancements after the specification was moved to the Eclipse Foundation.
- The Jakarta Persistence 3.0 specification was the first release after moving the project to Eclipse Foundation. All APIs were moved from the package `javax.*` to the package `jakarta.*`. Every property name containing `javax` was renamed so that `javax` is replaced with `jakarta`.
- The Java Persistence 2.2 specification enhanced the API with support for repeating annotations; injection into attribute converters; support for mapping the `LocalDate`, `LocalTime`, `LocalDateTime`, `OffsetTime`, and `OffsetDateTime` types from `java.time`; and methods to retrieve the results of `Query` and `TypedQuery` as streams.
- The Java Persistence 2.1 specification added support for schema generation, type conversion methods, use of entity graphs in queries and find operations, unsynchronized persistence contexts, stored procedure invocation, and injection into entity listener classes. It also included enhancements to the query language, the Criteria API, and to the mapping of native queries.

1.1. Authorship

The Jakarta Persistence Specification incorporates work done over two decades by the EJB 3.0 expert group, the Java Persistence 2.0, 2.1, and 2.2 expert groups, under the aegis of the Java Community Process, and by the Jakarta Persistence project at the Eclipse Foundation.

1.2. Document Conventions

Regular serif font is used for information that is prescriptive under this specification.

Italic serif font is used for paragraphs that contain descriptive information, such as notes describing typical use, or notes clarifying the text with prescriptive specification.

Monospaced font is used for code examples and to specify the BNF of the Jakarta Persistence query language.

This document defines the semantics of a set of Java language annotations. An XML descriptor (as specified in [Chapter 12](#)) may be used as an alternative to annotations or to augment or override annotations. The elements of this descriptor mirror the annotations and have identical semantics to the corresponding annotations. When semantic requirements are written in terms of annotations, it should be understood that the same semantics apply to the corresponding elements of the XML descriptor.

Chapter 2. Entities

An entity is a lightweight persistent domain object.^[1] Entities support inheritance, polymorphic associations, and polymorphic queries.

The primary programming artifact is the *entity class*. An entity class may make use of auxiliary classes that serve as helper classes or that are used to represent the state of the entity.

This chapter describes requirements on entity classes and instances.

2.1. The Entity Class

The entity class must be annotated with the `Entity` annotation or declared as an entity in the XML descriptor.

- The entity class must be a top-level class or a static inner class. An enum, record, or interface may not be designated as an entity.
- The entity class must have a public or protected constructor with no parameters, which is called by the persistence provider runtime to instantiate the entity.^[2] The entity class may have additional constructors for use by the application.
- The entity class must be non-final. Every method and persistent instance variable of the entity class must be non-final.

An entity might be an abstract class, or it might be a concrete class. An entity may extend a non-entity class, or it may extend another entity class. A non-entity class may extend an entity class.

The persistent state of an entity is represented by instance variables, which may correspond to JavaBeans properties. An instance variable may be directly accessed only within the methods of the entity, by the entity instance itself. An instance variable of an entity must *not* be directly accessed by a client of the entity. The state of the entity is available to clients only through the methods of the entity—that is, via accessor (getter/setter) methods, or via other business methods.

2.2. Persistent Fields and Properties

The persistent state of an entity is accessed by the persistence provider runtime via either:

- *property access* using JavaBeans-style property accessors, or
- *field access*, that is, direct access to instance variables.

The instance variables of a class must have private, protected, or package visibility, independent of whether field access or property access is used. When property access is used, the property accessor methods must be public or protected.

The type of a persistent field or property of an entity class may be:

- any basic type listed below in [Section 2.6](#), including any Java `enum` type,
- an entity type or a collection of some entity type, as specified in [Section 2.11](#),
- an embeddable class, as defined in [Section 2.7](#), or
- a collection of a basic type or embeddable type, as specified in [Section 2.8](#).

Object/relational mapping metadata may be specified to customize the object/relational mapping and the loading and storing of the entity state and relationships, as specified in [Chapter 11](#).

The placement of object/relational mapping annotations depends on whether property access or field access is used:

- When field access is used, mapping annotations must be placed on instance variables, and the persistence provider runtime accesses instance variables directly. Every non-transient instance variable not annotated with the `Transient` annotation is persistent.
- When property-based access is used, mapping annotations must be placed on getter methods^[3], and the persistence provider runtime accesses persistent state via the property accessor methods. Every property not annotated with the `Transient` annotation is persistent.

Mapping annotations must not be applied to fields or properties marked `transient` or `Transient`, since those fields and properties are not persistent.

Whether property access, field access, or a mix of the two options is used by the provider to access the state of a given entity class or entity hierarchy is determined by the rules defined in [Section 2.3](#).



Terminology Note: The persistent fields and properties of an entity class are generically referred to in this document as “attributes” of the class.

Collection-valued persistent fields and properties must be defined in terms of one of the following collection-valued interfaces, regardless of whether the entity class otherwise adheres to the JavaBeans method conventions noted below, and of whether field or property access is used: `java.util.Collection`, `java.util.Set`, `java.util.List`^[4], `java.util.Map`.

Use of the generic variants of these collection types is strongly encouraged, for example, `Set<Order>` is preferred to the raw type `Set`.



Terminology Note: The terms “collection” and “collection-valued” are used in this specification to denote any of the above types, unless further qualified. In cases where a `java.util.Collection` type (or one of its subtypes) is to be distinguished, the type is identified as such. The terms “map” and “map collection” are used to denote a collection of type `java.util.Map`.

A collection implementation type such as `HashSet` or `ArrayList` may be used by the application to initialize a collection-valued field or property before the entity is made persistent. Once the entity becomes managed (or detached), subsequent access to the collection must be through the interface type.

2.2.1. Persistent Attribute Type

The enumeration `jakarta.persistence.metamodel.Attribute.PersistentAttributeType` defines a classification of persistent entity attributes: `BASIC` for basic attributes, `EMBEDDED` for embedded attributes, `ELEMENT_COLLECTION` for element collections, and `MANY_TO_ONE`, `ONE_TO_ONE`, `ONE_TO_MANY`, and `MANY_TO_MANY` for associations of the indicated multiplicity. Each persistent attribute of an entity belongs to exactly one of the listed types.

It is an error for an attribute of an entity to be annotated with mapping annotations indicating conflicting persistent attribute types. For example, an field may not be annotated `@Basic @Embedded`, `@ManyToOne @ElementCollection`, or `@OneToOne @ManyToOne`. The persistence provider must detect such contradictory combinations of mapping annotations and report the error.^[5]

2.2.2. Property Access

When property access is used, persistent properties of the entity class must follow the method signature conventions for JavaBeans read/write properties, as defined by the `JavaBeans Introspector` class. For every persistent property property of type `T` of the entity, there must be a getter method, `getProperty`, and setter method `setProperty`. For boolean properties, `isProperty` may be used as an alternative name for the getter method.^[6]

For single-valued persistent properties, these method signatures are:

```
T getProperty()  
  
void setProperty(T t)
```

For collection-valued persistent properties, the type `T` in the method signatures above must be one of the collection interface types listed above in [Section 2.2](#).

In addition to returning and setting the persistent state of the entity instance, a property accessor method may contain additional logic, for example, logic to perform validation. The persistence provider runtime triggers execution of this logic when property-based access is used.

Therefore, caution should be exercised in adding business logic to accessor methods when property access is used. The order in which the persistence provider runtime calls these methods when loading or storing persistent state is not defined. Logic contained in such methods should therefore not rely on any specific invocation order.

If property access is used and lazy fetching is specified, portable applications should not directly access the entity state underlying the property methods of managed instances until after it has been fetched by the persistence provider.^[7]

If a persistence context is joined to a transaction, runtime exceptions thrown by property accessor methods cause the current transaction to be marked for rollback; any exception thrown by such methods when called by the persistence runtime to load or store persistent state causes the persistence runtime to mark the current transaction for rollback and to throw a `PersistenceException` wrapping the application exception.

An entity subclass may override a property accessor method inherited from a superclass. However, portable applications must not override the object/relational mapping metadata applied to the persistent fields and properties of entity superclasses.

For example:

```
@Entity  
public class Customer implements Serializable {  
    private Long id;  
    private String name;  
    private Address address;  
    private Collection<Order> orders = new HashSet();  
    private Set<PhoneNumber> phones = new HashSet();  
  
    // No-arg constructor  
    public Customer() {}  
  
    @Id // property access is used  
    public Long getId() {  
        return id;  
    }  
  
    public void setId(Long id) {  
        this.id = id;  
    }  
  
    public String getName() {  
        return name;  
    }  
  
    public void setName(String name) {  
        this.name = name;  
    }  
  
    public Address getAddress() {  
        return address;  
    }  
}
```

```

public void setAddress(Address address) {
    this.address = address;
}

@OneToMany
public Collection<Order> getOrders() {
    return orders;
}

public void setOrders(Collection<Order> orders) {
    this.orders = orders;
}

@ManyToMany
public Set<PhoneNumber> getPhones() {
    return phones;
}

public void setPhones(Set<PhoneNumber> phones) {
    this.phones = phones;
}

// Business method to add a phone number to the customer
public void addPhone(PhoneNumber phone) {
    this.getPhones().add(phone);

    // Update the phone entity instance to refer to this customer
    phone.addCustomer(this);
}
}

```

2.3. Access Type

An *access type* determines how the persistence provider runtime reads and writes the persistent state of an entity from and to an instance of the entity class, as specified above in [Section 2.2](#). `AccessType` enumerates the two possibilities:

```

public enum AccessType {
    FIELD,
    PROPERTY
}

```

The access type for a persistent attribute depends on the placement of object/relational mapping annotations in the entity class, and may be explicitly overridden via use of the `Access` annotation defined in [Section 11.1.1](#).

2.3.1. Default Access Type

By default, a single access type (`FIELD` or `PROPERTY`) is inferred for an entity hierarchy. The *default access type* of an entity hierarchy is determined by the placement of mapping annotations on the attributes of the entity classes and mapped superclasses of the entity hierarchy which do not explicitly specify an access type.

- If mapping annotations are placed on instance variables, `FIELD` access is inferred.
- If mapping annotations are placed on getter methods, `PROPERTY` access is inferred.

An access type may be explicitly specified by means of the `Access` annotation^[8], as described below in [Section 2.3.2](#).

Every class in an entity hierarchy whose access type is defaulted in this way must be consistent in its placement of mapping annotations on either fields or properties, such that a single, consistent default access type applies within the hierarchy. Any embeddable class used by an entity within the hierarchy has the same access type as the default access type of the hierarchy unless the `Access` annotation is specified, as defined below.

It is an error if a default access type cannot be determined and an access type is not explicitly specified by a class-level `Access` annotation or the XML descriptor. The behavior of applications which mix the placement of mapping annotations on fields and properties within an entity hierarchy without explicitly specifying the class-level `Access` annotation is undefined.^[9]

2.3.2. Explicit Access Type

The access type of an individual entity class, mapped superclass, or embeddable class may be specified for that class, independent of the default for the entity hierarchy to which it belongs, by annotating the class with the `Access` annotation.

- When `Access(FIELD)` is applied to an entity class, mapped superclass, or embeddable class, mapping annotations may be placed on the instance variables of that class, and the persistence provider runtime accesses persistent state via direct access to the instance variables declared by the class. Every non-transient instance variable not annotated with the `Transient` annotation is persistent.
- When `Access(PROPERTY)` is applied to an entity class, mapped superclass, or embeddable class, mapping annotations may be placed on the properties of that class, and the persistence provider runtime accesses persistent state via the properties declared by that class. Every property not annotated with the `Transient` annotation is persistent.

The explicit access type may be overridden at the attribute level. That is, a class which explicitly specifies an access type using the `Access` annotation may also have fields or properties annotated `Access`, and so the class may have a mix of access types.

- When `Access(FIELD)` is specified at the class level, an individual attribute within the class may be selectively designated for property access by annotating a property getter `Access(PROPERTY)`. Mapping annotations for this attribute must be placed on the getter. If a mapping annotation is placed on a property getter which is not annotated `Access(PROPERTY)`, the behavior is undefined.
- When `Access(PROPERTY)` is specified at the class level, an individual attribute within the class may be selectively designated for field access by annotating an instance variable `Access(FIELD)`. Mapping annotations for this attribute must be placed on the field. If a mapping annotation is placed on a field which is not annotated `Access(FIELD)`, the behavior is undefined.

It is permitted (but redundant) to place `Access(FIELD)` on a field whose class has field access or `Access(PROPERTY)` on a property whose class has property access. On the other hand, the behavior is undefined if:

- `Access(PROPERTY)` annotates a field,
- `Access(FIELD)` annotates a property getter, or
- the `Access` annotation occurs on a property setter.

Portable application should avoid such misplaced `@Access` annotations.

When access types are combined within a class, the `Transient` annotation should be used to avoid duplicate persistent mappings. For example:

```
@Entity @Access(PROPERTY)
public class Customer {
    private Long id;

    @Access(FIELD) // use field access for name
    private String name;

    @Id
    public Long getId() {
        return id;
    }
}
```

```

    public void setId(Long id) {
        this.id = id;
    }

    @Transient // suppress duplicated name attribute
    public String getName() {
        return name;
    }

    public void setName(String name) {
        this.name = name;
    }

    ...
}

```

The `Access` annotation does not affect the access type of other entity classes or mapped superclasses in the entity hierarchy. In particular, persistent state inherited from a superclass is always accessed according to the access type of that superclass.

2.3.3. Access Type of an Embeddable Class

The access type of an embeddable class is determined by the access type of the entity class, mapped superclass, or embeddable class in which it is embedded (including as a member of an element collection) independent of whether the access type of the containing class is explicitly specified or defaulted. A different access type for an embeddable class can be specified for that embeddable class by means of the `Access` annotation as described above in [Section 2.3.2](#).

2.3.4. Defaulted Access Types of Embeddable Classes and Mapped Superclasses

Care must be taken when implementing an embeddable class or mapped superclass which is used both in a context of field access and in a context of property access, and whose access type is not explicitly specified by means of the `Access` annotation or XML mapping file.

Such a class should be implemented so that the number, names, and types of its persistent attributes are independent of the access type in use. The behavior of an embeddable class or mapped superclass whose attributes are *not* independent of access type is undefined with regard to use with the metamodel API if the class occurs in contexts of differing access types within the same persistence unit.

2.4. Primary Keys and Entity Identity

Every entity must have a primary key. The value of its primary key uniquely identifies an entity instance within a persistence context and to operations of the `EntityManager`, as described in [Chapter 3](#).

The primary key must be declared by:

- the entity class that is the root of the entity hierarchy, or
- a mapped superclass that is a (direct or indirect) superclass of all entity classes in the entity hierarchy.

A primary key must be defined exactly once in each entity hierarchy.

- A primary key comprises one or more fields or properties (“attributes”) of the entity class.
- A *simple primary key* is a single persistent field or property of the entity class whose type is one of the legal simple primary key types listed below. The `Id` annotation defined in [Section 11.1.22](#) or `id` XML element must be used to identify the simple primary key.

- A *composite primary key* must correspond to either a single persistent field or property, or to a set of fields or properties, as described below.^[10] A *primary key class* must be defined to represent the composite primary key.
 - If the composite primary key corresponds to a single field or property of the entity, the `EmbeddedId` annotation defined by [Section 11.1.17](#) identifies the primary key, and the type of the annotated field or property is the primary key class.
 - Otherwise, when the composite primary key corresponds to multiple fields or properties, the `Id` annotation defined by [Section 11.1.22](#) identifies the fields and properties which comprise the composite key, and the `IdClass` annotation defined by [Section 11.1.23](#) must specify the primary key class.

A simple primary key or field or property belonging to a composite primary key should have one of the following basic types:

- any Java primitive type, or `java.lang` wrapper for a primitive type,^[11]
- `java.lang.String`,
- `java.util.UUID`,
- `java.time.LocalDate`, `java.util.Date`, or `java.sql.Date`,
- `BigDecimal` or `BigInteger` from `java.math`.

If a primary key field or property has type `java.util.Date`, the temporal type must be explicitly specified as `DATE` using the `Temporal` annotation defined by [Section 11.1.54](#), or by equivalent XML.

If the primary key is a composite primary key derived from the primary key of another entity, the primary key may contain an attribute whose type is that of the primary key of the referenced entity, as specified below in [Section 2.4.2](#).

An entity with a primary key involving any type other than the types listed above is not portable. If the primary key is generated by the persistence provider, as defined by [Section 11.1.21](#), and its type is not `long`, `int`, `java.util.UUID`, `java.lang.String`, `java.lang.Long`, or `java.lang.Integer`, the entity is not portable.

The application must not change the value of the primary key of an entity instance after the instance is made persistent^[12]. If the application does change the value of a primary key of an entity instance after the entity instance is made persistent, the behavior is undefined.^[13]

2.4.1. Composite primary keys

The following rules apply to composite primary keys:

- The primary key class may be a non-abstract regular Java class with a public or protected constructor with no parameters. Alternatively, the primary key class may be any Java record type, in which case it need not have a constructor with no parameters.
- The access type (`FIELD` or `PROPERTY`) of a primary key class is determined by the access type of the entity for which it is the primary key, unless the primary key is an embedded id and an explicit access type is specified using the `Access` annotation, as defined in [Section 2.3.2](#).
- If property-based access is used, the properties of the primary key class must be public or protected.
- The primary key class must define `equals` and `hashCode` methods. The semantics of value equality for these methods must be consistent with the database equality for the database types to which the key is mapped.
- A composite primary key must either be represented and mapped as an embeddable class (see [Section 11.1.17](#)) or it must be represented as an id class and mapped to multiple fields or properties of the entity class (see [Section 11.1.23](#)).
- If the composite primary key class is represented as an id class, the names of primary key fields or properties of the primary key class and those of the entity class to which the id class is mapped must correspond and their types must be the same.

- A primary key which corresponds to a derived identity must conform to the rules specified below in [Section 2.4.2](#).

2.4.2. Primary Keys Corresponding to Derived Identities

The identity of an entity is said to be partially *derived* from the identity of a second entity when the *child* or *dependent* first entity is the owner of a many-to-one or one-to-one relationship which targets the *parent* second entity and the foreign key referencing the parent entity forms part of the primary key of the dependent entity.

A derived identity might be represented as a simple primary key or as a composite primary key, as described in [Section 2.4.2.1](#) below. The dependent entity class has a composite primary key if

- it declares one or more primary key attributes in addition to those corresponding to the primary key of the parent, or
- the parent itself has a composite primary key

and then an embedded id or id class must be used to represent the primary key of the dependent entity. In the case that the parent has a composite key, it is *not* required that parent entity and dependent entity both use embedded ids, nor that both use id classes.

A `ManyToOne` or `OneToOne` relationship which maps a primary key column or columns may be declared using either:

- the `Id` annotation, when no other `Id` or `EmbeddedId` attribute maps the same primary key column or columns, or
- the `MapsId` annotation, if some other attribute or attributes annotated `Id` or `EmbeddedId` also map the primary key column or columns.

If a `ManyToOne` or `OneToOne` relationship declared by a dependent entity is annotated `Id` or `MapsId`, an instance of the entity cannot be made persistent until the relationship has been assigned a reference to an instance of the parent entity, since the identity of the dependent entity declaring the relationship is derived from the referenced parent entity.^[14]

A dependent entity may have more than one parent entity.

2.4.2.1. Specification of Derived Identities

If a dependent entity uses an id class to represent its primary key, one of the two following rules must be observed:

- The names and types of the attributes of the id class and the `Id` attributes of the dependent entity class must correspond as follows:
 - The `Id` attribute of the dependent entity class and the corresponding attribute in the id class must have the same name.
 - If an `Id` attribute of the dependent entity class is of basic type, the corresponding attribute in the id class must have the same type.
 - If an `Id` attribute of the entity is a `ManyToOne` or `OneToOne` relationship to the parent entity, the corresponding attribute in the id class must be of the same Java type as the id class or embedded id of the parent entity (if the parent entity has a composite primary key) or the type of the `Id` attribute of the parent entity (if the parent entity has a simple primary key).
- Alternatively, if the dependent entity declares a single primary key attribute, that is, a `OneToOne` relationship attribute annotated `Id`, then the id class specified by the dependent entity must be the same as the primary key class of the parent entity.

If a dependent entity uses an embedded id to represent its primary key, the relationship attribute which targets the parent entity must be annotated `MapsId`.

- If the embedded id of the dependent entity is of the same Java type as the primary key of the parent entity, then the

relationship attribute maps both the relationship to the parent and the primary key of the dependent entity, the relationship attribute must be a `OneToMany` association, and the `MapsId` annotation must leave the `value` element unspecified. ^[15]

- Otherwise, the `value` element of the `MapsId` annotation must specify the name of the attribute within the embedded id to which the relationship attribute corresponds and this attribute of the embedded id must be of the same type as the primary key of the parent entity.

An attribute of an embedded id which corresponds to a relationship targeting a parent entity is treated by the provider as “read only”—that is, any direct mutation of the attribute is not propagated to the database.

If a dependent entity has a single primary key attribute annotated `Id`, and the primary key of the parent entity is a simple primary key, then the primary key of the dependent entity is a simple primary key of the same Java type as that of the parent entity, the relationship attribute must be a `OneToMany` association targeting the parent entity, and either:

1. the primary key attribute annotated `Id` is the relationship attribute itself, or
2. the primary key attribute annotated `Id` has the same type as the simple primary key of the parent entity, the relationship attribute is annotated `MapsId`, and the `value` element of the `MapsId` annotation is left unspecified.

Neither `EmbeddedId` nor `IdClass` is specified for the dependent entity.

2.4.2.2. Mapping of Derived Identities

A dependent entity has derived primary key attributes, and might also have additional primary key attributes which are not derived from any parent entity.

- Any primary key attribute of a dependent entity which is derived from the identity of a parent entity is mapped by annotations of the corresponding `ManyToOne` or `OneToMany` relationship attribute. The default mapping for this relationship is specified in [Section 2.12](#). The default mapping may be overridden by annotating the relationship attribute with the `JoinColumn` or `JoinColumns` annotation.
- If the dependent entity uses an id class, the `Column` annotation may be used to override the default mapping of `Id` attributes which are not derived from any parent entity.
- If the dependent entity uses an embedded id to represent its primary key, the `AttributeOverride` annotation applied to the `EmbeddedId` attribute may be used to override the default mapping of embedded id attributes which are *not* derived from any parent entity.

2.4.2.3. Examples of Derived Identities

The following examples illustrate the rules specified above.

Example 1:

The parent entity has a simple primary key:

```
@Entity
public class Employee {
    @Id long empId;
    String empName;

    // ...
}
```

Case (a): The dependent entity uses `IdClass` to represent a composite key:

```
public class DependentId {
    String name; // matches name of @Id attribute
}
```

```

    long emp; // matches name of @Id attribute and type of Employee PK
}

@Entity
@IdClass(DependentId.class)
public class Dependent {
    @Id String name;

    // id attribute mapped by join column default
    @Id @ManyToOne
    Employee emp;

    // ...
}

```

Sample query:

```

SELECT d
FROM Dependent d
WHERE d.name = 'Joe' AND d.emp.empName = 'Sam'

```

Case(b): The dependent entity uses EmbeddedId to represent a composite key:

```

@Embeddable
public class DependentId {
    String name;
    long empPK; // corresponds to PK type of Employee
}

@Entity
public class Dependent {
    @EmbeddedId DependentId id;

    // id attribute mapped by join column default
    @MapsId("empPK") // maps empPK attribute of embedded id
    @ManyToOne
    Employee emp;

    // ...
}

```

Sample query:

```

SELECT d
FROM Dependent d
WHERE d.id.name = 'Joe' AND d.emp.empName = 'Sam'

```

Example 2:

The parent entity uses IdClass:

```

public class EmployeeId {
    String firstName;
    String lastName;

    // ...
}

@Entity
@IdClass(EmployeeId.class)
public class Employee {
    @Id String firstName
    @Id String lastName
}

```

```

    // ...
}

```

Case (a): The dependent entity uses IdClass:

```

public class DependentId {
    String name; // matches name of attribute
    EmployeeId emp; //matches name of attribute and type of Employee PK
}

@Entity
@IdClass(DependentId.class)
public class Dependent {
    @Id
    String name;

    @Id
    @JoinColumns({
        @JoinColumn(name="FK1", referencedColumnName="firstName"),
        @JoinColumn(name="FK2", referencedColumnName="lastName")
    })

    @ManyToOne
    Employee emp;
}

```

Sample query:

```

SELECT d
FROM Dependent d
WHERE d.name = 'Joe' AND d.emp.firstName = 'Sam'

```

Case (b): The dependent entity uses EmbeddedId. The type of the empPK attribute is the same as that of the primary key of Employee. The EmployeeId class needs to be annotated Embeddable or denoted as an embeddable class in the XML descriptor.

```

@Embeddable
public class DependentId {
    String name;
    EmployeeId empPK;
}

@Entity
public class Dependent {
    @EmbeddedId
    DependentId id;

    @MapsId("empPK")
    @JoinColumns({
        @JoinColumn(name="FK1", referencedColumnName="firstName"),
        @JoinColumn(name="FK2", referencedColumnName="lastName")
    })

    @ManyToOne
    Employee emp;

    // ...
}

```

Sample query:

```

SELECT d
FROM Dependent d
WHERE d.id.name = 'Joe' AND d.emp.firstName = 'Sam'

```

Note that the following alternative query will yield the same result:

```

SELECT d
FROM Dependent d
WHERE d.id.name = 'Joe' AND d.id.empPK.firstName = 'Sam'

```

Example 3:

The parent entity uses EmbeddedId:

```

@Embeddable
public class EmployeeId {
    String firstName;
    String lastName;

    // ...
}

@Entity
public class Employee {
    @EmbeddedId
    EmployeeId empId;

    // ...
}

```

Case (a): The dependent entity uses IdClass:

```

public class DependentId {
    String name; // matches name of @Id attribute
    EmployeeId emp; // matches name of @Id attribute and type of embedded id of Employee
}

@Entity
@IdClass(DependentId.class)
public class Dependent {
    @Id
    @Column(name="dep_name") // default column name is overridden
    String name;

    @Id
    @JoinColumns({
        @JoinColumn(name="FK1", referencedColumnName="firstName"),
        @JoinColumn(name="FK2", referencedColumnName="lastName")
    })

    @ManyToOne Employee
    emp;
}

```

Sample query:

```

SELECT d
FROM Dependent d
WHERE d.name = 'Joe' and d.emp.empId.firstName = 'Sam'

```

Case (b): The dependent entity uses EmbeddedId:

```

@Embeddable
public class DependentId {
    String name;
    EmployeeId empPK; // corresponds to PK type of Employee
}

@Entity
public class Dependent {
    // default column name for "name" attribute is overridden
    @AttributeOverride(name="name", column=@Column(name="dep_name"))
    @EmbeddedId DependentId id;

    @MapsId("empPK")
    @JoinColumns({
        @JoinColumn(name="FK1", referencedColumnName="firstName"),
        @JoinColumn(name="FK2", referencedColumnName="lastName")
    })
    @ManyToOne
    Employee emp;

    // ...
}

```

Sample query:

```

SELECT d
FROM Dependent d
WHERE d.id.name = 'Joe' and d.emp.empId.firstName = 'Sam'

```

Note that the following alternative query will yield the same result:

```

SELECT d
FROM Dependent d
WHERE d.id.name = 'Joe' AND d.id.empPK.firstName = 'Sam'

```

Example 4:

The parent entity has a simple primary key:

```

@Entity
public class Person {
    @Id
    String ssn;

    // ...
}

```

Case (a): The dependent entity has a single primary key attribute which is mapped by the relationship attribute. The primary key of MedicalHistory is of type String.

```

@Entity
public class MedicalHistory {
    // default join column name is overridden
    @Id
    @OneToOne
    @JoinColumn(name="FK")
    Person patient;

    // ...
}

```

Sample query:

```
SELECT m
FROM MedicalHistory m
WHERE m.patient.ssn = '123-45-6789'
```

Case (b): The dependent entity has a single primary key attribute corresponding to the relationship attribute. The primary key attribute is of the same basic type as the primary key of the parent entity. The `MapsId` annotation applied to the relationship attribute indicates that the primary key is mapped by the relationship attribute.^[16]

```
@Entity
public class MedicalHistory {
    @Id
    String id; // overriding not allowed

    // ...

    // default join column name is overridden
    @MapsId
    @JoinColumn(name="FK")
    @OneToOne
    Person patient;

    // ...
}
```

Sample query:

```
SELECT m
FROM MedicalHistory m WHERE m.patient.ssn = '123-45-6789'
```

Example 5:

The parent entity uses `IdClass`. The dependent's primary key class is of same type as that of the parent entity.

```
public class PersonId {
    String firstName;
    String lastName;
}

@Entity
@IdClass(PersonId.class)
public class Person {
    @Id
    String firstName;

    @Id
    String lastName;

    // ...
}
```

Case (a): The dependent entity uses `IdClass`:

```
@Entity
@IdClass(PersonId.class)
public class MedicalHistory {
    @Id
    @JoinColumns({
        @JoinColumn(name="FK1", referencedColumnName="firstName"),
        @JoinColumn(name="FK2", referencedColumnName="lastName")
    })
}
```

```

    @OneToOne
    Person patient;

    // ...
}

```

Sample query:

```

SELECT m
FROM MedicalHistory m
WHERE m.patient.firstName = 'Charles'

```

Case (b): The dependent entity uses the `EmbeddedId` and `MapsId` annotations. The `PersonId` class needs to be annotated `Embeddable` or denoted as an embeddable class in the XML descriptor.

```

@Entity
public class MedicalHistory {
    // all attributes map to relationship:
    AttributeOverride not allowed

    @EmbeddedId
    PersonId id;

    // ...

    @MapsId
    @JoinColumns({
        @JoinColumn(name="FK1", referencedColumnName="firstName"),
        @JoinColumn(name="FK2", referencedColumnName="lastName")
    })

    @OneToOne Person patient;

    // ...
}

```

Sample query:

```

SELECT m
FROM MedicalHistory m
WHERE m.patient.firstName = 'Charles'

```

Note that the following alternative query will yield the same result:

```

SELECT m
FROM MedicalHistory m
WHERE m.id.firstName = 'Charles'

```

Example 6:

The parent entity uses `EmbeddedId`. The dependent's primary key is of the same type as that of the parent.

```

@Embeddable
public class PersonId {
    String firstName;
    String lastName;
}

@Entity
public class Person {
    @EmbeddedId PersonId id;
}

```

```

    // ...
}

```

Case (a): The dependent class uses `IdClass`:

```

@Entity
@IdClass(PersonId.class)
public class MedicalHistory {
    @Id
    @OneToOne
    @JoinColumns({
        @JoinColumn(name="FK1", referencedColumnName="firstName"),
        @JoinColumn(name="FK2", referencedColumnName="lastName")
    })

    Person patient;

    // ...
}

```

Case (b): The dependent class uses `EmbeddedId`:

```

@Entity
public class MedicalHistory {
    // All attributes are mapped by the relationship
    // AttributeOverride is not allowed
    @EmbeddedId PersonId id;

    // ...

    @MapsId
    @JoinColumns({
        @JoinColumn(name="FK1", referencedColumnName="firstName"),
        @JoinColumn(name="FK2", referencedColumnName="lastName")
    })
    @OneToOne
    Person patient;

    // ...
}

```

2.5. Entity Versions

An entity might have a *version*, a persistent field or property used by the persistence provider to perform optimistic locking, as specified in [Section 3.5.2](#). The version field or property holds a version number or timestamp identifying the revision of the entity data held by an entity class instance. In the course of performing lifecycle operations involving the entity instance, the persistence provider gets and sets the version field or property of the entity instance to determine or modify its version number or timestamp. The `Version` annotation defined in [Section 11.1.57](#) or `version` XML element must be used to explicitly identify the version field or property of an entity.

An entity class may access the state of its version field or property or export a method which allows other user-written code to access the version, but user-written code must not directly modify the value of the version field or property of an entity instance after the entity is made persistent.^[17] With the exception noted in [Section 4.11](#), only the persistence provider is permitted to set or update the entity version. If the application does directly modify the value of the version field or property of an entity instance after it is made persistent, the behavior is undefined.

The version must be of one of the following basic types:

- `int`, `Integer`, `short`, `Short`, `long`, `Long`, or

- `java.time.LocalDateTime`, `java.time.Instant`, or `java.sql.Timestamp`.

A portable application must not declare a version field or property with any other type.

An entity class should have at most one version. A portable application must not define an entity class having more than one version field or property.

The version should be declared by the root entity class in an entity class hierarchy, or by one of its mapped superclasses. A portable application must not declare a version field or property in a subclass of the root class of an entity class hierarchy.

2.6. Basic Types

The following Java types are considered *basic types*:

- any Java primitive type, or `java.lang` wrapper class for a primitive type,
- `java.lang.String`,
- `java.util.UUID`,
- `BigInteger` or `BigDecimal` from `java.math`,
- `LocalDate`, `LocalTime`, `LocalDateTime`, `OffsetTime`, `OffsetDateTime`, `Instant`, or `Year` from `java.time`,
- `Date` or `Calendar` ^[18] from `java.util` ^[19],
- `Date`, `Time`, or `Timestamp` from `java.sql` ^[20],
- `byte[]` or `Byte[]`, `char[]` or `Character[]` ^[21],
- any Java enum type,
- any other type which implements `java.io.Serializable`.

Persistence for basic types is defined in [Section 11.1.6](#) and [Section 11.1.18](#).

2.7. Embeddable Classes

An entity may use other fine-grained classes to represent entity state. Instances of these classes, unlike entity instances, do not have persistent identity of their own. Instead, they exist only as part of the state of the entity to which they belong. An entity may have collections of embeddables as well as single-valued embeddable attributes. Embeddables may also be used as map keys and map values. Embedded objects belong strictly to their owning entity, and are not sharable across persistent entities. Attempting to share an embedded object across entities has undefined semantics.

Embeddable classes must be annotated as `Embeddable` or denoted in the XML descriptor as such. The access type for an embedded object is determined as described in [Section 2.3](#).

An embeddable class may be a regular Java class which adheres to the requirements specified in [Section 2.1](#) for entities, with the exception that an embeddable class is not annotated as `Entity`, and an embeddable class may not be abstract.

Alternatively, an embeddable class may be any Java record type.

An embeddable class may be used to represent the state of another embeddable class.

An embeddable class (including an embeddable class within another embeddable class) may contain a collection of a basic type or other embeddable class.^[22]

An embeddable class may contain a relationship to an entity or collection of entities. Since instances of embeddable classes themselves have no persistent identity, the relationship *from* the referenced entity is to the *entity* that contains the embeddable instance(s) and not to the embeddable itself.^[23] An embeddable class that is used as an embedded id or

as a map key must not contain such a relationship.

Additional requirements and restrictions on embeddable classes are described in [Section 2.8](#).

2.8. Collections of Embeddable Classes and Basic Types

A persistent field or property of an entity or embeddable class may correspond to a collection of a basic type or embeddable class (“element collection”). Such a collection, when specified as such by the `ElementCollection` annotation, is mapped by means of a collection table, as defined in [Section 11.1.8](#). If the `ElementCollection` annotation (or XML equivalent) is not specified for the collection-valued field or property, the rules of [Section 2.10](#) apply.

An embeddable class (including an embeddable class within another embeddable class) that is contained within an element collection must not contain an element collection, nor may it contain a relationship to an entity other than a many-to-one or one-to-one relationship. The embeddable class must be on the owning side of such a relationship and the relationship must be mapped by a foreign key mapping. (See [Section 2.11](#))

2.9. Map Collections

Collections of elements and entity relationships can be represented as `java.util.Map` collections.

The map key and the map value independently can each be a basic type, an embeddable class, or an entity.

The `ElementCollection`, `OneToMany`, and `ManyToMany` annotations are used to specify the map as an element collection or entity relationship as follows: when the map value is a basic type or embeddable class, the `ElementCollection` annotation is used; when the map value is an entity, the `OneToMany` or `ManyToMany` annotation is used.

Bidirectional relationships represented as `java.util.Map` collections support the use of the `Map` datatype on one side of the relationship only.

2.9.1. Map Keys

If the map key type is a basic type, the `MapKeyColumn` annotation can be used to specify the column mapping for the map key. If the `MapKeyColumn` annotation is not specified, the default values of the `MapKeyColumn` annotation apply as described in [Section 11.1.34](#).

If the map key type is an embeddable class, the mappings for the map key columns are defaulted according to the default column mappings for the embeddable class. (See [Section 11.1.9](#)). The `AttributeOverride` and `AttributeOverrides` annotations can be used to override these mappings, as described in [Section 11.1.4](#) and [Section 11.1.5](#). If an embeddable class is used as a map key, the embeddable class must implement the `hashCode` and `equals` methods consistently with the database columns to which the embeddable is mapped^[24].

If the map key type is an entity, the `MapKeyJoinColumn` and `MapKeyJoinColumns` annotations are used to specify the column mappings for the map key. If the primary key of the referenced entity is a simple primary key and the `MapKeyJoinColumn` annotation is not specified, the default values of the `MapKeyJoinColumn` annotation apply as described in [Section 11.1.36](#).

If Java generic types are not used in the declaration of a relationship attribute of type `java.util.Map`, the `MapKeyClass` annotation must be used to specify the type of the key of the map.

The `MapKey` annotation is used to specify the special case where the map key is itself the primary key or a persistent field or property of the entity that is the value of the map. The `MapKeyClass` annotation is not used when `MapKey` is specified.

2.9.2. Map Values

When the value type of the map is a basic type or an embeddable class, a collection table is used to map the map. If Java generic types are not used, the `targetClass` element of the `ElementCollection` annotation must be used to specify the value type for the map. The default column mappings for the map value are derived according to the default mapping rules for the `CollectionTable` annotation defined in [Section 11.1.8](#). The `Column` annotation is used to override these defaults for a map value of basic type. The `AttributeOverride(s)` and `AssociationOverride(s)` annotations are used to override the mappings for a map value that is an embeddable class.

When the value type of the map is an entity, a join table is used to map the map for a many-to-many relationship or, by default, for a one-to-many unidirectional relationship. If the relationship is a bidirectional one-to-many/many-to-one relationship, by default the map is mapped in the table of the entity that is the value of the map. If Java generic types are not used, the `targetEntity` element of the `OneToMany` or `ManyToMany` annotation must be used to specify the value type for the map. Default mappings are described in [Section 2.12](#).

2.10. Mapping Defaults for Non-Relationship Fields or Properties

If a persistent field or property other than a relationship property is *not* annotated with one of the mapping annotations defined in [Chapter 11](#) (and no equivalent mapping information is specified in any XML descriptor), the following default mapping rules are applied in order:

- If the type of the field or property is a class annotated with the `Embeddable` annotation, the field or property is mapped as if it were annotated with the `Embedded` annotation. See [Section 11.1.15](#) and [Section 11.1.16](#).
- Otherwise, if the type of the field or property is one of the one of the basic types listed in [Section 2.6](#), it is mapped in the same way as if it were annotated as `Basic`. See [Section 11.1.6](#), [Section 11.1.18](#), [Section 11.1.29](#), and [Section 11.1.54](#).

It is an error if no annotation is present and neither of the above rules apply.

2.11. Entity Relationships

Relationships among entities may be one-to-one, one-to-many, many-to-one, or many-to-many. Relationships are polymorphic.

If there is an association between two entities, one of the following relationship modeling annotations must be applied to the corresponding persistent property or field of the referencing entity: `OneToOne`, `OneToMany`, `ManyToOne`, `ManyToMany`. For associations that do not specify the target type (e.g., where Java generic types are not used for collections), it is necessary to specify the entity that is the target of the relationship.^[25] Equivalent XML elements may be used as an alternative to these mapping annotations.

These annotations mirror common practice in relational database schema modeling. The use of the relationship modeling annotations allows the object/relationship mapping of associations to the relational database schema to be fully defaulted, to provide an ease-of-development facility. This is described in [Section 2.12](#).

Relationships may be bidirectional or unidirectional. A bidirectional relationship has both an owning side and an inverse (non-owning) side. A unidirectional relationship has only an owning side. The owning side of a relationship determines the updates to the relationship in the database, as described in [Section 3.3.4](#).

The following rules apply to bidirectional relationships:

The inverse side of a bidirectional relationship must refer to its owning side by use of the `mappedBy` element of the `OneToOne`, `OneToMany`, or `ManyToMany` annotation. The `mappedBy` element designates the property or field in the entity that is the owner of the relationship.

- The many side of one-to-many / many-to-one bidirectional relationships must be the owning side, hence the `mappedBy` element cannot be specified on the `ManyToOne` annotation.
- For one-to-one bidirectional relationships, the owning side corresponds to the side that contains the corresponding foreign key.
- For many-to-many bidirectional relationships either side may be the owning side.

The relationship modeling annotation constrains the use of the `cascade=REMOVE` specification. The `cascade=REMOVE` specification should only be applied to associations that are specified as `OneToOne` or `OneToMany`. Applications that apply `cascade=REMOVE` to other associations are not portable.

Associations that are specified as `OneToOne` or `OneToMany` support use of the `orphanRemoval` option. The following behaviors apply when `orphanRemoval` is in effect:

- If an entity that is the target of the relationship is removed from the relationship (by setting the relationship to null or removing the entity from the relationship collection), the remove operation will be applied to the entity being orphaned. The remove operation is applied at the time of the flush operation. The `orphanRemoval` functionality is intended for entities that are privately “owned” by their parent entity. Portable applications must otherwise not depend upon a specific order of removal, and must not reassign an entity that has been orphaned to another relationship or otherwise attempt to persist it. If the entity being orphaned is a detached, new, or removed entity, the semantics of `orphanRemoval` do not apply.
- If the remove operation is applied to a managed source entity, the remove operation will be cascaded to the relationship target in accordance with the rules of [Section 3.3.3](#), (and hence it is not necessary to specify `cascade=REMOVE` for the relationship)^[26].

[Section 2.12](#), defines relationship mapping defaults for entity relationships. Additional mapping annotations (e.g., column and table mapping annotations) may be specified to override or further refine the default mappings and mapping strategies described in [Section 2.12](#).

In addition, this specification also requires support for the following alternative mapping strategies:

- The mapping of unidirectional one-to-many relationships by means of foreign key mappings. The `JoinColumn` annotation or corresponding XML element must be used to specify such non-default mappings. See [Section 11.1.26](#).
- The mapping of unidirectional and bidirectional one-to-one relationships, bidirectional many-to-one/one-to-many relationships, and unidirectional many-to-one relationships by means of join table mappings. The `JoinTable` annotation or corresponding XML element must be used to specify such non-default mappings. See [Section 11.1.28](#).

Such mapping annotations must be specified on the owning side of the relationship. Any overriding of mapping defaults must be consistent with the relationship modeling annotation that is specified. For example, if a many-to-one relationship mapping is specified, it is not permitted to specify a unique key constraint on the foreign key for the relationship.

The persistence provider handles the object/relational mapping of the relationships, including their loading and storing to the database as specified in the metadata of the entity class, and the referential integrity of the relationships as specified in the database (e.g., by foreign key constraints).



Note that it is the application that bears responsibility for maintaining the consistency of runtime relationships—for example, for insuring that the “one” and the “many” sides of a bidirectional relationship are consistent with one another when the application updates the relationship at runtime.

If there are no associated entities for a multi-valued relationship of an entity fetched from the database, the persistence provider is responsible for returning an empty collection as the value of the relationship.

2.12. Relationship Mapping Defaults

This section defines the mapping defaults that apply to the use of the `OneToOne`, `OneToMany`, `ManyToOne`, and `ManyToMany` relationship modeling annotations. The same mapping defaults apply when the XML descriptor is used to denote the relationship cardinalities.

2.12.1. Bidirectional OneToOne Relationships

Assuming that:

- Entity A references a single instance of Entity B.
- Entity B references a single instance of Entity A.
- Entity A is specified as the owner of the relationship.

The following mapping defaults apply:

- Entity A is mapped to a table named A.
- Entity B is mapped to a table named B.
- Table A contains a foreign key to table B. The foreign key column name is formed as the concatenation of the following: the name of the relationship property or field of entity A; " _ "; the name of the primary key column in table B. The foreign key column has the same type as the primary key of table B and there is a unique key constraint on it.

Example:

```
@Entity
public class Employee {
    private Cubicle assignedCubicle;

    @OneToOne
    public Cubicle getAssignedCubicle() {
        return assignedCubicle;
    }

    public void setAssignedCubicle(Cubicle cubicle) {
        this.assignedCubicle = cubicle;
    }

    // ...
}

@Entity
public class Cubicle {
    private Employee residentEmployee;

    @OneToOne(mappedBy="assignedCubicle")
    public Employee getResidentEmployee() {
        return residentEmployee;
    }

    public void setResidentEmployee(Employee employee) {
        this.residentEmployee = employee;
    }

    // ...
}
```

In this example:

- Entity `Employee` references a single instance of Entity `Cubicle`.
- Entity `Cubicle` references a single instance of Entity `Employee`.
- Entity `Employee` is the owner of the relationship.

The following mapping defaults apply:

- Entity `Employee` is mapped to a table named `EMPLOYEE`.
- Entity `Cubicle` is mapped to a table named `CUBICLE`.
- Table `EMPLOYEE` contains a foreign key to table `CUBICLE`. The foreign key column is named `ASSIGNEDCUBICLE_<PK of CUBICLE>`, where `<PK of CUBICLE>` denotes the name of the primary key column of table `CUBICLE`. The foreign key column has the same type as the primary key of `CUBICLE`, and there is a unique key constraint on it.

2.12.2. Bidirectional ManyToOne / OneToMany Relationships

Assuming that:

- Entity `A` references a single instance of Entity `B`.
- Entity `B` references a collection of Entity `A`^[27].
- Entity `A` must be the owner of the relationship.

The following mapping defaults apply:

- Entity `A` is mapped to a table named `A`.
- Entity `B` is mapped to a table named `B`.
- Table `A` contains a foreign key to table `B`. The foreign key column name is formed as the concatenation of the following: the name of the relationship property or field of entity `A`; `"_"`; the name of the primary key column in table `B`. The foreign key column has the same type as the primary key of table `B`.

Example:

```

@Entity
public class Employee {
    private Department department;

    @ManyToOne
    public Department getDepartment() {
        return department;
    }

    public void setDepartment(Department department) {
        this.department = department;
    }

    // ...
}

@Entity
public class Department {
    private Collection<Employee> employees = new HashSet();

    @OneToMany(mappedBy="department")
    public Collection<Employee> getEmployees() {
        return employees;
    }

    public void setEmployees(Collection<Employee> employees) {
        this.employees = employees;
    }
}

```

```
    // ...  
}
```

In this example:

- Entity `Employee` references a single instance of Entity `Department`.
- Entity `Department` references a collection of Entity `Employee`.
- Entity `Employee` is the owner of the relationship.

The following mapping defaults apply:

- Entity `Employee` is mapped to a table named `EMPLOYEE`.
- Entity `Department` is mapped to a table named `DEPARTMENT`.
- Table `EMPLOYEE` contains a foreign key to table `DEPARTMENT`. The foreign key column is named `DEPARTMENT_<PK of DEPARTMENT>`, where `<PK of DEPARTMENT>` denotes the name of the primary key column of table `DEPARTMENT`. The foreign key column has the same type as the primary key of `DEPARTMENT`.

2.12.3. Unidirectional Single-Valued Relationships

Assuming that:

- Entity A references a single instance of Entity B.
- Entity B does not reference Entity A.

A unidirectional relationship has only an owning side, which in this case must be Entity A.

The unidirectional single-valued relationship modeling case can be specified as either a unidirectional `OneToOne` or as a unidirectional `ManyToOne` relationship.

2.12.3.1. Unidirectional OneToOne Relationships

The following mapping defaults apply:

- Entity A is mapped to a table named A.
- Entity B is mapped to a table named B.
- Table A contains a foreign key to table B. The foreign key column name is formed as the concatenation of the following: the name of the relationship property or field of entity A; " _ "; the name of the primary key column in table B. The foreign key column has the same type as the primary key of table B and there is a unique key constraint on it.

Example:

```
@Entity  
public class Employee {  
    private TravelProfile profile;  
  
    @OneToOne  
    public TravelProfile getProfile() {  
        return profile;  
    }  
  
    public void setProfile(TravelProfile profile) {  
        this.profile = profile;  
    }  
  
    // ...  
}
```

```

@Entity
public class TravelProfile {
    // ...
}

```

In this example:

- Entity `Employee` references a single instance of Entity `TravelProfile`.
- Entity `TravelProfile` does not reference Entity `Employee`.
- Entity `Employee` is the owner of the relationship.

The following mapping defaults apply:

- Entity `Employee` is mapped to a table named `EMPLOYEE`.
- Entity `TravelProfile` is mapped to a table named `TRAVELPROFILE`.
- Table `EMPLOYEE` contains a foreign key to table `TRAVELPROFILE`. The foreign key column is named `PROFILE_<PK of TRAVELPROFILE>`, where `<PK of TRAVELPROFILE>` denotes the name of the primary key column of table `TRAVELPROFILE`. The foreign key column has the same type as the primary key of `TRAVELPROFILE`, and there is a unique key constraint on it.

2.12.3.2. Unidirectional ManyToOne Relationships

The following mapping defaults apply:

- Entity `A` is mapped to a table named `A`.
- Entity `B` is mapped to a table named `B`.
- Table `A` contains a foreign key to table `B`. The foreign key column name is formed as the concatenation of the following: the name of the relationship property or field of entity `A`; `"_"`; the name of the primary key column in table `B`. The foreign key column has the same type as the primary key of table `B`.

Example:

```

@Entity
public class Employee {
    private Address address;

    @ManyToOne
    public Address getAddress() {
        return address;
    }

    public void setAddress(Address address) {
        this.address = address;
    }

    // ...
}

@Entity
public class Address {
    // ...
}

```

In this example:

- Entity `Employee` references a single instance of Entity `Address`.
- Entity `Address` does not reference Entity `Employee`.

- Entity `Employee` is the owner of the relationship.

The following mapping defaults apply:

- Entity `Employee` is mapped to a table named `EMPLOYEE`.
- Entity `Address` is mapped to a table named `ADDRESS`.
- Table `EMPLOYEE` contains a foreign key to table `ADDRESS`. The foreign key column is named `ADDRESS_<PK of ADDRESS>`, where `<PK of ADDRESS>` denotes the name of the primary key column of table `ADDRESS`. The foreign key column has the same type as the primary key of `ADDRESS`.

2.12.4. Bidirectional ManyToMany Relationships

Assuming that:

- Entity A references a collection of Entity B.
- Entity B references a collection of Entity A.
- Entity A is the owner of the relationship.

The following mapping defaults apply:

- Entity A is mapped to a table named A.
- Entity B is mapped to a table named B.
- There is a join table that is named `A_B` (owner name first). This join table has two foreign key columns. One foreign key column refers to table A and has the same type as the primary key of table A. The name of this foreign key column is formed as the concatenation of the following: the name of the relationship property or field of entity B; `"_"`; the name of the primary key column in table A. The other foreign key column refers to table B and has the same type as the primary key of table B. The name of this foreign key column is formed as the concatenation of the following: the name of the relationship property or field of entity A; `"_"`; the name of the primary key column in table B.

Example:

```

@Entity
public class Project {
    private Collection<Employee> employees;

    @ManyToMany
    public Collection<Employee> getEmployees() {
        return employees;
    }

    public void setEmployees(Collection<Employee> employees) {
        this.employees = employees;
    }

    // ...
}

@Entity
public class Employee {
    private Collection<Project> projects;

    @ManyToMany(mappedBy="employees")
    public Collection<Project> getProjects() {
        return projects;
    }

    public void setProjects(Collection<Project> projects) {

```

```

        this.projects = projects;
    }

    // ...
}

```

In this example:

- Entity `Project` references a collection of Entity `Employee`.
- Entity `Employee` references a collection of Entity `Project`.
- Entity `Project` is the owner of the relationship.

The following mapping defaults apply:

- Entity `Project` is mapped to a table named `PROJECT`.
- Entity `Employee` is mapped to a table named `EMPLOYEE`.
- There is a join table that is named `PROJECT_EMPLOYEE` (owner name first). This join table has two foreign key columns. One foreign key column refers to table `PROJECT` and has the same type as the primary key of `PROJECT`. The name of this foreign key column is `PROJECTS_<PK of PROJECT>`, where `<PK of PROJECT>` denotes the name of the primary key column of table `PROJECT`. The other foreign key column refers to table `EMPLOYEE` and has the same type as the primary key of `EMPLOYEE`. The name of this foreign key column is `EMPLOYEES_<PK of EMPLOYEE>`, where `<PK of EMPLOYEE>` denotes the name of the primary key column of table `EMPLOYEE`.

2.12.5. Unidirectional Multi-Valued Relationships

Assuming that:

- Entity `A` references a collection of Entity `B`.
- Entity `B` does not reference Entity `A`.

A unidirectional relationship has only an owning side, which in this case must be Entity `A`.

The unidirectional multi-valued relationship modeling case can be specified as either a unidirectional `OneToMany` or as a unidirectional `ManyToMany` relationship.

2.12.5.1. Unidirectional OneToMany Relationships

The following mapping defaults apply:

- Entity `A` is mapped to a table named `A`.
- Entity `B` is mapped to a table named `B`.
- There is a join table that is named `A_B` (owner name first). This join table has two foreign key columns. One foreign key column refers to table `A` and has the same type as the primary key of table `A`. The name of this foreign key column is formed as the concatenation of the following: the name of entity `A`; " _ "; the name of the primary key column in table `A`. The other foreign key column refers to table `B` and has the same type as the primary key of table `B` and there is a unique key constraint on it. The name of this foreign key column is formed as the concatenation of the following: the name of the relationship property or field of entity `A`; " _ "; the name of the primary key column in table `B`.

Example:

```

@Entity
public class Employee {
    private Collection<AnnualReview> annualReviews;
}

```

```

@OneToMany
public Collection<AnnualReview> getAnnualReviews() {
    return annualReviews;
}

public void setAnnualReviews(Collection<AnnualReview> annualReviews) {
    this.annualReviews = annualReviews;
}

// ...
}

@Entity
public class AnnualReview {
    // ...
}

```

In this example:

- Entity `Employee` references a collection of Entity `AnnualReview`.
- Entity `AnnualReview` does not reference Entity `Employee`.
- Entity `Employee` is the owner of the relationship.

The following mapping defaults apply:

- Entity `Employee` is mapped to a table named `EMPLOYEE`.
- Entity `AnnualReview` is mapped to a table named `ANNUALREVIEW`.
- There is a join table that is named `EMPLOYEE_ANNUALREVIEW` (owner name first). This join table has two foreign key columns. One foreign key column refers to table `EMPLOYEE` and has the same type as the primary key of `EMPLOYEE`. This foreign key column is named `EMPLOYEE_<PK of EMPLOYEE>`, where `<PK of EMPLOYEE>` denotes the name of the primary key column of table `EMPLOYEE`. The other foreign key column refers to table `ANNUALREVIEW` and has the same type as the primary key of `ANNUALREVIEW`. This foreign key column is named `ANNUALREVIEWS_<PK of ANNUALREVIEW>`, where `<PK of ANNUALREVIEW>` denotes the name of the primary key column of table `ANNUALREVIEW`. There is a unique key constraint on the foreign key that refers to table `ANNUALREVIEW`.

2.12.5.2. Unidirectional ManyToMany Relationships

The following mapping defaults apply:

- Entity A is mapped to a table named A.
- Entity B is mapped to a table named B.
- There is a join table that is named `A_B` (owner name first). This join table has two foreign key columns. One foreign key column refers to table A and has the same type as the primary key of table A. The name of this foreign key column is formed as the concatenation of the following: the name of entity A; " _ "; the name of the primary key column in table A. The other foreign key column refers to table B and has the same type as the primary key of table B. The name of this foreign key column is formed as the concatenation of the following: the name of the relationship property or field of entity A; " _ "; the name of the primary key column in table B.

Example:

```

@Entity
public class Employee {
    private Collection<Patent> patents;

    @ManyToMany
    public Collection<Patent> getPatents() {
        return patents;
    }
}

```

```

    }

    public void setPatents(Collection<Patent> patents) {
        this.patents = patents;
    }

    // ...
}

@Entity
public class Patent {
    //...
}

```

In this example:

- Entity `Employee` references a collection of Entity `Patent`.
- Entity `Patent` does not reference Entity `Employee`.
- Entity `Employee` is the owner of the relationship.

The following mapping defaults apply:

- Entity `Employee` is mapped to a table named `EMPLOYEE`.
- Entity `Patent` is mapped to a table named `PATENT`.
- There is a join table that is named `EMPLOYEE_PATENT` (owner name first). This join table has two foreign key columns. One foreign key column refers to table `EMPLOYEE` and has the same type as the primary key of `EMPLOYEE`. This foreign key column is named `EMPLOYEE_<PK of EMPLOYEE>`, where `<PK of EMPLOYEE>` denotes the name of the primary key column of table `EMPLOYEE`. The other foreign key column refers to table `PATENT` and has the same type as the primary key of `PATENT`. This foreign key column is named `PATENTS_<PK of PATENT>`, where `<PK of PATENT>` denotes the name of the primary key column of table `PATENT`.

2.13. Inheritance

An entity may inherit from another entity class. Entities support inheritance, polymorphic associations, and polymorphic queries.

Both abstract and concrete classes can be entities. Both abstract and concrete classes can be annotated with the `Entity` annotation, mapped as entities, and queried for as entities.

Entities can extend non-entity classes and non-entity classes can extend entity classes.

These concepts are described further in the following sections.

2.13.1. Abstract Entity Classes

An abstract class can be specified as an entity. An abstract entity differs from a concrete entity only in that it cannot be directly instantiated. An abstract entity is mapped as an entity and can be the target of queries (which will operate over and/or retrieve instances of its concrete subclasses).

An abstract entity class is annotated with the `Entity` annotation or denoted in the XML descriptor as an entity.

The following example shows the use of an abstract entity class in the entity inheritance hierarchy.

Example: Abstract class as an Entity

```

@Entity
@Table(name="EMP")

```

```

@Inheritance(strategy=JOINED)
public abstract class Employee {
    @Id
    protected Integer empId;

    @Version
    protected Integer version;

    @ManyToOne
    protected Address address;

    // ...
}

@Entity
@Table(name="FT_EMP")
@DiscriminatorValue("FT")
@PrimaryKeyJoinColumn(name="FT_EMPID")
public class FullTimeEmployee extends Employee {
    // Inherit empId, but mapped in this class to FT_EMP.FT_EMPID
    // Inherit version mapped to EMP.VERSION
    // Inherit address mapped to EMP.ADDRESS fk

    // Defaults to FT_EMP.SALARY
    protected Integer salary;

    // ...
}

@Entity
@Table(name="PT_EMP")
@DiscriminatorValue("PT")
// PK column is PT_EMP.EMPID due to `PrimaryKeyJoinColumn` default
public class PartTimeEmployee extends Employee {
    protected Float hourlyWage;

    // ...
}

```

2.13.2. Mapped Superclasses

An entity may inherit from a superclass that provides persistent entity state and mapping information, but which is not itself an entity. Typically, the purpose of such a mapped superclass is to define state and mapping information that is common to multiple entity classes.

A mapped superclass, unlike an entity, is not queryable and must not be passed as an argument to `EntityManager` or `Query` operations. Persistent relationships defined by a mapped superclass must be unidirectional.

Both abstract and concrete classes may be specified as mapped superclasses. The `MappedSuperclass` annotation (or mapped-superclass XML descriptor element) is used to designate a mapped superclass.

A class designated as a mapped superclass has no separate table defined for it. Its mapping information is applied to the entities that inherit from it.

The persistent attributes of a mapped superclass may be mapped in the same way as the attributes of an entity class. Such mappings apply only to the entity subclasses of the mapped superclass, since no table exists for the mapped superclass itself. When applied to a subclass, the inherited mappings are interpreted in the context of the tables mapped by subclass. Mapping information inherited from a mapped superclass can be overridden in such subclasses using the `AttributeOverride` and `AssociationOverride` annotations or corresponding XML elements.

All other entity mapping defaults apply equally to a class designated as a mapped superclass.

The following example illustrates the definition of a concrete class as a mapped superclass.

Example: Concrete class as a mapped superclass

```
@MappedSuperclass
public class Employee {
    @Id
    protected Integer empId;

    @Version
    protected Integer version;

    @ManyToOne
    @JoinColumn(name="ADDR")
    protected Address address;

    public Integer getEmpId() { ... }

    public void setEmpId(Integer id) { ... }

    public Address getAddress() { ... }

    public void setAddress(Address addr) { ... }
}

// Default table is FEMPLOYEE table
@Entity
public class FTEmployee extends Employee {
    // Inherited empId field mapped to FEMPLOYEE.EMPID
    // Inherited version field mapped to FEMPLOYEE.VERSION
    // Inherited address field mapped to FEMPLOYEE.ADDR fk

    // Defaults to FEMPLOYEE.SALARY
    protected Integer salary;

    public FTEmployee() {}

    public Integer getSalary() { ... }

    public void setSalary(Integer salary) { ... }
}

@Entity
@Table(name="PT_EMP")
@AssociationOverride(name="address", joincolumns=@JoinColumn(name="ADDR_ID"))
public class PartTimeEmployee extends Employee {
    // Inherited empId field mapped to PT_EMP.EMPID
    // Inherited version field mapped to PT_EMP.VERSION
    // address field mapping overridden to PT_EMP.ADDR_ID fk
    @Column(name="WAGE")
    protected Float hourlyWage;

    public PartTimeEmployee() {}

    public Float getHourlyWage() { ... }

    public void setHourlyWage(Float wage) { ... }
}
```

2.13.3. Non-Entity Classes in the Entity Inheritance Hierarchy

An entity can have a non-entity superclass, which may be either a concrete or abstract class.^[28]

The non-entity superclass serves for inheritance of behavior only. The state of a non-entity superclass is not persistent.

Any state inherited from non-entity superclasses is non-persistent in an inheriting entity class. This non-persistent state is not managed by the entity manager^[29]. Any annotations on such superclasses are ignored.

Non-entity classes cannot be passed as arguments to methods of the `EntityManager` or `Query` interfaces^[30] and cannot bear mapping information.

The following example illustrates the use of a non-entity class as a superclass of an entity.

Example: Non-entity superclass

```
public class Cart {
    protected Integer operationCount; // transient state

    public Cart() {
        operationCount = 0;
    }

    public Integer getOperationCount() {
        return operationCount;
    }

    public void incrementOperationCount() {
        operationCount++;
    }
}

@Entity
public class ShoppingCart extends Cart {
    Collection<Item> items = new Vector<Item>();

    public ShoppingCart() {
        super();
    }

    // ...

    @OneToMany
    public Collection<Item> getItems() {
        return items;
    }

    public void addItem(Item item) {
        items.add(item);
        incrementOperationCount();
    }
}
```

2.14. Inheritance Mapping Strategies

The mapping of class hierarchies is specified through metadata.

There are three basic strategies that are used when mapping a class or class hierarchy to a relational database:

- a single table per class hierarchy
- a joined subclass strategy, in which fields that are specific to a subclass are mapped to a separate table than the fields that are common to the parent class, and a join is performed to instantiate the subclass.
- a table per concrete entity class

An implementation is required to support the single table per class hierarchy inheritance mapping strategy and the joined subclass strategy.



Support for the table per concrete class inheritance mapping strategy is optional in this release. Applications that use this mapping strategy will not be portable.

Support for the combination of inheritance strategies within a single entity inheritance hierarchy is not required by this specification.

2.14.1. Single Table per Class Hierarchy Strategy

In this strategy, all the classes in a hierarchy are mapped to a single table. The table has a column that serves as a “discriminator column”, that is, a column whose value identifies the specific subclass to which the instance that is represented by the row belongs.

This mapping strategy provides good support for polymorphic relationships between entities and for queries that range over the class hierarchy.

It has the drawback, however, that it requires that the columns that correspond to state specific to the subclasses be nullable.

2.14.2. Joined Subclass Strategy

In the joined subclass strategy, the root of the class hierarchy is represented by a single table. Each subclass is represented by a separate table that contains those fields that are specific to the subclass (not inherited from its superclass), as well as the column(s) that represent its primary key. The primary key column(s) of the subclass table serves as a foreign key to the primary key of the superclass table.

This strategy provides support for polymorphic relationships between entities.

It has the drawback that it requires that one or more join operations be performed to instantiate instances of a subclass. In deep class hierarchies, this may lead to unacceptable performance. Queries that range over the class hierarchy likewise require joins.

2.14.3. Table per Concrete Class Strategy

In this mapping strategy, each class is mapped to a separate table. All properties of the class, including inherited properties, are mapped to columns of the table for the class.

This strategy has the following drawbacks:

- It provides poor support for polymorphic relationships.
- It typically requires that SQL UNION queries (or a separate SQL query per subclass) be issued for queries that are intended to range over the class hierarchy.

2.15. Naming of Database Objects

Many annotations and annotation elements contain names of database objects or assume default names for database objects.

This specification requires the following with regard to the interpretation of the names referencing database objects. These names include the names of tables, columns, and other database elements. Such names also include names that result from defaulting (e.g., a table name that is defaulted from an entity name or a column name that is defaulted from a field or property name).

By default, the names of database objects must be treated as un delimited identifiers and passed to the database as such.

For example, assuming the use of an English locale, the following must be passed to the database as undelimited identifiers so that they will be treated as equivalent for all databases that comply with the SQL Standard's requirements for the treatment of "regular identifiers" (undelimited identifiers) and "delimited identifiers" [2]:

```
@Table(name="Customer")
@Table(name="customer")
@Table(name="cUsTomer")
```

Similarly, the following must be treated as equivalent:

```
@JoinColumn(name="CUSTOMER")
@ManyToOne Customer customer;

@JoinColumn(name="customer")
@ManyToOne Customer customer;

@ManyToOne Customer customer;
```

To specify delimited identifiers, one of the following approaches must be used:

- It is possible to specify that all database identifiers in use for a persistence unit be treated as delimited identifiers by specifying the `<delimited-identifiers/>` element within the `persistence-unit-defaults` element of the object/relational xml mapping file. If the `<delimited-identifiers/>` element is specified, it cannot be overridden.
- It is possible to specify on a per-name basis that a name for a database object is to be interpreted as a delimited identifier as follows:
 - Using annotations, a name is specified as a delimited identifier by enclosing the name within double quotes, whereby the inner quotes are escaped, e.g., `@Table(name="\"customer\"")`.
 - When using XML, a name is specified as a delimited identifier by use of double quotes, e.g., `<table name="\"customer\""/>` ^[31]

The following annotations contain elements whose values correspond to names of database identifiers and for which the above rules apply, including when their use is nested within that of other annotations:

- `EntityResult(discriminatorColumn element)`
- `FieldResult(column element)`
- `ColumnResult(name element)`
- `CollectionTable(name, catalog, schema elements)`
- `Column(name, columnDefinition, table elements)`
- `DiscriminatorColumn(name, columnDefinition elements)`
- `ForeignKey(name, foreignKeyDefinition elements)`
- `Index(name, columnList elements)`
- `JoinColumn(name, referencedColumnName, columnDefinition, table elements)`
- `JoinTable(name, catalog, schema elements)`
- `MapKeyColumn(name, columnDefinition, table elements)`
- `MapKeyJoinColumn(name, referencedColumnName, columnDefinition, table elements)`
- `NamedStoredProcedureQuery(procedureName element)`
- `OrderColumn(name, columnDefinition elements)`
- `PrimaryKeyJoinColumn(name, referencedColumnName, columnDefinition elements)`
- `SecondaryTable(name, catalog, schema elements)`
- `SequenceGenerator(sequenceName, catalog, schema elements)`
- `StoredProcedureParameter(name element)`

- `Table(name, catalog, schema elements)`
- `TableGenerator(table, catalog, schema, pkColumnName, valueColumnName elements)`
- `UniqueConstraint(name, columnNames elements)`

The following XML elements and types contain elements or attributes whose values correspond to names of database identifiers and for which the above rules apply:

- `entity-mappings(schema, catalog elements)`
- `persistence-unit-defaults(schema, catalog elements)`
- `collection-table(name, catalog, schema attributes)`
- `column(name, table, column-definition attributes)`
- `column-result(name attribute)`
- `discriminator-column(name, column-definition attributes)`
- `entity-result(discriminator-column attribute)`
- `field-result(column attribute)`
- `foreign-key(name, foreign-key-definition attributes)`
- `index(name attribute, column-list element)`
- `join-column(name, referenced-column-name, column-definition, table attributes)`
- `join-table(name, catalog, schema attributes)`
- `map-key-column(name, column-definition, table attributes)`
- `map-key-join-column(name, referenced-column-name, column-definition, table attributes)`
- `named-stored-procedure-query(procedure-name attribute)`
- `order-column(name, column-definition attributes)`
- `primary-key-join-column(name, referenced-column-name, column-definition attributes)`
- `secondary-table(name, catalog, schema attributes)`
- `sequence-generator(sequence-name, catalog, schema attributes)`
- `stored-procedure-parameter(name attribute)`
- `table(name, catalog, schema attributes)`
- `table-generator(table, catalog, schema, pk-column-name, value-column-name attributes)`
- `unique-constraint(name attribute, column-name element)`

[1] An entity instance is a local object inaccessible to remote processes. If instances of an entity are to be passed by value as detached objects (e.g., via a remote interface), the entity class must be serializable.

[2] The term "persistence provider runtime" refers to the runtime environment of the persistence implementation. In a JakartaEE environment, this might be the Jakarta EE container itself, or a third-party persistence provider implementation integrated with the container.

[3] These annotations must not be applied to the setter methods.

[4] Portable applications should not expect the order of a list to be maintained across persistence contexts unless the `OrderColumn` or `OrderBy` annotation is used and modifications to the list observe the specified ordering.

[5] A persistence provider is permitted—but not required—to accept the combinations `@Basic @ElementCollection` and `@Embedded @ElementCollection`.

[6] Specifically, if `getX` is the name of the getter method and `setX` is the name of the setter method, where `X` is any string, the name of the persistent property is obtained by calling `java.beans.Introspector.decapitalize(X)`.

[7] Lazy fetching is a hint to the persistence provider and can be specified by means of the `Basic`, `OneToOne`, `OneToMany`, `ManyToOne`, `ManyToMany`, and `ElementCollection` annotations and their XML equivalents. See [Chapter 11](#).

[8] The use of XML as an alternative and the interaction between Java language annotations and XML elements in

defining default and explicit access types is described in [Chapter 12](#).

[9] An `Access` annotation of a field or property getter is considered a "mapping annotation" for the purposes of this section. Therefore, an attribute-level `Access` annotation may not be used to selectively override the access type of an attribute of an entity class with a defaulted access type.

[10] Composite primary keys often arise when mapping a legacy database with primary keys comprising multiple columns.

[11] In general, however, approximate numeric types (e.g., floating point types) should never be used in primary keys.

[12] This includes not changing the value of a mutable type that is primary key or an attribute of a composite primary key.

[13] The implementation may, but is not required to, throw an exception. Portable applications must not rely on any such specific behavior.

[14] If the application does not set a primary key attribute mapped to the same column or columns as the relationship, the value of that attribute might not be available until after the entity has been flushed to the database.

[15] The primary key of the parent might be represented as an embedded id or as an id class.

[16] Note that the use of `PrimaryKeyJoinColumn` instead of `MapsId` would result in the same mapping in this example. Use of `MapsId` is preferred for the mapping of derived identities.

[17] Bulk update statements, however, are permitted to set the version of an entity. See [Section 4.11](#).

[18] Note that an instance of `Calendar` must be fully initialized for the SQL type it maps.

[19] The use of `java.util.Calendar` or of `java.util.Date` is strongly discouraged. Newly-written programs should use the date/time types defined in the package `java.time`.

[20] The use of date/time types defined in the package `java.sql` is strongly discouraged. Newly-written programs should use the date/time types defined in `java.time`.

[21] The use of `Byte` arrays or of `Character` arrays is discouraged. Newly-written programs should use `byte` or `char` arrays instead.

[22] Direct or indirect circular containment dependencies among embeddable classes are not permitted.

[23] An entity cannot have a unidirectional relationship to the embeddable class of another entity (or itself).

[24] Note that when an embeddable instance is used as a map key, these attributes represent its identity. Changes to embeddable instances used as map keys have undefined behaviour and should be avoided.

[25] For associations of type `java.util.Map`, *target type* refers to the type that is the `Map` value.

[26] If the parent is detached or new or was previously removed before the orphan was associated with it, the `remove` operation is not applied to the entity being orphaned.

[27] When the relationship is modeled as a `java.util.Map`, "Entity B references a collection of Entity A" means that Entity B references a map collection in which the type of the `Map` value is Entity A. The map key may be a basic type, embeddable class, or an entity.

[28] The superclass must not be an embeddable class or id class.

[29] If a transaction-scoped persistence context is used, it is not required to be retained across transactions.

[30] This includes instances of a non-entity class that extends an entity class.

[31] If `<delimited-identifiers>` is specified and individual annotations or XML elements or attributes use escaped double quotes, the double-quotes appear in the name of the database identifier.

Chapter 3. Entity Operations

This chapter describes:

- the use of the `EntityManager` and `Query` APIs to retrieve instances of entity classes representing persistent state held in the database, and of `EntityGraph` to control the limits of the object graph returned by such operations,
- the use of the `EntityManager` API to manage the lifecycle of entity instances associated with a persistence context, and to control the synchronization of state held in the persistence context with the database,
- the use of the second-level cache, and
- entity listeners and lifecycle callbacks, attribute converters, and integration with Bean Validation.

3.1. Overview

Every instance of `EntityManager` has an associated *persistence context*. A persistence context is a set of entity instances in which for any given persistent entity identity there is a unique entity instance. Within the persistence context, the entity instances and their lifecycle are managed. The entity instance lifecycle is defined in [Section 3.3](#). The relationship between entity managers and persistence contexts is described in [Section 3.4](#), and again in further detail in [Chapter 7](#).

The `EntityManager` interface defines the methods used to interact with its persistence context. The `EntityManager` API is used to create and remove persistent entity instances, to find persistent entities by primary key, and to query over persistent entity types. [Section 3.2](#) describes the `EntityManager` interface. [Section 3.5](#) describes mechanisms for concurrency control and locking. [Section 3.12](#) provides a summary of exceptions.

The `EntityManager` acts as a factory for instances of `Query`, which are used to control query execution. `Query`, `TypedQuery`, `StoredProcedureQuery`, and related interfaces are described in [Section 3.11](#). The Jakarta Persistence query language is defined in [Chapter 4](#) and APIs for the construction of Criteria queries in [Chapter 6](#). [Section 3.8](#) describes the use of entity graphs to control and limit the data fetched during find and query operations.

Each `EntityManager` belongs to an `EntityManagerFactory` with an associated *persistence unit*. A persistence unit defines a set of related entities which map to a single database. Entities belonging to the same persistence unit may participate in associations. An `EntityManager` may only manage instances of entities belonging to its persistence unit. The definition of persistence units is described in [Chapter 8](#). An `EntityManagerFactory` might have an associated second-level cache. [Section 3.10](#) describes mechanisms for portable configuration of the second-level cache.

Jakarta Persistence features several mechanisms allowing user-written code to react to events occurring within the persistence context. [Section 3.6](#) describes entity listeners and lifecycle callback methods for entities. [Section 3.7](#) describes support for automatic use of Bean Validation. [Section 3.8](#) describes mechanisms for defining conversions between entity and database representations for attributes of basic types.

3.2. EntityManager Interface

The `EntityManager` interface may be found in [Section B.1](#).

The `persist`, `merge`, `remove`, and `refresh` methods must be invoked within a transaction context when an entity manager with a transaction-scoped persistence context is used. If there is no transaction context, the `jakarta.persistence.TransactionRequiredException` is thrown.

Methods that specify a lock mode other than `LockModeType.NONE` must be invoked within a transaction. If there is no transaction or if the entity manager has not been joined to the transaction, the `jakarta.persistence.TransactionRequiredException` is thrown.

The `find` method (provided it is invoked without a lock or invoked with `LockModeType.NONE`) and the `getReference` method

are not required to be invoked within a transaction. If an entity manager with transaction-scoped persistence context is in use, the resulting entities will be detached; if an entity manager with an extended persistence context is used, they will be managed. See [Section 3.4](#) for entity manager use outside a transaction.

The `Query`, `TypedQuery`, `StoredProcedureQuery`, `CriteriaBuilder`, `Metamodel`, and `EntityTransaction` objects obtained from an entity manager are valid while that entity manager is open.

If the argument to the `createQuery` method is not a valid Jakarta Persistence query string or a valid `CriteriaQuery` object, the `IllegalArgumentException` may be thrown or the query execution will fail and a `PersistenceException` will be thrown. If the result class specification of a Jakarta Persistence query language query is incompatible with the result of the query, the `IllegalArgumentException` may be thrown when the `createQuery` method is invoked or the query execution will fail and a `PersistenceException` will be thrown when the query is executed. If a native query is not a valid query for the database in use or if the result set specification is incompatible with the result of the query, the query execution will fail and a `PersistenceException` will be thrown when the query is executed. The `PersistenceException` should wrap the underlying database exception when possible.

Runtime exceptions thrown by the methods of the `EntityManager` interface other than the `LockTimeoutException` will cause the current transaction to be marked for rollback if the persistence context is joined to that transaction.

The methods `close`, `isOpen`, `joinTransaction`, and `getTransaction` are used to manage application-managed entity managers and their lifecycle. See [Section 7.2.2](#).

The `EntityManager` interface and other interfaces defined by this specification contain methods that take properties and/or hints as arguments. This specification distinguishes between `properties` and `hints` as follows:

- A property defined by this specification must be observed by the provider unless otherwise explicitly stated.
- A hint specifies a preference on the part of the application. While a hint defined by this specification should be observed by the provider if possible, a hint may or may not always be observed. A portable application must not depend on the observance of a hint.

For example:

```
@Stateless
public class OrderEntryBean implements OrderEntry {
    @PersistenceContext
    EntityManager em;

    public void enterOrder(int custID, Order newOrder) {
        Customer cust = em.find(Customer.class, custID);
        cust.getOrders().add(newOrder);
        newOrder.setCustomer(cust);
        em.persist(newOrder);
    }
}
```

3.3. Entity Instance's Life Cycle

This section describes the `EntityManager` operations for managing an entity instance's lifecycle. An entity instance can be characterized as being new, managed, detached, or removed.

- A new entity instance has no persistent identity, and is not yet associated with a persistence context.
- A managed entity instance is an instance with a persistent identity that is currently associated with a persistence context.
- A detached entity instance is an instance with a persistent identity that is not (or no longer) associated with a persistence context.

- A removed entity instance is an instance with a persistent identity, associated with a persistence context, that will be removed from the database upon transaction commit.

The following subsections describe the effect of lifecycle operations upon entities. Use of the `cascade` annotation element may be used to propagate the effect of an operation to associated entities. The cascade functionality is most typically used in parent-child relationships.

3.3.1. Entity Instance Creation

Entity instances are created by means of the `new` operation. An entity instance, when first created by `new` is not yet persistent. An instance becomes persistent by means of the `EntityManager` API.

3.3.2. Persisting an Entity Instance

A new entity instance becomes both managed and persistent by invoking the `persist` method on it or by cascading the `persist` operation.

The semantics of the `persist` operation, applied to an entity X are as follows:

- If X is a new entity, it becomes managed. The entity X will be entered into the database at or before transaction commit or as a result of the flush operation.
- If X is a preexisting managed entity, it is ignored by the `persist` operation. However, the `persist` operation is cascaded to entities referenced by X, if the relationships from X to these other entities are annotated with the `cascade=PERSIST` or `cascade=ALL` annotation element value or specified with the equivalent XML descriptor element.
- If X is a removed entity, it becomes managed.
- If X is a detached object, the `EntityExistsException` may be thrown when the `persist` operation is invoked, or the `EntityExistsException` or another `PersistenceException` may be thrown at flush or commit time.
- For all entities Y referenced by a relationship from X, if the relationship to Y has been annotated with the `cascade` element value `cascade=PERSIST` or `cascade=ALL`, the `persist` operation is applied to Y.

3.3.3. Removal

A managed entity instance becomes removed by invoking the `remove` method on it or by cascading the `remove` operation.

The semantics of the `remove` operation, applied to an entity X are as follows:

- If X is a new entity, it is ignored by the `remove` operation. However, the `remove` operation is cascaded to entities referenced by X, if the relationship from X to these other entities is annotated with the `cascade=REMOVE` or `cascade=ALL` annotation element value.
- If X is a managed entity, the `remove` operation causes it to become removed. The `remove` operation is cascaded to entities referenced by X, if the relationships from X to these other entities is annotated with the `cascade=REMOVE` or `cascade=ALL` annotation element value.
- If X is a detached entity, an `IllegalArgumentException` will be thrown by the `remove` operation (or the transaction commit will fail).
- If X is a removed entity, it is ignored by the `remove` operation.
- A removed entity X will be removed from the database at or before transaction commit or as a result of the flush operation.

After an entity has been removed, its state (except for generated state) will be that of the entity at the point at which the `remove` operation was called.

3.3.4. Synchronization to the Database

In general, a persistence context will be synchronized to the database as described below. However, a persistence context of type `SynchronizationType.UNSYNCHRONIZED` or an application-managed persistence context that has been created outside the scope of the current transaction will only be synchronized to the database if it has been joined to the current transaction by the application's use of the `EntityManager.joinTransaction` method.

The state of persistent entities is synchronized to the database at transaction commit. This synchronization involves writing to the database any updates to persistent entities and their relationships as specified above.

An update to the state of an entity includes both the assignment of a new value to a persistent property or field of the entity as well as the modification of a mutable value of a persistent property or field^[1].

Synchronization to the database does not involve a refresh of any managed entities unless the refresh operation is explicitly invoked on those entities or cascaded to them as a result of the specification of the `cascade=REFRESH` or `cascade=ALL` annotation element value.

Bidirectional relationships between managed entities will be persisted based on references held by the owning side of the relationship. It is the developer's responsibility to keep the in-memory references held on the owning side and those held on the inverse side consistent with each other when they change. In the case of unidirectional one-to-one and one-to-many relationships, it is the developer's responsibility to ensure that the semantics of the relationships are adhered to.^[2]



It is particularly important to ensure that changes to the inverse side of a relationship result in appropriate updates on the owning side, so as to ensure the changes are not lost when they are synchronized to the database.

The persistence provider runtime is permitted to perform synchronization to the database at other times as well when a transaction is active and the persistence context is joined to the transaction. The `flush` method can be used by the application to force synchronization. It applies to entities associated with the persistence context. The `setFlushMode` methods of the `EntityManager`, `Query`, `TypedQuery`, and `StoredProcedureQuery` interfaces can be used to control synchronization semantics. The effect of `FlushModeType.AUTO` is defined in [Section 3.11.2](#). If `FlushModeType.COMMIT` is specified, flushing will occur at transaction commit; the persistence provider is permitted, but not required, to perform to flush at other times. If there is no transaction active or if the persistence context has not been joined to the current transaction, the persistence provider must not flush to the database.

The semantics of the flush operation, applied to an entity X are as follows:

- If X is a managed entity, it is synchronized to the database.
 - For all entities Y referenced by a relationship from X, if the relationship to Y has been annotated with the `cascade` element value `cascade=PERSIST` or `cascade=ALL`, the `persist` operation is applied to Y.
 - For any entity Y referenced by a relationship from X, where the relationship to Y has not been annotated with the `cascade` element value `cascade=PERSIST` or `cascade=ALL`:
 - If Y is new or removed, an `IllegalStateException` will be thrown by the flush operation (and the transaction marked for rollback) or the transaction commit will fail.
 - If Y is detached, the semantics depend upon the ownership of the relationship. If X owns the relationship, any changes to the relationship are synchronized with the database; otherwise, if Y owns the relationships, the behavior is undefined.
- If X is a removed entity, it is removed from the database. No `cascade` options are relevant.

3.3.5. Refreshing an Entity Instance

The state of a managed entity instance is refreshed from the database by invoking the `refresh` method on it or by cascading the refresh operation.

The semantics of the refresh operation, applied to an entity `X` are as follows:

- If `X` is a managed entity, the state of `X` is refreshed from the database, overwriting changes made to the entity, if any. The refresh operation is cascaded to entities referenced by `X` if the relationship from `X` to these other entities is annotated with the `cascade=REFRESH` or `cascade=ALL` annotation element value.
- If `X` is a new, detached, or removed entity, the `IllegalArgumentException` is thrown.

3.3.6. Evicting an Entity Instance from the Persistence Context

An entity instance is removed from the persistence context by invoking the `detach` method on it or cascading the detach operation. Changes made to the entity, if any (including removal of the entity), will not be synchronized to the database after such eviction has taken place.

Applications must use the `flush` method prior to the `detach` method to ensure portable semantics if changes have been made to the entity (including removal of the entity). Because the persistence provider may write to the database at times other than the explicit invocation of the `flush` method, portable applications must not assume that changes have not been written to the database if the `flush` method has not been called prior to `detach`.

The semantics of the detach operation, applied to an entity `X` are as follows:

- If `X` is a managed entity, the detach operation causes it to become detached. The detach operation is cascaded to entities referenced by `X` if the relationships from `X` to these other entities is annotated with the `cascade=DETACH` or `cascade=ALL` annotation element value. Entities which previously referenced `X` will continue to reference `X`.
- If `X` is a new or detached entity, it is ignored by the detach operation.
- If `X` is a removed entity, the detach operation causes it to become detached. The detach operation is cascaded to entities referenced by `X` if the relationships from `X` to these other entities is annotated with the `cascade=DETACH` or `cascade=ALL` annotation element value. Entities which previously referenced `X` will continue to reference `X`. Portable applications should not pass removed entities that have been detached from the persistence context to further `EntityManager` operations.

3.3.7. Detached Entities

A detached entity results from transaction commit if a transaction-scoped persistence context is used (see [Section 3.4](#)); from transaction rollback (see [Section 3.4.3](#)); from detaching the entity from the persistence context; from clearing the persistence context; from closing an entity manager; or from serializing an entity or otherwise passing an entity by value—e.g., to a separate application tier, through a remote interface, etc.

Detached entity instances continue to live outside the persistence context in which they were persisted or retrieved. Their state is no longer guaranteed to be synchronized with the database state.

The application may access the available state of available detached entity instances after the persistence context ends. The available state includes:

- Any persistent field or property not marked `fetch=LAZY`
- Any persistent field or property that was accessed by the application or fetched by means of an entity graph

If the persistent field or property is an association, the available state of an associated instance may only be safely accessed if the associated instance is available. The available instances include:

- Any entity instance retrieved using `find()`.
- Any entity instances retrieved using a query or explicitly requested in a fetch join.
- Any entity instance for which an instance variable holding non-primary-key persistent state was accessed by the application.
- Any entity instance that can be reached from another available instance by navigating associations marked `fetch=EAGER`.

3.3.7.1. Merging Detached Entity State

The merge operation allows for the propagation of state from detached entities onto persistent entities managed by the entity manager.

The semantics of the merge operation applied to an entity X are as follows:

- If X is a detached entity, the state of X is copied onto a pre-existing managed entity instance X' of the same identity or a new managed copy X' of X is created.
- If X is a new entity instance, a new managed entity instance X' is created and the state of X is copied into the new managed entity instance X'.
- If X is a removed entity instance, an `IllegalArgumentException` will be thrown by the merge operation (or the transaction commit will fail).
- If X is a managed entity, it is ignored by the merge operation, however, the merge operation is cascaded to entities referenced by relationships from X if these relationships have been annotated with the `cascade` element value `cascade=MERGE` or `cascade=ALL` annotation.
- For all entities Y referenced by relationships from X having the `cascade` element value `cascade=MERGE` or `cascade=ALL`, Y is merged recursively as Y'. For all such Y referenced by X, X' is set to reference Y'. (Note that if X is managed then X is the same object as X'.)
- If X is an entity merged to X', with a reference to another entity Y, where `cascade=MERGE` or `cascade=ALL` is not specified, then navigation of the same association from X' yields a reference to a managed object Y' with the same persistent identity as Y.

The persistence provider must not merge fields marked `LAZY` that have not been fetched: it must ignore such fields when merging.

Any `Version` columns used by the entity must be checked by the persistence runtime implementation during the merge operation and/or at flush or commit time. In the absence of `Version` columns there is no additional version checking done by the persistence provider runtime during the merge operation.

3.3.7.2. Detached Entities and Lazy Loading

Serializing entities and merging those entities back into a persistence context may not be interoperable across vendors when lazy properties or fields and/or relationships are used.

A vendor is required to support the serialization and subsequent deserialization and merging of detached entity instances (which may contain lazy properties or fields and/or relationships that have not been fetched) back into a separate JVM instance of that vendor's runtime, where both runtime instances have access to the entity classes and any required vendor persistence implementation classes.

When interoperability across vendors is required, the application must not use lazy loading.

3.3.8. Managed Instances

It is the responsibility of the application to insure that an instance is managed in only a single persistence context. The behavior is undefined if the same Java instance is made managed in more than one persistence context.

The `contains()` method can be used to determine whether an entity instance is managed in the current persistence context.

The `contains` method returns true:

- If the entity has been retrieved from the database or has been returned by `getReference`, and has not been removed or detached.
- If the entity instance is new, and the `persist` method has been called on the entity or the `persist` operation has been cascaded to it.

The `contains` method returns false:

- If the instance is detached.
- If the `remove` method has been called on the entity, or the `remove` operation has been cascaded to it.
- If the instance is new, and the `persist` method has not been called on the entity or the `persist` operation has not been cascaded to it.

Note that the effect of the cascading of `persist`, `merge`, `remove`, or `detach` is immediately visible to the `contains` method, whereas the actual insertion, modification, or deletion of the database representation for the entity may be deferred until the end of the transaction.

3.3.9. Load State

An entity is considered to be loaded if all attributes with `FetchType.EAGER`—whether explicitly specified or by default—including relationship and other collection-valued attributes) have been loaded from the database or assigned by the application. Attributes with `FetchType.LAZY` may or may not have been loaded. The available state of the entity instance and associated instances is as described in [Section 3.3.7](#).

An attribute that is an embeddable is considered to be loaded if the embeddable attribute was loaded from the database or assigned by the application, and, if the attribute references an embeddable instance (i.e., is not null), the embeddable instance state is known to be loaded (i.e., all attributes of the embeddable with `FetchType.EAGER` have been loaded from the database or assigned by the application).

A collection-valued attribute is considered to be loaded if the collection was loaded from the database or the value of the attribute was assigned by the application, and, if the attribute references a collection instance (i.e., is not null), each element of the collection (e.g. entity or embeddable) is considered to be loaded.

A single-valued relationship attribute is considered to be loaded if the relationship attribute was loaded from the database or assigned by the application, and, if the attribute references an entity instance (i.e., is not null), the entity instance state is known to be loaded.

A basic attribute is considered to be loaded if its state has been loaded from the database or assigned by the application.

The `PersistenceUtil.isLoaded` methods can be used to determine the load state of an entity and its attributes regardless of the persistence unit with which the entity is associated. The `PersistenceUtil.isLoaded` methods return true if the above conditions hold, and false otherwise. If the persistence unit is known, the `PersistenceUnitUtil.isLoaded` methods can be used instead. See [Section 7.11](#).

Persistence provider contracts for determining the load state of an entity or entity attribute are described in [Section](#)

3.4. Persistence Context Lifetime and Synchronization Type

The lifetime of a container-managed persistence context can either be scoped to a transaction (transaction-scoped persistence context), or have a lifetime scope that extends beyond that of a single transaction (extended persistence context). The enum `PersistenceContextType` is used to define the persistence context lifetime scope for container-managed entity managers. The persistence context lifetime scope is defined when the `EntityManager` instance is created (whether explicitly, or in conjunction with injection or JNDI lookup). See [Section 7.7](#).

```
/**
 * Specifies whether a transaction-scoped or extended persistence
 * context is to be used in {@link PersistenceContext}. If not
 * specified, a transaction-scoped persistence context is used.
 *
 * @since 1.0
 */
public enum PersistenceContextType {

    /** Transaction-scoped persistence context */
    TRANSACTION,

    /** Extended persistence context */
    EXTENDED
}
```

By default, the lifetime of the persistence context of a container-managed entity manager corresponds to the scope of a transaction (i.e., it is of type `PersistenceContextType.TRANSACTION`).

When an extended persistence context is used, the extended persistence context exists from the time the `EntityManager` instance is created until it is closed. This persistence context might span multiple transactions and non-transactional invocations of the `EntityManager`.

An `EntityManager` with an extended persistence context maintains its references to the entity objects after a transaction has committed. Those objects remain managed by the `EntityManager`, and they can be updated as managed objects between transactions.^[3] Navigation from a managed object in an extended persistence context results in one or more other managed objects regardless of whether a transaction is active.

When an `EntityManager` with an extended persistence context is used, the `persist`, `remove`, `merge`, and `refresh` operations can be called regardless of whether a transaction is active. The effects of these operations will be committed to the database when the extended persistence context is enlisted in a transaction and the transaction commits.

The scope of the persistence context of an application-managed entity manager is extended. It is the responsibility of the application to manage the lifecycle of the persistence context.

Container-managed persistence contexts are described further in [Section 7.7](#). Persistence contexts managed by the application are described further in [Section 7.8](#).

3.4.1. Synchronization with the Current Transaction

By default, a container-managed persistence context is of `SynchronizationType.SYNCHRONIZED` and is automatically joined to the current transaction. A persistence context of `SynchronizationType.UNSYNCHRONIZED` will not be enlisted in the current transaction, unless the `EntityManager.joinTransaction` method is invoked.

By default, an application-managed persistence context that is associated with a JTA entity manager and that is created within the scope of an active transaction is automatically joined to that transaction. An application-managed JTA

persistence context that is created outside the scope of a transaction or an application-managed persistence context of type `SynchronizationType.UNSYNCHRONIZED` will not be joined to that transaction unless the `EntityManager.joinTransaction` method is invoked.

An application-managed persistence context associated with a resource-local entity manager is always automatically joined to any resource-local transaction that is begun for that entity manager.

Persistence context synchronization type is described further in [Section 7.7.1](#).

3.4.2. Transaction Commit

The managed entities of a transaction-scoped persistence context become detached when the transaction commits; the managed entities of an extended persistence context remain managed.

3.4.3. Transaction Rollback

For both transaction-scoped persistence contexts and for extended persistence contexts that are joined to the current transaction, transaction rollback causes all *pre-existing* managed instances and removed instances^[4] to become detached. The instances' state will be the state of the instances at the point at which the transaction was rolled back. Transaction rollback typically causes the persistence context to be in an inconsistent state at the point of rollback. In particular, the state of version attributes and generated state (e.g., generated primary keys) may be inconsistent. Instances that were formerly managed by the persistence context (including new instances that were made persistent in that transaction) may therefore not be reusable in the same manner as other detached objects—for example, they may fail when passed to the merge operation.^[5]



Because a transaction-scoped persistence context's lifetime is scoped to a transaction regardless of whether it is joined to that transaction, the container closes the persistence context upon transaction rollback. However, an extended persistence context that is not joined to a transaction is unaffected by transaction rollback.

3.5. Locking and Concurrency

This specification assumes the use of optimistic concurrency control. It assumes that the databases to which persistence units are mapped will be accessed by the implementation using read-committed isolation (or a vendor equivalent in which long-term read locks are not held), and that writes to the database will typically occur only when the `flush` method has been invoked—whether explicitly by the application, or by the persistence provider runtime in accordance with the flush mode setting.



If a transaction is active and the persistence context is joined to the transaction, a compliant implementation of this specification is permitted to write to the database immediately (i.e., whenever a managed entity is updated, created, and/or removed), however, the configuration of an implementation to require such non-deferred database writes is outside the scope of this specification.^[6]

In addition, both pessimistic and optimistic locking are supported for selected entities by means of specified lock modes. Optimistic locking is described in [Section 3.5.1](#) and [Section 3.5.2](#); pessimistic locking in [Section 3.5.3](#). [Section 3.5.4](#) describes the setting of optimistic and pessimistic lock modes. The configuration of the setting of optimistic lock modes is described in [Section 3.5.4.1](#), and the configuration of the setting of pessimistic lock modes is described in [Section 3.5.4.2](#).

3.5.1. Optimistic Locking

Optimistic locking is a system of concurrency control where each revision of an item of data is assigned a version number or timestamp. When the data is read and then updated within a given unit of work, the version or timestamp is:

1. read from the database when the data itself is read, and
2. verified and then updated in the database when the data is updated.

Similarly, when the data is read and then deleted within a given unit of work, the version or timestamp is:

1. read from the database when the data itself is read, and
2. verified when the data is deleted.

An *optimistic lock failure* occurs when verification fails, that is, if the version or timestamp held in the database changes between reading the data (step 1), and attempting to update or delete the data (step 2).

Thus, the unit of work is prevented from updating the data and creating a new revision, or from deleting the data, unless the revision it previously obtained is still the current revision. Optimistic lock verification ensures that an update of a given item is successful only when no intervening transaction has already updated the item, preventing the loss of updates made by such intervening transactions.

The persistence provider is required to perform optimistic locking automatically for every entity with a version, as defined in [Section 2.5](#). A portable application which wishes to take advantage of automatic optimistic locking must specify a version field or property for each optimistically-locked entity using the `@Version` annotation defined in [Section 11.1.57](#) or equivalent XML element.

When an optimistic lock failure is detected, the persistence provider must:

- throw an `OptimisticLockException` and
- mark the current transaction for rollback.

A persistence provider might offer alternative implementations of optimistic locking, which do not depend on the entity having a version, but such functionality is not portable between providers.^[7]



Applications are strongly encouraged to enable optimistic locking for every entity which may be concurrently accessed or which may be merged from a detached state. Failure to make use of optimistic locking often leads to inconsistent entity state, lost updates, and other anomalies. If an entity does not have a version, the application itself must bear the burden of maintaining data consistency during optimistic units of work.

For the purposes of versioning and optimistic locking, the state of a given entity is considered to include:

- every persistent field or property which is not a relationship to another entity, and
- every relationship owned by the entity, as defined by [Section 2.11](#).^[8]

Unowned relationships are not considered part of the state of the entity.

3.5.2. Entity Versions and Optimistic Locking

The entity version must be updated by the persistence provider each time the state of an entity instance is written to the database.^[9] Furthermore, if the current persistence context contains a revision of the entity instance when the instance is written to the database, the persistence provider must verify that the revision held in the persistence context is identical to the revision held in the database by comparing the versions held in memory and in the database.

^[10] If the versions do not match, the persistence provider must throw an `OptimisticLockException`.

The persistence provider must examine the version field or property of a detached entity instance when it is merged, as defined in [Section 3.3.7.1](#), and throw an `OptimisticLockException` if the instance being merged holds a stale revision of the state of the entity—that is, if the entity was updated since the entity instance became detached. The timing of this version check is provider-dependent:

- the version check might occur synchronously with the call to `merge()`, or
- a provider might choose to delay the version check until a flush operation occurs, as defined in [Section 3.3.4](#), or until the transaction commits.

If an update or merge operation involves entities with versions, and entities without versions, the persistence provider runtime is only required to perform optimistic lock verification for those entities which do have a version, and the consistency of the whole object graph is not guaranteed. The absence a version for some entity involved in the update or merge operation does not impede completion of the operation.

3.5.3. Pessimistic Locking

While optimistic locking is typically appropriate in dealing with moderate contention among concurrent transactions, in some applications it may be useful to immediately obtain long-term database locks for selected entities because of the often late failure of optimistic transactions. Such immediately obtained long-term database locks are referred to here as “pessimistic” locks.^[11]

Pessimistic locking guarantees that once a transaction has obtained a pessimistic lock on an entity instance:

- no other transaction (whether a transaction of an application using the Jakarta Persistence API or any other transaction using the underlying resource) may successfully modify or delete that instance until the transaction holding the lock has ended.
- if the pessimistic lock is an exclusive lock^[12], that same transaction may modify or delete that entity instance.

When an entity instance is locked using pessimistic locking, the persistence provider must lock the database row(s) that correspond to the non-collection-valued persistent state of that instance. If a joined inheritance strategy is used, or if the entity is otherwise mapped to a secondary table, this entails locking the row(s) for the entity instance in the additional table(s). Entity relationships for which the locked entity contains the foreign key will also be locked, but not the state of the referenced entities (unless those entities are explicitly locked). Element collections and relationships for which the entity does not contain the foreign key (such as relationships that are mapped to join tables or unidirectional one-to-many relationships for which the target entity contains the foreign key) will not be locked by default.

Element collections and relationships owned by the entity that are contained in join tables will be locked if the `jakarta.persistence.lock.scope` property is specified with a value of `PessimisticLockScope.EXTENDED`. The state of entities referenced by such relationships will not be locked (unless those entities are explicitly locked). This property may be passed as an argument to the methods of the `EntityManager`, `Query`, and `TypedQuery` interfaces that allow lock modes to be specified or used with the `NamedQuery` annotation.

Locking such a relationship or element collection generally locks only the rows in the join table or collection table for that relationship or collection. This means that phantoms will be possible.

The values of the `jakarta.persistence.lock.scope` property are defined by the `PessimisticLockScope` enum.

```
/**
 *
 * Defines the values of the {@code jakarta.persistence.lock.scope}
 * property for pessimistic locking. This property may be passed as an
 * argument to the methods of the {@link EntityManager}, {@link Query},
 * and {@link TypedQuery} interfaces that allow lock modes to be specified
```

```

* or used with the {@link NamedQuery} annotation.
*
* @since 2.0
*/
public enum PessimisticLockScope implements FindOption, RefreshOption, LockOption {

    /**
     * This value defines the default behavior for pessimistic locking.
     *
     * <p>The persistence provider must lock the database row(s) that
     * correspond to the non-collection-valued persistent state of
     * that instance. If a joined inheritance strategy is used, or if
     * the entity is otherwise mapped to a secondary table, this
     * entails locking the row(s) for the entity instance in the
     * additional table(s). Entity relationships for which the locked
     * entity contains the foreign key will also be locked, but not
     * the state of the referenced entities (unless those entities are
     * explicitly locked). Element collections and relationships for
     * which the entity does not contain the foreign key (such as
     * relationships that are mapped to join tables or unidirectional
     * one-to-many relationships for which the target entity contains
     * the foreign key) will not be locked by default.
     */
    NORMAL,

    /**
     * In addition to the locking behavior specified for {@link #NORMAL},
     * element collections and relationships owned by the entity that
     * are contained in join tables are locked if the property
     * {@code jakarta.persistence.lock.scope} is specified with a value
     * of {@code PessimisticLockScope#EXTENDED}. The state of entities
     * referenced by such relationships is not locked (unless those
     * entities are explicitly locked). Locking such a relationship or
     * element collection generally locks only the rows in the join table
     * or collection table for that relationship or collection. This means
     * that phantoms are possible.
     */
    EXTENDED
}

```

This specification does not define the mechanisms a persistence provider uses to obtain database locks, and a portable application should not rely on how pessimistic locking is achieved on the database.^[13] In particular, a persistence provider or the underlying database management system may lock more rows than the ones selected by the application.

Whenever a pessimistically locked entity containing a version attribute is updated on the database, the persistence provider must also update (increment) the entity’s version column to enable correct interaction with applications using optimistic locking. See [Section 3.5.2](#) and [Section 3.5.4](#).

Pessimistic locking may be applied to entities that do not contain version attributes. However, in this case correct interaction with applications using optimistic locking cannot be ensured.

3.5.4. Lock Modes

Lock modes are intended to provide a facility that enables the effect of “repeatable read” semantics for the items read, whether “optimistically” (as described in [Section 3.5.4.1](#)) or “pessimistically” (as described in [Section 3.5.4.2](#)).

A lock mode may be explicitly specified as an argument to the `lock()` method of `EntityManager` or to any other method of `EntityManager`, `Query`, and `TypedQuery` which accepts a lock mode, or via the `NamedQuery` annotation.

Lock mode values are defined by the `LockModeType` enum which may be found in [Section B.4](#). Six distinct lock modes are

defined.^[14] The lock mode type values `READ` and `WRITE` are synonyms for `OPTIMISTIC` and `OPTIMISTIC_FORCE_INCREMENT` respectively. The latter are to be preferred for new applications.

3.5.4.1. OPTIMISTIC, OPTIMISTIC_FORCE_INCREMENT

The lock modes `OPTIMISTIC` and `OPTIMISTIC_FORCE_INCREMENT` are used for optimistic locking. The lock mode type values `READ` and `WRITE` are synonymous with `OPTIMISTIC` and `OPTIMISTIC_FORCE_INCREMENT` respectively.

The semantics of requesting locks of type `LockModeType.OPTIMISTIC` and `LockModeType.OPTIMISTIC_FORCE_INCREMENT` are the following.

If transaction T1 calls `lock(entity, LockModeType.OPTIMISTIC)` on a versioned object, the entity manager must ensure that neither of the following phenomena can occur:

- P1 (Dirty read): Transaction T1 modifies a row. Another transaction T2 then reads that row and obtains the modified value, before T1 has committed or rolled back. Transaction T2 eventually commits successfully; it does not matter whether T1 commits or rolls back and whether it does so before or after T2 commits.
- P2 (Non-repeatable read): Transaction T1 reads a row. Another transaction T2 then modifies or deletes that row, before T1 has committed. Both transactions eventually commit successfully.

This will generally be achieved by the entity manager acquiring a lock on the underlying database row. While with optimistic concurrency, long-term database read locks are typically not obtained immediately, a compliant implementation is permitted to obtain an immediate lock (so long as it is retained until commit completes). If the lock is deferred until commit time, it must be retained until the commit completes. Any implementation that supports repeatable reads in a way that prevents the above phenomena is permissible.

The persistence implementation is not required to support calling `lock(entity, LockModeType.OPTIMISTIC)` on a non-versioned object. When it cannot support such a lock call, it must throw the `PersistenceException`. When supported, whether for versioned or non-versioned objects, `LockModeType.OPTIMISTIC` must always prevent the phenomena P1 and P2. Applications that call `lock(entity, LockModeType.OPTIMISTIC)` on non-versioned objects are not portable.

If transaction T1 calls `lock(entity, LockModeType.OPTIMISTIC_FORCE_INCREMENT)` on a versioned object, the entity manager must avoid the phenomena P1 and P2 (as with `LockModeType.OPTIMISTIC`) and must also force an update (increment) to the entity's version column. A forced version update may be performed immediately, or may be deferred until a flush or commit. If an entity is removed before a deferred version update was to have been applied, the forced version update is omitted.

The persistence implementation is not required to support calling `lock(entity, LockModeType.OPTIMISTIC_FORCE_INCREMENT)` on a non-versioned object. When it cannot support such a lock call, it must throw the `PersistenceException`. When supported, whether for versioned or non-versioned objects, `LockModeType.OPTIMISTIC_FORCE_INCREMENT` must always prevent the phenomena P1 and P2. For non-versioned objects, whether or not `LockModeType.OPTIMISTIC_FORCE_INCREMENT` has any additional behavior is vendor-specific. Applications that call `lock(entity, LockModeType.OPTIMISTIC_FORCE_INCREMENT)` on non-versioned objects will not be portable.

For versioned objects, it is permissible for an implementation to use `LockModeType.OPTIMISTIC_FORCE_INCREMENT` where `LockModeType.OPTIMISTIC` was requested, but not vice versa.

If a versioned object is otherwise updated or removed, then the implementation must ensure that the requirements of `LockModeType.OPTIMISTIC_FORCE_INCREMENT` are met, even if no explicit call to `EntityManager.lock` was made.

For portability, an application should not depend on vendor-specific hints or configuration to ensure repeatable read for objects that are not updated or removed via any mechanism other than the use of version attributes and the `EntityManager.lock` method. However, it should be noted that if an implementation has acquired up-front pessimistic locks on some database rows, then it is free to ignore `lock(entity, LockModeType.OPTIMISTIC)` calls on the entity objects

representing those rows.

3.5.4.2. PESSIMISTIC_READ, PESSIMISTIC_WRITE, PESSIMISTIC_FORCE_INCREMENT

The lock modes `PESSIMISTIC_READ`, `PESSIMISTIC_WRITE`, and `PESSIMISTIC_FORCE_INCREMENT` are used to immediately obtain long-term database locks.^[15]

The semantics of requesting locks of type `LockModeType.PESSIMISTIC_READ`, `LockModeType.PESSIMISTIC_WRITE`, and `LockModeType.PESSIMISTIC_FORCE_INCREMENT` are the following.

If transaction T1 calls `lock(entity, LockModeType.PESSIMISTIC_READ)` or `lock(entity, LockModeType.PESSIMISTIC_WRITE)` on an object, the entity manager must ensure that neither of the following phenomena can occur:

- P1 (Dirty read): Transaction T1 modifies a row. Another transaction T2 then reads that row and obtains the modified value, before T1 has committed or rolled back.
- P2 (Non-repeatable read): Transaction T1 reads a row. Another transaction T2 then modifies or deletes that row, before T1 has committed or rolled back.

Any such lock must be obtained immediately and retained until transaction T1 completes (commits or rolls back).

Avoidance of phenomena P1 and P2 is generally achieved by the entity manager acquiring a long-term lock on the underlying database row(s). Any implementation that supports pessimistic repeatable reads as described above is permissible.



A lock with `LockModeType.PESSIMISTIC_WRITE` can be obtained on an entity instance to force serialization among transactions attempting to update the entity data. A lock with `LockModeType.PESSIMISTIC_READ` can be used to query data using repeatable-read semantics without the need to reread the data at the end of the transaction to obtain a lock, and without blocking other transactions reading the data. A lock with `LockModeType.PESSIMISTIC_WRITE` can be used when querying data and there is a high likelihood of deadlock or update failure among concurrent updating transactions.

The persistence implementation must support calling `lock(entity, LockModeType.PESSIMISTIC_READ)` and `lock(entity, LockModeType.PESSIMISTIC_WRITE)` on a non-versioned entity as well as on a versioned entity.

It is permissible for an implementation to use `LockModeType.PESSIMISTIC_WRITE` where `LockModeType.PESSIMISTIC_READ` was requested, but not vice versa.

When the lock cannot be obtained, and the database locking failure results in transaction-level rollback, the provider must throw the `PessimisticLockException` and ensure that the JTA transaction or `EntityTransaction` has been marked for rollback.

When the lock cannot be obtained, and the database locking failure results in only statement-level rollback, the provider must throw the `LockTimeoutException` (and must not mark the transaction for rollback).

When an application locks an entity with `LockModeType.PESSIMISTIC_READ` and later updates that entity, the lock must be converted to an exclusive lock when the entity is flushed to the database.^[16] If the lock conversion fails, and the database locking failure results in transaction-level rollback, the provider must throw the `PessimisticLockException` and ensure that the JTA transaction or `EntityTransaction` has been marked for rollback. When the lock conversion fails, and the database locking failure results in only statement-level rollback, the provider must throw the `LockTimeoutException` (and must not mark the transaction for rollback).

When `lock(entity, LockModeType.PESSIMISTIC_READ)`, `lock(entity, LockModeType.PESSIMISTIC_WRITE)`, or `lock(entity, LockModeType.PESSIMISTIC_FORCE_INCREMENT)` is invoked on a versioned entity that is already in the persistence context, the provider must also perform optimistic version checks when obtaining the lock. An `OptimisticLockException` must be

thrown if the version checks fail. Depending on the implementation strategy used by the provider, it is possible that this exception may not be thrown until flush is called or commit time, whichever occurs first.

If transaction T1 calls `lock(entity, LockModeType.PESSIMISTIC_FORCE_INCREMENT)` on a versioned object, the entity manager must avoid the phenomenon P1 and P2 (as with `LockModeType.PESSIMISTIC_READ` and `LockModeType.PESSIMISTIC_WRITE`) and must also force an update (increment) to the entity's version column.

The persistence implementation is not required to support calling `lock(entity, LockModeType.PESSIMISTIC_FORCE_INCREMENT)` on a non-versioned object. When it cannot support such a lock call, it must throw the `PersistenceException`. When supported, whether for versioned or non-versioned objects, `LockModeType.PESSIMISTIC_FORCE_INCREMENT` must always prevent the phenomena P1 and P2. For non-versioned objects, whether or not `LockModeType.PESSIMISTIC_FORCE_INCREMENT` has any additional behavior is vendor-specific. Applications that call `lock(entity, LockModeType.PESSIMISTIC_FORCE_INCREMENT)` on non-versioned objects will not be portable.

For versioned objects, it is permissible for an implementation to use `LockModeType.PESSIMISTIC_FORCE_INCREMENT` where `LockModeType.PESSIMISTIC_READ` or `LockModeType.PESSIMISTIC_WRITE` was requested, but not vice versa.

If a versioned object locked with `LockModeType.PESSIMISTIC_READ` or `LockModeType.PESSIMISTIC_WRITE` is updated, then the implementation must ensure that the requirements of `LockModeType.PESSIMISTIC_FORCE_INCREMENT` are met.

3.5.4.3. Lock Mode Properties and Uses

The following property is defined by this specification for use in pessimistic locking, as described in [Section 3.5.3](#):

```
jakarta.persistence.lock.scope
```

This property may be used with the methods of the `EntityManager` interface that allow lock modes to be specified, the `Query` and `TypedQuery` `setLockMode` methods, and the `NamedQuery` annotation. When specified, this property must be observed. The provider is permitted to lock more (but not fewer) rows than requested.

The following hint is defined by this specification for use in pessimistic locking.

```
jakarta.persistence.lock.timeout // time in milliseconds
```

This hint may be used with the methods of the `EntityManager` interface that allow lock modes to be specified, the `Query.setLockMode` method and the `NamedQuery` annotation. It may also be passed as a property to the `Persistence.createEntityManagerFactory` method and used in the `properties` element of the `persistence.xml` file. See [Section 3.2](#), [Section 3.11.3](#), [Section 8.2.1.11](#), [Section 9.7](#), and [Section 10.4.1](#). When used in the `createEntityManagerFactory` method, the `persistence.xml` file, and the `NamedQuery` annotation, the `timeout` hint serves as a default value which can be selectively overridden by use in the methods of the `EntityManager`, `Query`, and `TypedQuery` interfaces as specified above. When this hint is not specified, database timeout values are assumed to apply.

A timeout value of 0 is used to specify “no wait” locking.

Portable applications should not rely on this hint. Depending on the database in use and the locking mechanisms used by the persistence provider, the hint may or may not be observed.

Vendors are permitted to support the use of additional, vendor-specific locking hints. Vendor-specific hints must not use the `jakarta.persistence` namespace. Vendor-specific hints must be ignored if they are not understood.

If the same property or hint is specified more than once, the following order of overriding applies, in order of decreasing precedence:

- argument to method of `EntityManager`, `Query`, or `TypedQuery` interface

- specification to `NamedQuery` (annotation or XML)
- argument to `createEntityManagerFactory` method
- specification in `persistence.xml`

3.5.5. OptimisticLockException

Provider implementations may defer writing to the database until the end of the transaction, when consistent with the lock mode and flush mode settings in effect. In this case, an optimistic lock check may not occur until commit time, and the `OptimisticLockException` may be thrown in the “before completion” phase of the commit. If the `OptimisticLockException` must be caught or handled by the application, the `flush` method should be used by the application to force the database writes to occur. This will allow the application to catch and handle optimistic lock exceptions.

The `OptimisticLockException` provides an API to return the object that caused the exception to be thrown. The object reference is not guaranteed to be present every time the exception is thrown but should be provided whenever the persistence provider can supply it. Applications cannot rely upon this object being available.

In some cases an `OptimisticLockException` will be thrown and wrapped by another exception, such as a `RemoteException`, when VM boundaries are crossed. Entities that may be referenced in wrapped exceptions should implement `Serializable` so that marshalling will not fail.

An `OptimisticLockException` always causes the transaction to be marked for rollback.

Refreshing objects or reloading objects in a new transaction context and then retrying the transaction is a potential response to an `OptimisticLockException`.

3.6. Entity Listeners and Callback Methods

A method may be designated as a lifecycle callback method to receive notification of entity lifecycle events. A lifecycle callback method can be defined on an entity class, a mapped superclass, or an entity listener class associated with an entity or mapped superclass. An entity listener class is a class whose methods are invoked in response to lifecycle events on an entity. Any number of entity listener classes can be defined for an entity class or mapped superclass.

Default entity listeners—entity listener classes whose callback methods apply to all entities in the persistence unit—can be specified by means of the XML descriptor.

Lifecycle callback methods and entity listener classes are defined by means of metadata annotations or the XML descriptor. When annotations are used, one or more entity listener classes are denoted using the `EntityListeners` annotation on the entity class or mapped superclass. If multiple entity listeners are defined, the order in which they are invoked is determined by the order in which they are specified in the `EntityListeners` annotation. The XML descriptor may be used as an alternative to specify the invocation order of entity listeners or to override the order specified in metadata annotations.

Any subset or combination of annotations may be specified on an entity class, mapped superclass, or listener class. A single class must not have more than one lifecycle callback method for the same lifecycle event. The same method may be used for multiple callback events.

Multiple entity classes and mapped superclasses in an inheritance hierarchy may define listener classes and/or lifecycle callback methods directly on the class. [Section 3.6.4](#) describes the rules that apply to method invocation order in this case.

3.6.1. Entity Listeners

The entity listener class must have a public no-arg constructor.

Entity listener classes in Jakarta EE environments support dependency injection through the Contexts and Dependency Injection API (CDI) [7] when CDI is enabled^[17]. An entity listener class that makes use of CDI injection may also define lifecycle callback methods annotated with the `PostConstruct` and `PreDestroy` annotations. These methods will be invoked after injection has taken place and before the entity listener instance is destroyed respectively.

The persistence provider is responsible for using the CDI SPI to create instances of the entity listener class; to perform injection upon such instances; to invoke their `PostConstruct` and `PreDestroy` methods, if any; and to dispose of the entity listener instances.

The persistence provider is only required to support CDI injection into entity listeners in Jakarta EE container environments^[18]. If the CDI is not enabled, the persistence provider must not invoke entity listeners that depend upon CDI injection.

An entity listener is a noncontextual object. In supporting injection into entity listeners, the persistence provider must behave as if it carries out the following steps involving the use of the CDI SPI. (See [7]).

- Obtain a `BeanManager` instance. (See Section 9.1)
- Create an `AnnotatedType` instance for the entity listener class.
- Create an `InjectionTarget` instance for the annotated type.
- Create a `CreationalContext`.
- Instantiate the listener by calling the `InjectionTarget` `produce` method.
- Inject the listener instance by calling the `InjectionTarget` `inject` method on the instance.
- Invoke the `PostConstruct` callback, if any, by calling the `InjectionTarget` `postConstruct` method on the instance.

When the listener instance is to be destroyed, the persistence provider must behave as if it carries out the following steps.

- Call the `InjectionTarget` `preDestroy` method on the instance.
- Call the `InjectionTarget` `dispose` method on the instance
- Call the `CreationalContext` `release` method.

Persistence providers may optimize the steps above, e.g. by avoiding calls to the actual CDI SPI and relying on container-specific interfaces instead, as long as the outcome is the same.

Entity listeners that do not make use of CDI injection are stateless. The lifecycle of such entity listeners is unspecified.

When invoked from within a Jakarta EE environment, the callback listeners for an entity share the enterprise naming context of the invoking component, and the entity callback methods are invoked in the transaction and security contexts of the calling component at the time at which the callback method is invoked.^[19]

3.6.2. Lifecycle Callback Methods

Entity lifecycle callback methods can be defined on an entity listener class and/or directly on an entity class or mapped superclass.

A lifecycle callback method must be either:

- annotated with annotations designating the callback events for which it is invoked, or
- mapped to a callback event type using the XML descriptor.

The same annotations (and XML elements) are used to declare:

- callback methods of an entity class or mapped superclass, and
- callback methods of an entity listener class.

The signatures of the callback methods differ between these two cases:

- a callback method defined by an entity class or mapped superclass has the signature:

```
void <METHOD>()
```

- a callback method defined by an entity listener class has the signature:

```
void <METHOD>(S)
```

where *S* is any supertype of the entity class or mapped superclass to which the entity listener is applied. At runtime, the argument to the entity listener callback method is the entity instance for which the callback method is being invoked.

Callback methods can have public, private, protected, or package level access, but must not be static or final.

The following annotations designate lifecycle event callback methods of the corresponding types.

- PrePersist
- PostPersist
- PreRemove
- PostRemove
- PreUpdate
- PostUpdate
- PostLoad

The following rules apply to lifecycle callback methods:

- Lifecycle callback methods may throw unchecked/runtime exceptions. A runtime exception thrown by a callback method that executes within a transaction causes that transaction to be marked for rollback if the persistence context is joined to the transaction.
- Lifecycle callbacks can invoke JNDI, JDBC, JMS, and enterprise beans.
- A lifecycle callback method may modify the non-relationship state of the entity on which it is invoked.
- In general, the lifecycle method of a portable application should not invoke `EntityManager` or query operations, access other entity instances, or modify relationships within the same persistence context^[20].

3.6.3. Semantics of the Life Cycle Callback Methods for Entities

The `PrePersist` and `PreRemove` callback methods are invoked for a given entity before the respective `EntityManager` `persist` and `remove` operations for that entity are executed. For entities to which the merge operation has been applied and causes the creation of newly managed instances, the `PrePersist` callback methods will be invoked for the managed instance after the entity state has been copied to it. These `PrePersist` and `PreRemove` callbacks will also be invoked on all entities to which these operations are cascaded. The `PrePersist` and `PreRemove` methods will always be invoked as part of the synchronous `persist`, `merge`, and `remove` operations. Primary key values generated using the `SEQUENCE`, `TABLE`, or `UUID` strategy are available in the `PrePersist` method. Primary key values generated using the `IDENTITY` strategy are not available in the `PrePersist` method.

The `PostPersist` and `PostRemove` callback methods are invoked for an entity after the entity has been made persistent or

removed. These callbacks will also be invoked on all entities to which these operations are cascaded. The `PostPersist` and `PostRemove` methods will be invoked after the database insert and delete operations respectively. These database operations may occur directly after the persist, merge, or remove operations have been invoked or they may occur directly after a flush operation has occurred (which may be at the end of the transaction). Generated primary key values are always available in the `PostPersist` method.

The `PreUpdate` and `PostUpdate` callbacks occur before and after the database update operations to entity data respectively. These database operations may occur at the time the entity state is updated or they may occur at the time state is flushed to the database (which may be at the end of the transaction).



Note that it is implementation-dependent as to whether `PreUpdate` and `PostUpdate` callbacks occur when an entity is persisted and subsequently modified in a single transaction or when an entity is modified and subsequently removed within a single transaction. Portable applications should not rely on such behavior.

The `PostLoad` method for an entity is invoked after the entity has been loaded into the current persistence context from the database or after the refresh operation has been applied to it. The `PostLoad` method is invoked before a query result is returned or accessed or before an association is traversed.

It is implementation-dependent as to whether callback methods are invoked before or after the cascading of the lifecycle events to related entities. Applications should not depend on this ordering.

For example:

```
@Entity
@EntityListeners(com.acme.AlertMonitor.class)
public class Account {
    Long accountId;
    Integer balance;
    boolean preferred;

    @Id
    public Long getAccountId() { ... }

    // ...

    public Integer getBalance() { ... }

    // ...

    @Transient // because status depends upon non-persistent context
    public boolean isPreferred() { ... }

    // ...

    public void deposit(Integer amount) { ... }

    public Integer withdraw(Integer amount) throws NSFException { ... }

    @PrePersist
    protected void validateCreate() {
        if (getBalance() < MIN_REQUIRED_BALANCE)
            throw new AccountException("Insufficient balance to open an account");
    }

    @PostLoad
    protected void adjustPreferredStatus() {
        preferred = (getBalance() >= AccountManager.getPreferredStatusLevel());
    }
}
```

```

public class AlertMonitor {
    @PostPersist
    public void newAccountAlert(Account acct) {
        Alerts.sendMarketingInfo(acct.getAccountId(), acct.getBalance());
    }
}

```

3.6.4. Multiple Lifecycle Callback Methods for an Entity Lifecycle Event

If multiple callback methods are defined for an entity lifecycle event, the ordering of the invocation of these methods is as follows.

Default listeners, if any, are invoked first, in the order specified in the XML descriptor. Default listeners apply to all entities in the persistence unit, unless explicitly excluded by means of the `ExcludeDefaultListeners` annotation or `exclude-default-listeners` XML element.

The lifecycle callback methods defined on the entity listener classes for an entity class or mapped superclass are invoked in the same order as the specification of the entity listener classes in the `EntityListeners` annotation.

If multiple classes in an inheritance hierarchy—entity classes and/or mapped superclasses—define entity listeners, the listeners defined for a superclass are invoked before the listeners defined for its subclasses in this order. The `ExcludeSuperclassListeners` annotation or `exclude-superclass-listeners` XML element may be applied to an entity class or mapped superclass to exclude the invocation of the listeners defined by the entity listener classes for the superclasses of the entity or mapped superclass. The excluded listeners are excluded from the class to which the `ExcludeSuperclassListeners` annotation or element has been specified and its subclasses^[21]. The `ExcludeSuperclassListeners` annotation (or `exclude-superclass-listeners` XML element) does not cause default entity listeners to be excluded from invocation.

If a lifecycle callback method for the same lifecycle event is also specified on the entity class and/or one or more of its entity or mapped superclasses, the callback methods on the entity class and/or superclasses are invoked after the other lifecycle callback methods, most general superclass first. A class is permitted to override an inherited callback method of the same callback type, and in this case, the overridden method is not invoked^[22].

Callback methods are invoked by the persistence provider runtime in the order specified. If the callback method execution terminates normally, the persistence provider runtime then invokes the next callback method, if any.

The XML descriptor may be used to override the lifecycle callback method invocation order specified in annotations.

For example:

There are several entity classes and listeners for animals:

```

@Entity
public class Animal {

    // ...

    @PostPersist
    protected void postPersistAnimal() {
        // ...
    }
}

@Entity
@EntityListeners(PetListener.class)
public class Pet extends Animal {
    // ...
}

```

```

@Entity
@EntityListeners({CatListener.class, CatListener2.class})
public class Cat extends Pet {
    // ...
}

public class PetListener {
    @PostPersist
    protected void postPersistPetListenerMethod(Object pet) {
        // ...
    }
}

public class CatListener {
    @PostPersist
    protected void postPersistCatListenerMethod(Object cat) {
        // ...
    }
}

public class CatListener2 {
    @PostPersist
    protected void postPersistCatListener2Method(Object cat) {
        // ...
    }
}

```

If a PostPersist event occurs on an instance of Cat, the following methods are called in order:

1. postPersistPetListenerMethod
2. postPersistCatListenerMethod
3. postPersistCatListener2Method
4. postPersistAnimal

Assume that SiameseCat is defined as a subclass of Cat:

```

@EntityListeners(SiameseCatListener.class)
@Entity
public class SiameseCat extends Cat {
    // ...

    @PostPersist
    protected void postPersistSiameseCat() {
        // ...
    }
}

public class SiameseCatListener {
    @PostPersist
    protected void postPersistSiameseCatListenerMethod(Object cat) {
        // ...
    }
}

```

If a PostPersist event occurs on an instance of SiameseCat, the following methods are called in order:

1. postPersistPetListenerMethod
2. postPersistCatListenerMethod
3. postPersistCatListener2Method
4. postPersistSiameseCatListenerMethod

5. postPersistAnimal
6. postPersistSiameseCat

Assume the definition of SiameseCat were instead:

```
@EntityListeners(SiameseCatListener.class)
@Entity
public class SiameseCat extends Cat {
    // ...

    @PostPersist
    protected void postPersistAnimal() {
        // ...
    }
}
```

In this case, the following methods would be called in order, where postPersistAnimal is the PostPersist method defined in the SiameseCat class:

1. postPersistPetListenerMethod
2. postPersistCatListenerMethod
3. postPersistCatListener2Method
4. postPersistSiameseCatListenerMethod
5. postPersistAnimal

3.6.5. Exceptions

Lifecycle callback methods may throw runtime exceptions. A runtime exception thrown by a callback method that executes within a transaction causes that transaction to be marked for rollback if the persistence context is joined to the transaction. No further lifecycle callback methods will be invoked after a runtime exception is thrown.

3.6.6. Specification of Callback Listener Classes and Lifecycle Methods in the XML Descriptor

The XML descriptor can be used as an alternative to metadata annotations to specify entity listener classes and their binding to entities or to override the invocation order of lifecycle callback methods as specified in annotations.

3.6.6.1. Specification of Callback Listeners

The entity-listener XML descriptor element is used to specify the lifecycle listener methods of an entity listener class. The lifecycle listener methods are specified by using the pre-persist, post-persist, pre-remove, post-remove, pre-update, post-update, and/or post-load elements.

An entity listener class can define multiple callback methods. However, at most one method of an entity listener class can be designated as a pre-persist method, post-persist method, pre-remove method, post-remove method, pre-update method, post-update method, and/or post-load method, regardless of whether the XML descriptor is used to define entity listeners or whether some combination of annotations and XML descriptor elements is used.

3.6.6.2. Specification of the Binding of Entity Listener Classes to Entities

The entity-listeners subelement of the persistence-unit-defaults element is used to specify the default entity listeners for the persistence unit.

The entity-listeners subelement of the entity or mapped-superclass element is used to specify the entity listener classes for the respective entity or mapped superclass and its subclasses.

The binding of entity listeners to entity classes is additive. The entity listener classes bound to the superclasses of an entity or mapped superclass are applied to it as well.

The `exclude-superclass-listeners` element specifies that the listener methods for superclasses are not to be invoked for an entity class (or mapped superclass) and its subclasses.

The `exclude-default-listeners` element specifies that default entity listeners are not to be invoked for an entity class (or mapped superclass) and its subclasses.

Explicitly listing an excluded default or superclass listener for a given entity class or mapped superclass causes it to be applied to that entity or mapped superclass and its subclasses.

In the case of multiple callback methods for a single lifecycle event, the invocation order rules described in [Section 3.6.4](#) apply.

3.7. Bean Validation

This specification defines support for use of Bean Validation [\[5\]](#) within Jakarta Persistence applications.

Managed classes (entities, mapped superclasses, and embeddable classes) may be configured to include Bean Validation constraints.

Automatic validation using these constraints is achieved by specifying that Jakarta Persistence delegate validation to the Bean Validation implementation upon the pre-persist, pre-update, and pre-remove entity lifecycle events described in [Section 3.6.3](#).

Validation can also be achieved by the application calling the `validate` method of a `Validator` instance upon an instance of a managed class, as described in the Bean Validation specification [\[5\]](#).

3.7.1. Automatic Validation Upon Lifecycle Events

This specification supports the use of bean validation for the automatic validation of entities upon the pre-persist, pre-update, and pre-remove lifecycle validation events. These lifecycle validation events occur immediately after the point at which all the `PrePersist`, `PreUpdate`, and `PreRemove` lifecycle callback method invocations respectively have been completed, or immediately after the point at which such lifecycle callback methods would have been completed (in the event that such callback methods are not present).



In the case where an entity is persisted and subsequently modified in a single transaction or when an entity is modified and subsequently removed in a single transaction, it is implementation dependent as to whether the pre-update validation event occurs. Portable applications should not rely on this behavior.

3.7.1.1. Enabling Automatic Validation

The `validation-mode` element of the `persistence.xml` file determines whether the automatic lifecycle event validation is in effect. The values of the `validation-mode` element are `AUTO`, `CALLBACK`, `NONE`. The default validation mode is `AUTO`.

If the application creates the entity manager factory using the `Persistence.createEntityManagerFactory` method, the validation mode can be specified using the `jakarta.persistence.validation.mode` map key, which will override the value specified (or defaulted) in the `persistence.xml` file. The map values for this key are `"auto"`, `"callback"`, `"none"`.

If the auto validation mode is specified by the `validation-mode` element or the `jakarta.persistence.validation.mode` property, or if neither the `validation-mode` element nor the `jakarta.persistence.validation.mode` property is specified, and a Bean Validation provider is present in the environment, the persistence provider must perform the automatic

validation of entities as described in [Section 3.7.1.2](#). If no Bean Validation provider is present in the environment, no lifecycle event validation takes place.

If the callback validation mode is specified by the `validation-mode` element or the `jakarta.persistence.validation.mode` property, the persistence provider must perform the lifecycle event validation as described in [Section 3.7.1.2](#). It is an error if there is no Bean Validation provider present in the environment, and the provider must throw the `PersistenceException` if the `jakarta.persistence.validation.mode` property value *"callback"* has been passed to the `Persistence.createEntityManagerFactory` method.

If the none validation mode is specified by the `validation-mode` element or the `jakarta.persistence.validation.mode` property, the persistence provider must not perform lifecycle event validation.

3.7.1.2. Requirements for Automatic Validation upon Lifecycle Events

For each event type, a list of groups is targeted for validation. By default, the default Bean Validation group (the group `Default`) will be validated upon the pre-persist and pre-update lifecycle validation events, and no group will be validated upon the pre-remove event.

This default validation behavior can be overridden by specifying the target groups using the following validation properties in the `persistence.xml` file or by passing these properties in the configuration of the entity manager factory through the `createEntityManagerFactory` method:

- `jakarta.persistence.validation.group.pre-persist`
- `jakarta.persistence.validation.group.pre-update`
- `jakarta.persistence.validation.group.pre-remove`

The value of a validation property must be a list of the targeted groups. A targeted group must be specified by its fully qualified class name. Names must be separated by a comma.

When one of the above events occurs for an entity, the persistence provider must validate that entity by obtaining a `Validator` instance from the validator factory in use (see [Section 3.7.2](#)) and invoking its `validate` method with the targeted groups. If the list of targeted groups is empty, no validation is performed. If the set of `ConstraintViolation` objects returned by the `validate` method is not empty, the persistence provider must throw the `jakarta.validation.ConstraintViolationException` containing a reference to the returned set of `ConstraintViolation` objects, and must mark the transaction for rollback if the persistence context is joined to the transaction.

The validator instance that is used for automatic validation upon lifecycle events must use a `TraversableResolver` that has the following behavior:

- Attributes that have not been loaded must not be loaded.
- Validation cascade (`@Valid`) must not occur for entity associations (single- or multi-valued).

These requirements guarantee that no unloaded attribute or association will be loaded by side effect and that no entity will be validated more than once during a given flush cycle.

Embeddable attributes must be validated only if the `Valid` annotation has been specified on them.

It is the responsibility of the persistence provider to pass an instance implementing the `jakarta.validation.TraversableResolver` interface to the Bean Validation provider by calling `ValidatorFactory.usingContext().traversableResolver(tr).getValidator()` where `tr` is the resolver having the behavior described above.

3.7.2. Providing the ValidatorFactory

In Jakarta EE environments, a `ValidatorFactory` instance is made available by the Jakarta EE container. The container is responsible for passing this validator factory to the persistence provider via the map that is passed as an argument to the `createContainerEntityManagerFactory` call. The map key used by the container must be the standard property name `jakarta.persistence.validation.factory`.

In Java SE environments, the application can pass the `ValidatorFactory` instance via the map that is passed as an argument to the `Persistence.createEntityManagerFactory` call. The map key used must be the standard property name `jakarta.persistence.validation.factory`. If no `ValidatorFactory` instance is provided by the application, and if a Bean Validation provider is present in the classpath, the persistence provider must instantiate the `ValidatorFactory` using the default bootstrapping approach defined by the Bean Validation specification [5], namely `Validation.buildDefaultValidatorFactory()`.

3.8. Entity Graphs

An entity graph is a template that captures the path and boundaries for an operation or query. It is defined in the form of metadata or an object created by the dynamic `EntityGraph` API.

Entity graphs are used in the specification of “fetch plans” for query or find operations.

The `EntityGraph`, `AttributeNode`, and `Subgraph` interfaces found in [Appendix B](#) are used to dynamically construct entity graphs.

The annotations `NamedEntityGraph`, `NamedAttributeNode`, and `NamedSubgraph` described in [Section 10.3](#) are used to statically define entity graphs. The `named-entity-graph` XML element and its subelements may be used to override these annotations or to define additional named entity graphs.

The semantics of entity graphs with regard to find and query operations are described in [Section 3.8.1](#).

3.8.1. Use of Entity Graphs in find and query operations

An entity graph can be used with the `find` method or as a query hint to override or augment `FetchType` semantics.

The standard properties `jakarta.persistence.fetchgraph` and `jakarta.persistence.loadgraph` are used to specify such graphs to queries and `find` operations.

The default fetch graph for an entity or embeddable is defined to consist of the transitive closure of all of its attributes that are specified as `FetchType.EAGER` (or defaulted as such).

The persistence provider is permitted to fetch additional entity state beyond that specified by a fetch graph or load graph. It is required, however, that the persistence provider fetch all state specified by the fetch or load graph.

3.8.1.1. Fetch Graph Semantics

When the `jakarta.persistence.fetchgraph` property is used to specify an entity graph, attributes that are specified by attribute nodes of the entity graph are treated as `FetchType.EAGER` and attributes that are not specified are treated as `FetchType.LAZY`.

The following rules apply, depending on attribute type. The rules of this section are applied recursively.

A primary key or version attribute never needs to be specified in an attribute node of a fetch graph. (This applies to composite primary keys as well, including embedded id primary keys.) When an entity is fetched, its primary key and version attributes are always fetched. It is not incorrect, however, to specify primary key attributes or version

attributes.

Attributes other than primary key and version attributes are assumed not to be fetched unless the attribute is specified. The following rules apply to the specification of attributes.

- If the attribute is an embedded attribute, and the attribute is specified in an attribute node, but a subgraph is not specified for the attribute, the default fetch graph for the embeddable is fetched. If a subgraph is specified for the attribute, the attributes of the embeddable are fetched according to their specification in the corresponding subgraph.
- If the attribute is an element collection of basic type, and the attribute is specified in an attribute node, the element collection together with its basic elements is fetched.
- If the attribute is an element collection of embeddables, and the attribute is specified in an attribute node, but a subgraph is not specified for the attribute, the element collection together with the default fetch graph of its embeddable elements is fetched. If a subgraph is specified for the attribute, the attributes of the embeddable elements are fetched according to the corresponding subgraph specification.
- If the attribute is a one-to-one or many-to-one relationship, and the attribute is specified in an attribute node, but a subgraph is not specified for the attribute, the default fetch graph of the target entity is fetched. If a subgraph is specified for the attribute, the attributes of the target entity are fetched according to the corresponding subgraph specification.
- If the attribute is a one-to-many or many-to-many relationship, and the attribute is specified in an attribute node, but a subgraph is not specified, the collection is fetched and the default fetch graphs of the referenced entities are fetched. If a subgraph is specified for the attribute, the entities in the collection are fetched according to the corresponding subgraph specification.
- If the key of a map which has been specified in an attribute node is a basic type, it is fetched. If the key of a map which has been specified in an attribute node is an embedded type, the default fetch graph is fetched for the embeddable. Otherwise, if the key of the map is an entity, and a map key subgraph is not specified for the attribute node, the map key is fetched according to its default fetch graph. If a key subgraph is specified for the map key attribute, the map key attribute is fetched according to the map key subgraph specification.

Examples:

```
@NamedEntityGraph
@Entity
public class Phonenumner {
    @Id
    protected String number;

    protected PhoneTypeEnum type;

    // ...
}
```

In the above example, only the number attribute would be eagerly fetched.

```
@NamedEntityGraph(
    attributeNodes={@NamedAttributeNode("projects")}
)
@Entity
public class Employee {
    @Id
    @GeneratedValue
    protected long id;

    @Basic
    protected String name;
```

```

    @Basic
    protected String employeeNumber;

    @OneToMany()
    protected List<Dependents> dependents;

    @OneToMany()
    protected List<Project> projects;

    @OneToMany()
    protected List<PhoneNumber> phoneNumbers;

    // ...
}

@Entity
@Inheritance
public class Project {
    @Id
    @GeneratedValue
    protected long id;

    String name;

    @OneToOne(fetch=FetchType.EAGER)
    protected Requirements doc;

    // ...
}

@Entity
public class LargeProject extends Project {
    @OneToOne(fetch=FetchType.LAZY)
    protected Employee approver;

    // ...
}

@Entity
public class Requirements {
    @Id
    protected long id;

    @Lob
    protected String description;

    @OneToOne(fetch=FetchType.LAZY)
    protected Approval approval;

    // ...
}

```

In the above example, the `Employee` entity's primary key will be fetched as well as the related `Project` instances, whose default fetch graph (`id`, `name`, and `doc` attributes) will be fetched. The related `Requirements` object will be fetched according to its default fetch graph.

If the `approver` attribute of `LargeProject` were `FetchType.EAGER`, and if any of the projects were instances of `LargeProject`, their `approver` attributes would also be fetched. Since the type of the `approver` attribute is `Employee`, the `approver`'s default fetch graph (`id`, `name`, and `employeeNumber` attributes) would also be fetched.

3.8.1.2. Load Graph Semantics

When the `jakarta.persistence.loadgraph` property is used to specify an entity graph, attributes that are specified by

attribute nodes of the entity graph are treated as FetchType.EAGER and attributes that are not specified are treated according to their specified or default FetchType.

The following rules apply. The rules of this section are applied recursively.

- A primary key or version attribute never needs to be specified in an attribute node of a load graph. (This applies to composite primary keys as well, including embedded id primary keys.) When an entity is fetched, its primary key and version attributes are always fetched. It is not incorrect, however, to specify primary key attributes or version attributes.
- If the attribute is an embedded attribute, and the attribute is specified in an attribute node, but a subgraph is not specified for the attribute, the default fetch graph for the embeddable is fetched. If a subgraph is specified for the attribute, attributes that are specified by the subgraph are also fetched.
- If the attribute is an element collection of basic type, and the attribute is specified in an attribute node, the element collection together with its basic elements is fetched.
- If the attribute is an element collection of embeddables, and the attribute is specified in an attribute node, the element collection together with the default fetch graph of its embeddable elements is fetched. If a subgraph is specified for the attribute, attributes that are specified by the subgraph are also fetched.
- If the attribute is a one-to-one or many-to-one relationship, and the attribute is specified in an attribute node, the default fetch graph of the target entity is fetched. If a subgraph is specified for the attribute, attributes that are specified by the subgraph are also fetched.
- If the attribute is a one-to-many or many-to-many relationship, and the attribute is specified in an attribute node, the collection is fetched and the default fetch graphs of the referenced entities are fetched. If a subgraph is specified for the attribute, attributes that are specified by the subgraph are also fetched.
- If the key of a map which has been specified in an attribute node is a basic type, it is fetched. If the key of a map which has been specified in an attribute node is an embedded type, the default fetch graph is fetched for the embeddable. Otherwise, if the key of the map is an entity, the map key is fetched according to its default fetch graph. If a key subgraph is specified for the map key attribute, additional attributes are fetched as specified in the key subgraph.

Examples:

```
@NamedEntityGraph
@Entity
public class Phonenummer {
    @Id
    protected String number;

    protected PhoneTypeEnum type;

    // ...
}
```

In the above example, the `number` and `type` attributes are fetched.

```
@NamedEntityGraph(
    attributeNodes={@NamedAttributeNode("projects")}
)
@Entity
public class Employee {
    @Id
    @GeneratedValue
    protected long id;

    @Basic
    protected String name;
```

```

    @Basic
    protected String employeeNumber;

    @OneToMany()
    protected List<Dependents> dependents;

    @OneToMany()
    protected List<Project> projects;

    @OneToMany()
    protected List<PhoneNumber> phoneNumbers;

    // ...
}

@Entity
@Inheritance
public class Project {
    @Id
    @GeneratedValue
    protected long id;

    String name;

    @OneToOne(fetch=FetchType.EAGER)
    protected Requirements doc;

    // ...
}

@Entity
public class LargeProject extends Project {
    @OneToOne(fetch=FetchType.LAZY)
    protected Employee approver;

    // ...
}

@Entity
public class Requirements {
    @Id
    protected long id;

    @Lob
    protected String description;

    @OneToOne(fetch=FetchType.LAZY)
    protected Approval approval;

    // ...
}

```

In the above example, the default fetch graph (id, name, employeeNumber attributes) of Employee is fetched. The default fetch graphs of the related Project instances (id, name, and doc attributes) and their Requirements instances (id and description attributes) are also fetched.

3.9. Type Conversion of Basic Attributes

The attribute conversion facility allows the developer to define custom attribute converters. A converter is a class whose methods convert between:

- the *target type* of the converter, an arbitrary Java type which may be used as the type of a persistent field or property, and

- a basic type (see [Section 2.6](#)) used as an intermediate step in mapping to the database representation.

A converter can be used to convert attributes defined by entity classes, mapped superclasses, or embeddable classes.^[23] A converted attribute is considered a basic attribute, since, with the aid of the converter, its values can be represented as instances of a basic type.

Every attribute converter class must implement the interface `jakarta.persistence.AttributeConverter` and must be annotated with the `Converter` annotation or declared as a converter in the XML descriptor. If the value of the `autoApply` element of the `Converter` annotation is `true`, the converter is automatically applied to all attributes of the target type, including to basic attribute values that are contained within other, more complex attribute types. See [Section 10.6](#).

```
/**
 * Interface implemented by custom attribute <em>converters</em>. A
 * converter is a class whose methods convert between:
 * <ul>
 * <li>the <em>target type</em> of the converter, an arbitrary Java
 *     type which may be used as the type of a persistent field or
 *     property, and
 * <li>a {@linkplain Basic basic type} used as an intermediate step
 *     in mapping to the database representation.
 * </ul>
 *
 * <p>A converted field or property is considered {@link Basic}, since,
 * with the aid of the converter, its values can be represented as
 * instances of a basic type.
 *
 * <p>A converter class must be annotated {@link Converter} or declared
 * as a converter in the object/relational mapping descriptor. The value
 * of {@link Converter#autoApply autoApply} determines if the converter
 * is automatically applied to persistent fields and properties of the
 * target type. The {@link Convert} annotation may be used to apply a
 * converter which is declared {@code autoApply=false}, to explicitly
 * {@linkplain Convert#disableConversion disable conversion}, or to
 * resolve ambiguities when multiple converters would otherwise apply.
 *
 * <p>Note that the target type {@code X} and the converted basic type
 * {@code Y} may be the same Java type.
 *
 * @param <X> the target type, that is, the type of the entity attribute
 * @param <Y> a basic type representing the type of the database column
 *
 * @see Converter
 * @see Convert#converter
 */
public interface AttributeConverter<X,Y> {

    /**
     * Converts the value stored in the entity attribute into the
     * data representation to be stored in the database.
     *
     * @param attribute the entity attribute value to be converted
     * @return the converted data to be stored in the database column
     */
    Y convertToDatabaseColumn(X attribute);

    /**
     * Converts the data stored in the database column into the value
     * to be stored in the entity attribute.
     *
     * <p>Note that it is the responsibility of the converter writer
     * to specify the correct {@code dbData} type for the corresponding
     * column for use by the JDBC driver: i.e., persistence providers
     * are not expected to do such type conversion.
     */
}
```

```

    * @param dbData the data from the database column to be converted
    * @return the converted value to be stored in the entity attribute
    */
    X convertToEntityAttribute(Y dbData);
}

```

Attribute converter classes in Jakarta EE environments support dependency injection through the Contexts and Dependency Injection API (CDI) [7] when CDI is enabled^[24]. An attribute converter class that makes use of CDI injection may also define lifecycle callback methods annotated with the `PostConstruct` and `PreDestroy` annotations. These methods will be invoked after injection has taken place and before the attribute converter instance is destroyed respectively.

The persistence provider is responsible for using the CDI SPI to create instances of the attribute converter class; to perform injection upon such instances; to invoke their `PostConstruct` and `PreDestroy` methods, if any; and to dispose of the attribute converter instances.

The persistence provider is only required to support CDI injection into attribute converters in Jakarta EE container environments^[25]. If CDI is not enabled, the persistence provider must not invoke attribute converters that depend upon CDI injection.

An attribute converter is a noncontextual object. In supporting injection into attribute converters, the persistence provider must behave as if it carries out the following steps involving the use of the CDI SPI. (See [7]).

- Obtain a `BeanManager` instance. (See [Section 9.1](#).)
- Create an `AnnotatedType` instance for the attribute converter class.
- Create an `InjectionTarget` instance for the annotated type.
- Create a `CreationalContext`.
- Instantiate the listener by calling the `InjectionTarget produce` method.
- Inject the listener instance by calling the `InjectionTarget inject` method on the instance.
- Invoke the `PostConstruct` callback, if any, by calling the `InjectionTarget postConstruct` method on the instance.

When the listener instance is to be destroyed, the persistence provider must behave as if it carries out the following steps.

- Call the `InjectionTarget preDestroy` method on the instance.
- Call the `InjectionTarget dispose` method on the instance.
- Call the `CreationalContext release` method.

Persistence providers may optimize the steps above, e.g. by avoiding calls to the actual CDI SPI and relying on container-specific interfaces instead, as long as the outcome is the same.

Attribute converters that do not make use of CDI injection are stateless. The lifecycle of such attribute converters is unspecified.

The conversion of all basic types is supported except for the following: Id attributes (including the attributes of embedded ids and derived identities), version attributes, relationship attributes, and attributes explicitly annotated as `Enumerated` or `Temporal` or designated as such in the XML descriptor. Auto-apply converters will not be applied to such attributes, and applications that apply converters to such attributes through use of the `Convert` annotation will not be portable.

Type conversion may be specified at the level of individual attributes by means of the `Convert` annotation. The `Convert` annotation may also be used to override or disable an auto-apply conversion. See [Section 11.1.10](#).

The `Convert` annotation may be applied directly to an attribute of an entity, mapped superclass, or embeddable class to specify conversion of the attribute or to override the use of a converter that has been specified as `autoApply=true`. When

persistent properties are used, the `Convert` annotation is applied to the getter method.

The `Convert` annotation may be applied to an entity that extends a mapped superclass to specify or override the conversion mapping for an inherited basic or embedded attribute.

The persistence provider runtime is responsible for invoking the specified conversion methods for the target attribute type when loading the entity attribute from the database and before storing the entity attribute state to the database. The persistence provider must apply any conversion methods to instances of attribute values in path expressions used within Jakarta Persistence query language queries or criteria queries (such as in comparisons, bulk updates, etc.) before sending them to the database for the query execution. When such converted attributes are used in comparison operations with literals or parameters, the value of the literal or parameter to which they are compared must also be converted. If the result of a Jakarta Persistence query language query or criteria query includes one or more entity attributes for which conversion mappings have been specified, the persistence provider must apply the specified conversions to the corresponding values in the query result before returning them to the application. The use of functions, including aggregates, on converted attributes is undefined. If an exception is thrown from a conversion method, the persistence provider must wrap the exception in a `PersistenceException` and, if the persistence context is joined to a transaction, mark the transaction for rollback.

3.10. Second-Level Cache

A persistence provider may support the use of a *second-level cache*, that is, it might have a way to store data read in one persistence context for use in subsequent persistence contexts. A second-level cache might enhance performance, but tends to undermine the semantics of transaction processing, possibly exposing the application to stale data or similar anomalies.

Access to the second-level cache, if enabled, is mediated via the persistence context, and is largely transparent to the application. As an exception, the `Cache` interface described below in [Section 3.10.3](#) allows the application to directly evict data from the second-level cache.

The persistence provider is not required to support use of a second-level cache.

3.10.1. The Shared Cache Mode and Cacheable Annotation

Whether a given entity is eligible for storage in the second level cache is determined by:

- the annotations of the entity class, and
- the value specified for the `shared-cache-mode` element of the `persistence.xml` file or by the configuration property `jakarta.persistence.sharedCache.mode`.

The value of the property `jakarta.persistence.sharedCache.mode` takes precedence over the value of the `shared-cache-mode` element.

The `shared-cache-mode` element takes one of five possible values, which are enumerated by `jakarta.persistence.SharedCacheMode`:

- `ALL` specifies that every entity and all its state may be cached.
- `NONE` specifies that caching is disabled for the persistence unit, and that the persistence provider must not cache any entity data.
- `ENABLE_SELECTIVE` specifies that an entity may be cached if the entity class is explicitly annotated `@Cacheable` or `@Cacheable(true)`, or if the equivalent setting is specified in XML.
- `DISABLE_SELECTIVE` specifies that an entity may be cached unless the entity class is explicitly annotated `@Cacheable(false)`, or unless the equivalent setting is specified in XML.

- UNSPECIFIED selects the provider-specific default behavior.

If neither the `shared-cache-mode` element nor the property `jakarta.persistence.sharedCache.mode` is specified, or if the specified value is UNSPECIFIED, the behavior is not defined, and provider-specific defaults may apply. In particular, the semantics of the `Cacheable` annotation (and XML equivalent) is undefined.

If the persistence provider does not support use of a second-level cache, or if a second-level cache is not installed or not enabled, this setting may be ignored and no caching will occur.

A persistence provider may support additional vendor-specific mechanisms for configuring the cache and marking entities eligible (or not) for storage in the second-level cache. However, if a second-level cache is supported, and enabled, the provider must respect the configuration options defined in this section, if specified by the application.

3.10.2. Cache Modes

The *cache retrieve mode* and *cache store mode* control how a given persistence context interacts with the second-level cache.

- The cache retrieve mode may be set by calling `setCacheRetrieveMode()` on `EntityManager` or `Query`.
- The cache store mode may be set by calling `setCacheStoreMode()` on `EntityManager` or `Query`.
- A cache store mode or cache retrieve mode, or both, may be passed to the `find()` method of `EntityManager` as a `FindOption`.
- A cache store mode may be passed to the `refresh()` method of `EntityManager` as a `RefreshOption`.

A cache mode specified for a given `Query` instance applies only to executions of that query, but takes precedence over the current cache mode of the `EntityManager` to which the `Query` belongs. A cache mode passed to `find()` or `refresh()` applies only to the method invocation, and takes precedence over the current cache mode of the `EntityManager`.

Alternatively, a cache mode may be specified using the property name `jakarta.persistence.cache.retrieveMode` or `jakarta.persistence.cache.storeMode` by:

- calling the `setProperty()` method of `EntityManager`,
- calling the `setHint()` method of `Query`, or
- passing a map containing one of these properties to `find()` or `refresh()`.

If second-level caching is not enabled (for example, if the `shared-cache-mode` element is set to `NONE`), cache modes must be ignored. Similarly, if a given entity is not eligible for storage in the second-level cache (for example, if the `shared-cache-mode` element is set to `ENABLE_SELECTIVE`, and the entity is not annotated `@Cacheable`), cache modes are ignored for operations applying to that entity.

Cache modes must be respected when caching is enabled, regardless of whether caching is enabled via the configuration options defined by this specification or via provider-specific mechanisms.

Applications which depend on the cache retrieve mode or cache store mode but which do not specify the `shared-cache-mode` element are not portable.

`CacheRetrieveMode` enumerates the cache retrieve modes recognized by this specification. The semantics of each mode is defined by its Javadoc.

```
/**
 * Specifies how the {@link EntityManager} interacts with the
 * second-level cache when data is read from the database via
 * the {@link EntityManager#find} methods and execution of
 * queries.
 * <ul>
 * <li>{@link #USE} indicates that data may be read from the
```

```

*    second-level cache.
* <li>{@link #BYPASS} indicates that data may not be read
*    from the second-level cache.
* </ul>
*
* <p>Enumerates legal values of the property
* {@code jakarta.persistence.cache.retrieveMode}.
*
* @see EntityManager#setCacheRetrieveMode(CacheRetrieveMode)
* @see Query#setCacheRetrieveMode(CacheRetrieveMode)
*
* @since 2.0
*/
public enum CacheRetrieveMode implements FindOption {

    /**
     * Read entity data from the cache: this is the default
     * behavior.
     */
    USE,

    /**
     * Bypass the cache: get data directly from the database.
     */
    BYPASS
}

```

`CacheStoreMode` enumerates the cache store modes recognized by this specification. The semantics of each mode is defined by its Javadoc.

```

/**
 * Specifies how the {@link EntityManager} interacts with the
 * second-level cache when data is read from the database and
 * when data is written to the database.
 * <ul>
 * <li>{@link #USE} indicates that data may be written to the
 *    second-level cache.
 * <li>{@link #BYPASS} indicates that data may not be written
 *    to the second-level cache.
 * <li>{@link #REFRESH} indicates that data must be written
 *    to the second-level cache, even when the data is already
 *    cached.
 * </ul>
 *
 * <p>Enumerates legal values of the property
 * {@code jakarta.persistence.cache.storeMode}.
 *
 * @see EntityManager#setCacheStoreMode(CacheStoreMode)
 * @see Query#setCacheStoreMode(CacheStoreMode)
 *
 * @since 2.0
*/
public enum CacheStoreMode implements FindOption, RefreshOption {

    /**
     * Insert entity data into cache when read from database and
     * insert/update entity data when written to the database:
     * this is the default behavior. Does not force refresh of
     * already cached items when reading from database.
     */
    USE,

    /**
     * Don't insert into cache.
     */
}

```

```

    BYPASS,

    /**
     * Insert/update entity data held in the cache when read from
     * the database and when written to the database. Force refresh
     * of cache for items read from database.
     */
    REFRESH
}

```

3.10.3. Cache Interface

The Cache interface found in [Section B.5](#) allows the application to request eviction of entity data from the second-level cache directly and immediately, outside the scope of any persistence context.

3.11. Query APIs

The Query and TypedQuery APIs are used for the execution of both static queries and dynamic queries. These APIs also support parameter binding and pagination control. The StoredProcedureQuery API is used for the execution of queries that invoke stored procedures defined in the database.

These interfaces may be found in [Appendix B](#).

3.11.1. Query Execution

Jakarta Persistence query language, Criteria API, and native SQL select queries are executed using the methods `getResultList`, `getSingleResult`, and `getSingleResultOrNull`. Update and delete operations (update and delete “queries”) are executed using the `executeUpdate` method.

- For TypedQuery instances, the query result type is determined in the case of criteria queries by the type of the query specified when the CriteriaQuery object is created, as described in [Section 6.3.1](#). In the case of Jakarta Persistence query language queries, the type of the result is determined by the `resultClass` argument to the `createQuery` or `createNamedQuery` method, and the select list of the query must contain only a single item which must be assignable to the specified type.
- For Query instances, the elements of a query result whose select list consists of more than one select expression are of type `Object[]`. If the select list consists of only one select expression, the elements of the query result are of type `Object`. When native SQL queries are used, the SQL result set mapping (see [Section 3.11.11](#)), determines how many items (entities, scalar values, etc.) are returned. If multiple items are returned, the elements of the query result are of type `Object[]`. If only a single item is returned as a result of the SQL result set mapping or if a result class is specified, the elements of the query result are of type `Object`.



The semantics of the methods

```
public <T> TypedQuery<T> createQuery(String qlString, Class<T> resultClass)
```

```
public <T> TypedQuery<T> createNamedQuery(String name, Class<T> resultClass)
```

may be extended in a future release of this specification to support other result types. Use of other result types, including `Tuple.class`, is not portable.

Stored procedure queries can be executed using the `getResultList`, `getSingleResult`, `getSingleResultOrNull`, and `execute` methods. Stored procedures that perform only updates or deletes can be executed using the `executeUpdate` method. Stored procedure query execution is described in detail in [Section 3.11.12.3](#).

An `IllegalArgumentException` is thrown if a parameter instance is specified that does not correspond to a parameter of the query, if a parameter name is specified that does not correspond to a named parameter of the query, if a positional value is specified that does not correspond to a positional parameter of the query, or if the type of the parameter is not valid for the query. This exception may be thrown when the parameter is bound, or the execution of the query may fail. See [Section 3.11.5](#), [Section 3.11.6](#), and [Section 3.11.7](#) for supported parameter usage.

The effect of applying `setMaxResults` or `setFirstResult` to a query involving fetch joins over collections is undefined. The use of `setMaxResults` and `setFirstResult` is not supported for stored procedure queries.

`Query` and `TypedQuery` methods other than the `executeUpdate` method are not required to be invoked within a transaction context, unless a lock mode other than `LockModeType.NONE` has been specified for the query. In particular, the `getResultList`, `getSingleResult`, and `getSingleResultOrNull` methods are not required to be invoked within a transaction context unless such a lock mode has been specified for the query^[26]. If an entity manager with transaction-scoped persistence context is in use, the resulting entities will be detached; if an entity manager with an extended persistence context is used, they will be managed. See [Chapter 7](#) for further discussion of entity manager use outside a transaction and persistence context types.

Whether a `StoredProcedureQuery` should be invoked in a transaction context should be determined by the transactional semantics and/or requirements of the stored procedure implementation and the database in use. In particular, problems may occur if the stored procedure initiates a transaction and a transaction is already in effect. The state of any entities returned by the stored procedure query invocation is determined as described above.

Runtime exceptions other than the `NoResultException`, `NonUniqueResultException`, `QueryTimeoutException`, and `LockTimeoutException` thrown by the methods of the `Query`, `TypedQuery`, and `StoredProcedureQuery` interfaces other than those methods specified below cause the current transaction to be marked for rollback if the persistence context is joined to the transaction. On database platforms on which a query timeout causes transaction rollback, the persistence provider must throw the `PersistenceException` instead of the `QueryTimeoutException`.

Runtime exceptions thrown by the following methods of the `Query`, `TypedQuery`, and `StoredProcedureQuery` interfaces do not cause the current transaction to be marked for rollback: `getParameters`, `getParameter`, `getParameterValue`, `getOutputParameterValue`, `getLockMode`.

Runtime exceptions thrown by the methods of the `Tuple`, `TupleElement`, and `Parameter` interfaces do not cause the current transaction to be marked for rollback.

For example:

```
public List findWithName(String name) {
    return em.createQuery("SELECT c FROM Customer c WHERE c.name LIKE :custName")
        .setParameter("custName", name)
        .setMaxResults(10)
        .getResultList();
}
```

3.11.2. Queries and Flush Mode

The flush mode setting affects the result of a query as follows.

When queries are executed within a transaction, if `FlushModeType.AUTO` is set on the `Query`, `TypedQuery`, or `StoredProcedureQuery` object, or if the flush mode setting for the persistence context is `AUTO` (the default) and a flush mode setting has not been specified for the query object, the persistence provider is responsible for ensuring that all updates to the state of all entities in the persistence context which could potentially affect the result of the query are visible to the processing of the query. The persistence provider implementation may achieve this by flushing those entities to the database or by some other means. If `FlushModeType.COMMIT` is set, the effect of updates made to entities in the persistence

context upon queries is unspecified.

If the persistence context has not been joined to the current transaction, the persistence provider must not flush to the database regardless of the flush mode setting.

```
/**
 * Enumerates flush modes recognized by the {@link EntityManager}.
 *
 * <p>When queries are executed within a transaction, if {@link #AUTO}
 * is set on the {@link Query Query} or {@link TypedQuery} object, or
 * if the flush mode setting for the persistence context is {@code AUTO}
 * (the default) and a flush mode setting has not been specified for the
 * {@code Query} or {@code TypedQuery} object, the persistence provider
 * is responsible for ensuring that all updates to the state of all
 * entities in the persistence context which could potentially affect
 * the result of the query are visible to the processing of the query.
 * The persistence provider implementation may achieve this by flushing
 * updates to those entities to the database or by some other means.
 *
 * <p>On the other hand, if {@link #COMMIT} is set, the effect of updates
 * made to entities in the persistence context on queries is unspecified.
 *
 * <p>If there is no transaction active or the persistence context is
 * not joined to the current transaction, the persistence provider must
 * not flush to the database.
 *
 * @see EntityManager#setFlushMode(FlushModeType)
 * @see Query#setFlushMode(FlushModeType)
 *
 * @since 1.0
 */
public enum FlushModeType {

    /**
     * Flushing to occur at transaction commit. The provider may flush
     * at other times, but is not required to.
     */
    COMMIT,

    /**
     * (Default) Flushing to occur at query execution.
     */
    AUTO
}
```

If there is no transaction active, the persistence provider must not flush to the database.

3.11.3. Queries and Lock Mode

The `setLockMode` method of the `Query` or `TypedQuery` interface or the `lockMode` element of the `NamedQuery` annotation may be used to lock the results of a query. A lock is obtained for each entity specified in the query result (including entities passed to constructors in the query `SELECT` clause).^[27]

If the lock mode type is `PESSIMISTIC_READ`, `PESSIMISTIC_WRITE`, or `PESSIMISTIC_FORCE_INCREMENT`, and the query returns scalar data (e.g., the values of entity field or properties, including scalar data passed to constructors in the query `SELECT` clause), the underlying database rows will be locked^[28], but the version columns (if any) for any entities corresponding to such scalar data will not be updated unless the entities themselves are also otherwise retrieved and updated.

If the lock mode type is `OPTIMISTIC` or `OPTIMISTIC_FORCE_INCREMENT`, and the query returns scalar data, any entities returned by the query will be locked, but no locking will occur for scalar data that does not correspond to the state of any entity instance in the query result.

If a lock mode other than `NONE` is specified for a query, the query must be executed within a transaction (and the persistence context must be joined to the transaction) or the `TransactionRequiredException` will be thrown.

Locking is supported for Jakarta Persistence query language queries and criteria queries only. If the `setLockMode` or `getLockMode` method is invoked on a query that is not a Jakarta Persistence query language select query or a criteria query, the `IllegalStateException` may be thrown or the query execution will fail.

3.11.4. Query Hints

The following hint is defined by this specification for use in query configuration.

```
jakarta.persistence.query.timeout // time in milliseconds
```

This hint may:

- be passed to the `setHint()` method of the `Query`, `TypedQuery`, and `StoredProcedureQuery` interfaces found in [Appendix B](#),
- used with the `NamedQuery`, `NamedNativeQuery`, and `NamedStoredProcedureQuery` annotations specified in [Section 10.4](#),
- passed as a property to the `createEntityManagerFactory()` method of the `Persistence` class, as defined in [Section 9.7](#), or
- used in the `properties` element of the `persistence.xml` file, as defined in [Section 8.2.1.11](#).

The timeout specified by calling the `createEntityManagerFactory()` method, via the `persistence.xml` file, or in annotations, serves as a default value which can be selectively overridden by calling the `setHint()` method.

Portable applications should not rely on this hint. Depending on the persistence provider and database in use, the hint may or may not be observed.

Vendors are permitted to support the use of additional, vendor-specific hints. Vendor-specific hints must not use the `jakarta.persistence` namespace. Vendor-specific hints must be ignored if they are not understood.

3.11.5. Parameter Objects

Parameter objects can be used for criteria queries and for Jakarta Persistence query language queries.

Implementations may support the use of `Parameter` objects for native queries, however support for `Parameter` objects with native queries is not required by this specification. The use of `Parameter` objects for native queries will not be portable. The mixing of parameter objects with named or positional parameters is invalid.

Portable applications should not attempt to reuse a `Parameter` object obtained from a `Query` or `TypedQuery` instance in the context of a different `Query` or `TypedQuery` instance.

3.11.6. Named Parameters

Named parameters can be used for Jakarta Persistence query language queries, for criteria queries (although use of `Parameter` objects is to be preferred), and for stored procedure queries that support named parameters.

Named parameters follow the rules for identifiers defined in [Section 4.4.1](#). Named parameters are case-sensitive. The mixing of named and positional parameters is invalid.

A named parameter of a Jakarta Persistence query language query is an identifier that is prefixed by the `" : "` symbol. The parameter names passed to the `setParameter` methods of the `Query` and `TypedQuery` interfaces do not include this `" : "` prefix.

3.11.7. Positional Parameters

Only positional parameter binding and positional access to result items may be portably used for native queries, except for stored procedure queries for which named parameters have been defined. When binding the values of positional parameters, the numbering starts as “ 1 ”. It is assumed that for native queries the parameters themselves use the SQL syntax (i.e., “ ? ”, rather than “ ?1 ”).

The use of positional parameters is not supported for criteria queries.

3.11.8. Arguments to query parameters

Arguments are assigned to query parameters by calling `Query.setParameter()`. The first parameter of `setParameter()` identifies the named or positional parameter of the query.

An argument may be assigned to a single-valued parameter of a JPQL or native SQL query by passing the argument to the second parameter of `setParameter()`.

```
query.setParameter("name", name)
```

A list of arguments may be assigned to a collection-valued parameter of a JPQL query by packaging the arguments in a non-null instance of `java.util.List` and passing the list as an argument to the second parameter of `setParameter()`. The list should contain at least one element. If the list is empty the behavior is undefined. Portable applications should not pass an empty list to a collection-valued parameter.

```
query.setParameter("names", List.of(name1, name2, name3))
```

3.11.9. Named Queries

Named queries are static queries expressed in metadata or queries registered by means of the `EntityManagerFactory` `addNamedQuery` method. Named queries can be defined in the Jakarta Persistence query language or in SQL. Query names are scoped to the persistence unit.

The following is an example of the definition of a named query defined in metadata:

```
@NamedQuery(  
    name="findAllCustomersWithName",  
    query="SELECT c FROM Customer c WHERE c.name LIKE :custName"  
)
```

The following is an example of the use of a named query:

```
@PersistenceContext  
public EntityManager em;  
    // ...  
  
customers = em.createNamedQuery("findAllCustomersWithName")  
    .setParameter("custName", "Smith")  
    .getResultList();
```

3.11.10. Polymorphic Queries

By default, all queries are polymorphic. That is, the FROM clause of a query designates not only instances of the specific entity class(es) to which it explicitly refers, but subclasses as well. The instances returned by a query include instances of the subclasses that satisfy the query conditions.

For example, the following query returns the average salary of all employees, including subtypes of `Employee`, such as `Manager` and `Exempt`.

```
select avg(e.salary) from Employee e where e.salary > 80000
```

Entity type expressions, described in [Section 4.7.12](#), as well as the use of downcasting, described in [Section 4.4.9](#), can be used to restrict query polymorphism.

3.11.11. SQL Queries

Queries may be expressed in native SQL. The result of a native SQL query may consist of entities, unmanaged instances created via constructors, scalar values, or some combination of these.



The SQL query facility is intended to provide support for those cases where it is necessary to use the native SQL of the target database in use (and/or where the Jakarta Persistence query language cannot be used). Native SQL queries are not expected to be portable across databases.

3.11.11.1. Returning Managed Entities from Native Queries

The persistence provider is responsible for performing the mapping between the values returned by the SQL query and entity attributes in accordance with the object/relational mapping metadata for the entity or entities. In particular, the names of the columns in the SQL result are used to map to the entity attributes as defined by this metadata. This mapping includes the mapping of the attributes of any embeddable classes that are part of the non-collection-valued entity state and attributes corresponding to foreign keys contained as part of the entity state^[29].

When an entity is to be returned from a native query, the SQL statement should select all of the columns that are mapped to the entity object. This should include foreign key columns to related entities. The results obtained when insufficient data is available are undefined.

In the simplest case—i.e., when the results of the query are limited to entities of a single entity class and the mapping information can be derived from the columns of the SQL result and the object/relational mapping metadata—it is sufficient to specify only the expected class of the entity result.

The following example illustrates the case where a native SQL query is created dynamically using the `createNativeQuery` method and the entity class that specifies the type of the result is passed in as an argument.

```
Query q = em.createNativeQuery(
    "SELECT o.id, o.quantity, o.item " +
    "FROM Order o, Item i " +
    "WHERE (o.item = i.id) AND (i.name = 'widget')",
    com.acme.Order.class);
```

When executed, this query will return a collection of all `Order` entities for items named “widget”.

The `SqlResultSetMapping` metadata annotation—which is designed to handle more complex cases—can be used as an alternative here. See [Section 10.4.4](#) for the definition of the `SqlResultSetMapping` metadata annotation and related annotations.

For the query shown above, the `SqlResultSetMapping` metadata for the query result type might be specified as follows:

```
@SqlResultSetMapping(
    name="WidgetOrderResults",
    entities=@EntityResult(entityClass=com.acme.Order.class))
```

The same results as produced by the query above can then obtained by the following:

```
Query q = em.createNativeQuery(
    "SELECT o.id, o.quantity, o.item " +
    "FROM Order o, Item i " +
    "WHERE (o.item = i.id) AND (i.name = 'widget')",
    "WidgetOrderResults");
```

When multiple entities are returned by a SQL query or when the column names of the SQL result do not correspond to those of the object/relational mapping metadata, a `SqlResultSetMapping` metadata definition must be provided to specify the entity mapping.

The following query and `SqlResultSetMapping` metadata illustrates the return of multiple entity types. It assumes default metadata and column name defaults.

```
Query q = em.createNativeQuery(
    "SELECT o.id, o.quantity, o.item, i.id, i.name, i.description " +
    "FROM Order o, Item i " +
    "WHERE (o.quantity > 25) AND (o.item = i.id)",
    "OrderItemResults");

@SqlResultSetMapping(name="OrderItemResults", entities={
    @EntityResult(entityClass=com.acme.Order.class),
    @EntityResult(entityClass=com.acme.Item.class)
})
```

When the column names of the SQL result do not correspond to those of the object/relational mapping metadata or introduce a conflict in mapping column defaults as in the example code above, more explicit SQL result mapping metadata must be provided to enable the persistence provider runtime to map the JDBC results into the expected objects. This might arise, for example, when column aliases must be used in the SQL `SELECT` clause when the SQL result would otherwise contain multiple columns of the same name or when columns in the SQL result are the results of operators or functions. The `FieldResult` annotation element within the `EntityResult` annotation is used to specify the mapping of such columns to entity attributes.

The following example combining multiple entity types includes aliases in the SQL statement. This requires that the column names be explicitly mapped to the entity fields corresponding to those columns. The `FieldResult` annotation is used for this purpose.

```
Query q = em.createNativeQuery(
    "SELECT o.id AS order_id, " +
    "o.quantity AS order_quantity, " +
    "o.item AS order_item, " +
    "i.id, i.name, i.description " +
    "FROM Order o, Item i " +
    "WHERE (order_quantity > 25) AND (order_item = i.id)",
    "OrderItemResults");

@SqlResultSetMapping(name="OrderItemResults", entities={
    @EntityResult(entityClass=com.acme.Order.class, fields={
        @FieldResult(name="id", column="order_id"),
        @FieldResult(name="quantity", column="order_quantity"),
        @FieldResult(name="item", column="order_item")}),
    @EntityResult(entityClass=com.acme.Item.class)
})
```

When the returned entity type contains an embeddable class, the `FieldResult` element must use a dot (“.”) notation to indicate which column maps to which field or property of the contained embeddable.

Example:

```

Query q = em.createNativeQuery(
    "SELECT c.id AS customer_id, " +
        "c.street AS customer_street, " +
        "c.city AS customer_city, " +
        "c.state AS customer_state, " +
        "c.status AS customer_status " +
        "FROM Customer c " +
        "WHERE c.status = 'GOLD' ",
    "CustomerResults");

@SqlResultSetMapping(name="CustomerResults", entities={
    @EntityResult(entityClass=com.acme.Customer.class, fields={
        @FieldResult(name="id", column="customer_id"),
        @FieldResult(name="address.street", column="customer_street"),
        @FieldResult(name="address.city", column="customer_city"),
        @FieldResult(name="address.state", column="customer_state"),
        @FieldResult(name="status", column="customer_status")
    })
})

```

When the returned entity type is the owner of a single-valued relationship and the foreign key is a composite foreign key (composed of multiple columns), a `FieldResult` element should be used for each of the foreign key columns. The `FieldResult` element must use the dot (“.”) notation form to indicate the column that maps to each property or field of the target entity primary key.

If the target entity has a primary key of type `IdClass`, this specification takes the form of the name of the field or property for the relationship, followed by a dot (“.”), followed by the name of the field or property of the primary key in the target entity. The latter will be annotated with `Id`, as specified in [Section 11.1.23](#).

Example:

```

Query q = em.createNativeQuery(
    "SELECT o.id AS order_id, " +
        "o.quantity AS order_quantity, " +
        "o.item_id AS order_item_id, " +
        "o.item_name AS order_item_name, " +
        "i.id, i.name, i.description " +
        "FROM Order o, Item i " +
        "WHERE (order_quantity > 25) AND (order_item_id = i.id) " +
        "AND (order_item_name = i.name)",
    "OrderItemResults");

@SqlResultSetMapping(name="OrderItemResults", entities={
    @EntityResult(entityClass=com.acme.Order.class, fields={
        @FieldResult(name="id", column="order_id"),
        @FieldResult(name="quantity", column="order_quantity"),
        @FieldResult(name="item.id", column="order_item_id")}),
    @FieldResult(name="item.name", column="order_item_name")),
    @EntityResult(entityClass=com.acme.Item.class)
})

```

If the target entity has a primary key of type `EmbeddedId`, this specification is composed of the name of the field or property for the relationship, followed by a dot (“.”), followed by the name or the field or property of the primary key (i.e., the name of the field or property annotated as `EmbeddedId`), followed by the name of the corresponding field or property of the embedded primary key class.

Example:

```

Query q = em.createNativeQuery(
    "SELECT o.id AS order_id, " +
        "o.quantity AS order_quantity, " +

```

```

        "o.item_id AS order_item_id, " +
        "o.item_name AS order_item_name, " +
        "i.id, i.name, i.description " +
        "FROM Order o, Item i " +
        "WHERE (order_quantity > 25) AND (order_item_id = i.id) AND (order_item_name = i.name)",
        "OrderItemResults");

```

```

@SqlResultSetMapping(name="OrderItemResults", entities={
    @EntityResult(entityClass=com.acme.Order.class, fields={
        @FieldResult(name="id", column="order_id"),
        @FieldResult(name="quantity", column="order_quantity"),
        @FieldResult(name="item.itemPk.id", column="order_item_id")),
    @FieldResult(name="item.itemPk.name", column="order_item_name"))},
    @EntityResult(entityClass=com.acme.Item.class)
})

```

The `FieldResult` elements for the composite foreign key are combined to form the primary key `EmbeddedId` class for the target entity. This may then be used to subsequently retrieve the entity if the relationship is to be eagerly loaded.

The dot-notation form is not required to be supported for any usage other than for embeddables, composite foreign keys, or composite primary keys.

3.11.11.2. Returning Unmanaged Instances

Instances of other classes (including non-managed entity instances) as well as scalar results can be returned by a native query. These can be used singly, or in combination, including with entity results.

Scalar Results

Scalar results can be included in the query result by specifying the `ColumnResult` annotation element of the `SqlResultSetMapping` annotation. The intended type of the result can be specified using the `type` element of the `ColumnResult` annotation.

```

Query q = em.createNativeQuery(
    "SELECT o.id AS order_id, " +
    "o.quantity AS order_quantity, " +
    "o.item AS order_item, " +
    "i.name AS item_name, " +
    "i.availabilityDate AS item_shipdate " +
    "FROM Order o, Item i " +
    "WHERE (order_quantity > 25) AND (order_item = i.id)",
    "OrderResults");

@SqlResultSetMapping(
    name="OrderResults",
    entities={
        @EntityResult(entityClass=com.acme.Order.class, fields={
            @FieldResult(name="id", column="order_id"),
            @FieldResult(name="quantity", column="order_quantity"),
            @FieldResult(name="item", column="order_item")}
        )},
    columns={
        @ColumnResult(name="item_name"),
        @ColumnResult(name="item_shipdate", type=java.util.Date.class)
    }
})

```

Constructor Results

The mapping to constructors is specified using the `ConstructorResult` annotation element of the `SqlResultSetMapping`

annotation. The `targetClass` element of the `ConstructorResult` annotation specifies the class whose constructor corresponds to the specified columns. All columns corresponding to arguments of the intended constructor must be specified using the `columns` element of the `ConstructorResult` annotation in the same order as that of the argument list of the constructor. Any entities returned as constructor results will be in either the new or the detached state, depending on whether a primary key is retrieved for the constructed object.

Example:

```
Query q = em.createNativeQuery(
    "SELECT c.id, c.name, COUNT(o) as orderCount, AVG(o.price) AS avgOrder " +
    "FROM Customer c, Orders o " +
    "WHERE o.cid = c.id " +
    "GROUP BY c.id, c.name",
    "CustomerDetailsResult");

@SqlResultSetMapping(name="CustomerDetailsResult", classes={
    @ConstructorResult(targetClass=com.acme.CustomerDetails.class, columns={
        @ColumnResult(name="id"),
        @ColumnResult(name="name"),
        @ColumnResult(name="orderCount"),
        @ColumnResult(name="avgOrder", type=Double.class)})
})
```

3.11.11.3. Combinations of Result Types

When a `SqlResultSetMapping` specifies more than one mapping type (i.e., more than one of `EntityResult`, `ConstructorResult`, `ColumnResult`), then for each row in the SQL result, the query execution will result in an `Object[]` instance whose elements are as follows, in order: any entity results (in the order in which they are defined in the `entities` element); any instances of classes corresponding to constructor results (in the order defined in the `classes` element); and any instances corresponding to column results (in the order defined in the `columns` element). If there are any columns whose result mappings have not been specified, they are ignored.

3.11.11.4. Restrictions

When an entity is being returned, the SQL statement should select all of the columns that are mapped to the entity object. This should include foreign key columns to related entities. The results obtained when insufficient data is available are undefined. A SQL result set mapping must not be used to map results to the non-persistent state of an entity.

The use of named parameters is not defined for native SQL queries. Only positional parameter binding for SQL queries may be used by portable applications.

3.11.12. Stored Procedures

The `StoredProcedureQuery` interface supports the use of database stored procedures.

Stored procedures can be specified either by means of the `NamedStoredProcedureQuery` annotation or dynamically. Annotations for the specification of stored procedures are described in [Section 10.4.3](#).

3.11.12.1. Named Stored Procedure Queries

Unlike in the case of a named native query, the `NamedStoredProcedureQuery` annotation names a stored procedure that exists in the database rather than providing a stored procedure definition. The `NamedStoredProcedureQuery` annotation specifies the types of all parameters to the stored procedure, their corresponding parameter modes (IN, OUT, INOUT, REF_CURSOR^[30]), and how result sets, if any, are to be mapped. The name that is assigned to the stored procedure in the

`NamedStoredProcedureQuery` annotation is passed as an argument to the `createNamedStoredProcedureQuery` method to create an executable `StoredProcedureQuery` object.

A stored procedure may return more than one result set. As with native queries, the mapping of result sets can be specified either in terms of a `resultClasses` or as a `resultSetMappings` annotation element. If there are multiple result sets, it is assumed that they will be mapped using the same mechanism — e.g., all via a set of result class mappings or all via a set of result set mappings. The order of the specification of these mappings must be the same as the order in which the result sets will be returned by the stored procedure invocation. If the stored procedure returns one or more result sets and no `resultClasses` or `resultSetMappings` element has been specified, any result set will be returned as a list of type `Object[]`. The combining of different strategies for the mapping of stored procedure result sets is undefined.

`StoredProcedureParameter` metadata needs to be provided for all parameters. Parameters must be specified in the order in which they occur in the parameter list of the stored procedure. If parameter names are used, the parameter name is used to bind the parameter value and to extract the output value (if the parameter is an INOUT or OUT parameter). If parameter names are not specified, it is assumed that positional parameters are used. The mixing of named and positional parameters is invalid.

3.11.12.2. Dynamically-specified Stored Procedure Queries

If the stored procedure is not defined using metadata, parameter and result set information must be provided dynamically.

All parameters of a dynamically-specified stored procedure query must be registered using the `registerStoredProcedureParameter` method of the `StoredProcedureQuery` interface.

Result set mapping information can be provided by means of the `createStoredProcedureQuery` method.

3.11.12.3. Stored Procedure Query Execution

Stored procedure query execution can be controlled as described below.

The `setParameter` methods are used to set the values of all required IN and INOUT parameters. It is not required to set the values of stored procedure parameters for which default values have been defined by the stored procedure.

When `getResultList`, `getSingleResult`, and `getSingleResultOrNull` are called on a `StoredProcedureQuery` object, the persistence provider will call `execute` on an unexecuted stored procedure query before processing `getResultList`, `getSingleResult` or `getSingleResultOrNull`.

When `executeUpdate` is called on a `StoredProcedureQuery` object, the persistence provider will call `execute` on an unexecuted stored procedure query followed by `getUpdateCount`. The results of `executeUpdate` will be those of `getUpdateCount`.

The `execute` method supports both the simple case where scalar results are passed back only via INOUT and OUT parameters as well as the most general case (multiple result sets and/or update counts, possibly also in combination with output parameter values).

The `execute` method returns `true` if the first result is a result set, and `false` if it is an update count or there are no results other than through INOUT and OUT parameters, if any.

If the `execute` method returns `true`, the pending result set can be obtained by calling `getResultList`, `getSingleResult`, or `getSingleResultOrNull`. The `hasMoreResults` method can then be used to test for further results.

If `execute` or `hasMoreResults` returns `false`, the `getUpdateCount` method can be called to obtain the pending result if it is an update count. The `getUpdateCount` method will return either the update count (zero or greater) or -1 if there is no update count (i.e., either the next result is a result set or there is no next update count).

For portability, results that correspond to JDBC result sets and update counts need to be processed before the values of any INOUT or OUT parameters are extracted.

After results returned through `getResultList` and `getUpdateCount` have been exhausted, results returned through INOUT and OUT parameters can be retrieved.

The `getOutputParameterValue` methods are used to retrieve the values passed back from the procedure through INOUT and OUT parameters.

When using `REF_CURSOR` parameters for result sets, the update counts should be exhausted before calling `getResultList` to retrieve the result set. Alternatively, the `REF_CURSOR` result set can be retrieved through `getOutputParameterValue`. Result set mappings will be applied to results corresponding to `REF_CURSOR` parameters in the order the `REF_CURSOR` parameters were registered with the query.

In the simplest case, where results are returned only via INOUT and OUT parameters, `execute` can be followed immediately by calls to `getOutputParameterValue`.

3.12. Summary of Exceptions

The following is a summary of the exceptions defined by this specification:

PersistenceException

The `PersistenceException` is thrown by the persistence provider when a problem occurs. It may be thrown to report that the invoked operation could not complete because of an unexpected error (e.g., failure of the persistence provider to open a database connection).

All other exceptions defined by this specification are subclasses of the `PersistenceException`. All instances of `PersistenceException` except for instances of `NoResultException`, `NonUniqueResultException`, `LockTimeoutException`, and `QueryTimeoutException` will cause the current transaction, if one is active and the persistence context has been joined to it, to be marked for rollback.

TransactionRequiredException

The `TransactionRequiredException` is thrown by the persistence provider when a transaction is required but is not active.

OptimisticLockException

The `OptimisticLockException` is thrown by the persistence provider when an optimistic locking conflict occurs. This exception may be thrown as part of an API call, at flush, or at commit time. The current transaction, if one is active, will be marked for rollback.

PessimisticLockException

The `PessimisticLockException` is thrown by the persistence provider when a pessimistic locking conflict occurs. The current transaction will be marked for rollback. Typically the `PessimisticLockException` occurs because the database transaction has been rolled back due to deadlock or because the database uses transaction-level rollback when a pessimistic lock cannot be granted.

LockTimeoutException

The `LockTimeoutException` is thrown by the persistence provider when a pessimistic locking conflict occurs that does not result in transaction rollback. Typically this occurs because the database uses statement-level rollback when a pessimistic lock cannot be granted (and there is no deadlock). The `LockTimeoutException` does not cause the current transaction to be marked for rollback.

RollbackException

The `RollbackException` is thrown by the persistence provider when `EntityTransaction.commit` fails.

EntityExistsException

The `EntityExistsException` may be thrown by the persistence provider when the `persist` operation is invoked and the entity already exists. The `EntityExistsException` may be thrown when the `persist` operation is invoked, or the `EntityExistsException` or another `PersistenceException` may be thrown at commit time. The current transaction, if one is active and the persistence context has been joined to it, will be marked for rollback.

EntityNotFoundException

The `EntityNotFoundException` is thrown by the persistence provider when an entity reference obtained by `getReference` is accessed but the entity does not exist. It is thrown by the `refresh` operation when the entity no longer exists in the database. It is also thrown by the `lock` operation when pessimistic locking is used and the entity no longer exists in the database. The current transaction, if one is active and the persistence context has been joined to it, will be marked for rollback.

NoResultException

The `NoResultException` is thrown by the persistence provider when `Query.getSingleResult` is invoked and there is no result to return. This exception will not cause the current transaction, if one is active, to be marked for rollback.

NonUniqueResultException

The `NonUniqueResultException` is thrown by the persistence provider when `Query.getSingleResult` or `Query.getSingleResultOrNull` is invoked and there is more than one result from the query. This exception will not cause the current transaction, if one is active, to be marked for rollback.

QueryTimeoutException

The `QueryTimeoutException` is thrown by the persistence provider when a query times out and only the statement is rolled back. The `QueryTimeoutException` does not cause the current transaction, if one is active, to be marked for rollback.

[1] This includes, for example, modifications to persistent attributes of type `char[]` and `byte[]`.

[2] This might be an issue if unique constraints (such as those described for the default mappings in [Section 2.12.3.1](#) and [Section 2.12.5.1](#)) were not applied in the definition of the object/relational mapping.

[3] Note that when a new transaction is begun, the managed objects in an extended persistence context are not reloaded from the database.

[4] These are instances that were persistent in the database at the start of the transaction.

[5] It is unspecified as to whether instances that were not persistent in the database behave as new instances or detached instances after rollback. This may be implementation-dependent.

[6] Applications may require that database isolation levels higher than read-committed be in effect. The configuration of the setting database isolation levels, however, is outside the scope of this specification.

[7] Such alternative mechanisms might be standardized by a future release of this specification.

[8] This includes owned relationships maintained in join tables.

[9] Typically, by incrementing the version number, or by replacing the previous timestamp with a timestamp representing the current time.

[10] Ideally, version verification and update happen in a single atomic operation against the datastore, for example, in a single SQL update statement.

[11] Implementations are permitted to use database mechanisms other than locking to achieve the semantic effects described here, for example, multiversion concurrency control mechanisms.

[12] This is achieved by using a lock with `LockModeType.PESSIMISTIC_WRITE` or `LockModeType.PESSIMISTIC_FORCE_INCREMENT` as

described in [Section 3.5.4](#).

[13] For example, a persistence provider may use an underlying database platform's SELECT FOR UPDATE statements to implement pessimistic locking if that construct provides appropriate semantics, or the provider may use an isolation level of repeatable read.

[14] The lock mode type NONE may be specified as a method argument and also provides a default value for annotations.

[15] Databases concurrency control mechanisms that provide comparable semantics, e.g., multiversion concurrency control, can be used by the provider.

[16] The persistence provider is not required to flush the entity to the database immediately.

[17] CDI is enabled by default in Jakarta EE. See the Jakarta EE specification [6].

[18] The persistence provider may support CDI injection into entity listeners in other environments in which the BeanManager is available.

[19] For example, if a transaction commit occurs as a result of the normal termination of a session bean business method with transaction attribute RequiresNew, the PostPersist and PostRemove callbacks are executed in the naming context, the transaction context, and the security context of that component.

[20] Note that this caution applies also to the actions of objects that might be injected into an entity listener

[21] Excluded listeners may be reintroduced on an entity class by listing them explicitly in the EntityListeners annotation or XML entity-listeners element.

[22] If a method overrides an inherited callback method but specifies a different lifecycle event or is not a lifecycle callback method, the overridden method will not be invoked.

[23] We plan to provide a facility for more complex attribute conversions in a future release of this specification.

[24] CDI is enabled by default in Jakarta EE. See the Jakarta EE specification [6].

[25] The persistence provider may support CDI injection into attribute converters in other environments in which the BeanManager is available.

[26] A lock mode is specified for a query by means of the setLockMode method or by specifying the lock mode in the NamedQuery annotation.

[27] Note that the setLockMode method may be called more than once (with different values) on a Query or TypedQuery object.

[28] Note that locking will not occur for data passed to aggregate functions. Further, queries involving aggregates with pessimistic locking may not be supported on all database platforms.

[29] Support for joins is currently limited to single-valued relationships that are mapped directly—i.e., not via join tables.

[30] Note that REF_CURSOR parameters are used by some databases to return result sets from stored procedures.

Chapter 4. Query Language

The Jakarta Persistence query language is a string-based query language used to define queries over entities and their persistent state. It enables the application developer to specify the semantics of queries in a portable way, independent of the particular database schema in use in an enterprise environment. The full range of the language may be used in both static and dynamic queries.

This chapter provides the full definition of the Jakarta Persistence query language.

4.1. Overview

The Jakarta Persistence query language is a query specification language for string-based dynamic queries and static queries expressed through metadata. It is used to define queries over the persistent entities defined by this specification and their persistent state and relationships.

The Jakarta Persistence query language can be compiled to a target language, such as SQL, of a database or other persistent store. This allows the execution of queries to be shifted to the native language facilities provided by the database, instead of requiring queries to be executed on the runtime representation of the entity state. As a result, query methods can be optimizable as well as portable.

The query language uses the abstract persistence schema of entities, including their embedded objects and relationships, for its data model, and it defines operators and expressions based on this data model. It uses a SQL-like syntax to select objects or values based on abstract schema types and relationships. It is possible to parse and validate queries before entities are deployed.



The term abstract persistence schema refers to the persistent schema abstraction (persistent entities, their state, and their relationships) over which Jakarta Persistence queries operate. Queries over this persistent schema abstraction are translated into queries that are executed over the database schema to which entities are mapped.

Queries may be defined in metadata annotations or the XML descriptor. The abstract schema types of a set of entities can be used in a query if the entities are defined in the same persistence unit as the query. Path expressions allow for navigation over relationships defined in the persistence unit.



A persistence unit defines the set of all classes that are related or grouped by the application and which must be colocated in their mapping to a single database.

4.2. Statement Types

A Jakarta Persistence query language statement may be either a select statement, an update statement, or a delete statement.



This chapter refers to all such statements as “queries”. Where it is important to distinguish among statement types, the specific statement type is referenced.

In BNF syntax, a query language statement is defined as:

```
QL_statement ::= select_statement | update_statement | delete_statement
```

Any Jakarta Persistence query language statement may be constructed dynamically or may be statically defined in a metadata annotation or XML descriptor element.

All statement types may have parameters.

4.2.1. Select Statements

A select query is a string with the following clauses:

- a `SELECT` clause, which determines the type of the objects or values to be selected.
- a `FROM` clause, which provides declarations that designate the domain to which the expressions specified in the other clauses of the query apply.
- an optional `WHERE` clause, which may be used to restrict the results that are returned by the query.
- an optional `GROUP BY` clause, which allows query results to be aggregated in terms of groups.
- an optional `HAVING` clause, which allows filtering over aggregated groups.
- an optional `ORDER BY` clause, which may be used to order the results that are returned by the query.

In BNF syntax, a select query is defined by:

```
select_query ::= [select_clause]? from_clause [where_clause] [groupby_clause] [having_clause] [orderby_clause]
```

Every select statement has a `FROM` clause. The square brackets `[]` in the BNF indicate that the other clauses are optional.

4.2.1.1. Set Operators in Select Statements

A select statement may be a single select query, or it may combine multiple select queries using the binary left-associative operators `UNION`, `UNION ALL`, `INTERSECT`, `INTERSECT ALL`, `EXCEPT`, and `EXCEPT ALL`. The semantics of these operators are identical to SQL. ^[1]

The full syntax for a select statement is defined by:

```
select_statement ::= union
union ::= intersection | union {UNION [ALL] | EXCEPT [ALL]} intersection
intersection ::= query_expression | intersection INTERSECT [ALL] query_expression
query_expression ::= select_query | (union)
```

A provider is only required to support select statements where every constituent select query has the same number of items in the select clause, and where corresponding items in the select clauses of the constituent select queries either:

- have exactly the same type, as defined by [Section 4.9.1](#), or
- are entity types which inherit a common entity type, as defined by [Section 2.13](#).

4.2.2. Update and Delete Statements

Update and delete statements provide bulk operations over sets of entities.

In BNF syntax, these operations are defined by:

```
update_statement ::= update_clause [where_clause]
delete_statement ::= delete_clause [where_clause]
```

The update and delete clauses determine the type of the entities to be updated or deleted. The `WHERE` clause may be used to restrict the scope of the update or delete operation.

Update and delete statements are described further in [Section 4.11](#).

4.3. Abstract Schema Types and Query Domains

The Jakarta Persistence query language is a typed language, and every expression has a type. The type of an expression is derived from the structure of the expression, the abstract schema types of the identification variable declarations, the types to which the persistent attributes evaluate, and the types of literals.

The abstract schema type of an entity or embeddable is derived from its class and the metadata information provided by Java language annotations or in the XML descriptor.

Informally, the abstract schema type of an entity or embeddable can be characterized as follows:

- For every non-relationship persistent field or get accessor method (for a persistent property) of the class, there is a field (“state field”) whose abstract schema type corresponds to that of the field or the result type of the accessor method.
- For every persistent relationship field or get accessor method (for a persistent relationship property) of the class, there is a field (“association field”) whose type is the abstract schema type of the related entity (or, if the relationship is a one-to-many or many-to-many, a collection of such).

Abstract schema types are specific to the query language data model. The persistence provider is not required to implement or otherwise materialize an abstract schema type.

The domain of a query consists of the abstract schema types of all entities and embeddables that are defined in the same persistence unit.

The domain of a query may be restricted by the *navigability* of the relationships of the entity and associated embeddable classes on which it is based. The association fields of an entity’s or embeddable’s abstract schema type determine navigability. Using the association fields and their values, a query can select related entities and use their abstract schema types in the query.

4.3.1. Naming

Entities are designated in query strings by their entity names. The entity name is defined by the `name` element of the Entity annotation (or the `entity-name` XML descriptor element), and defaults to the unqualified name of the entity class. Entity names are scoped within the persistence unit and must be unique within the persistence unit.

4.3.2. Example

This example assumes that the application developer provides several entity classes, representing orders, products, and line items, and an embeddable address class representing shipping addresses and billing addresses. The abstract schema types for the entities are `Order`, `Product`, and `LineItem` respectively. There is a one-to-many relationship between `Order` and `LineItem`. The entity `LineItem` is related to `Product` in a many-to-one relationship. The classes are logically in the same persistence unit, as shown in [Figure 1](#).

Queries to select orders can be defined by navigating over the association fields and state fields defined by `Order` and `LineItem`. A query to find all orders with pending line items might be written as follows:

```
SELECT DISTINCT o
FROM Order AS o JOIN o.lineItems AS l
WHERE l.shipped = FALSE
```

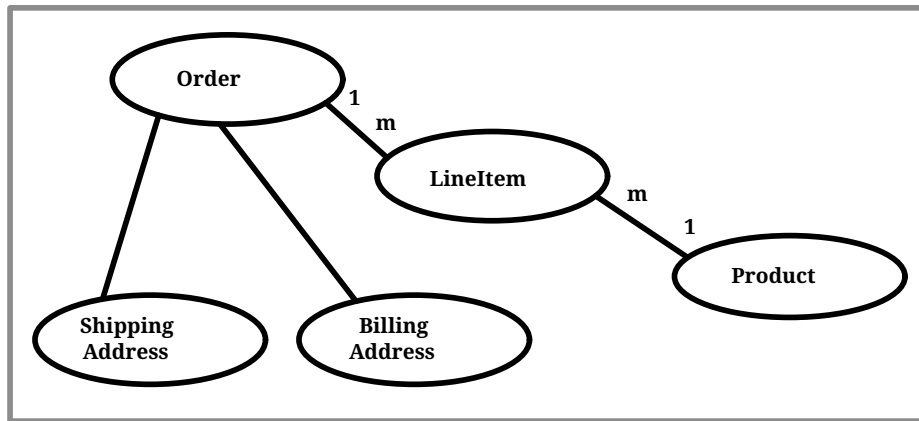


Figure 1. Abstract persistence schema of several entities defined in the same persistence unit.

This query navigates over the association field `lineItems` of the abstract schema type `Order` to find line items, and uses the state field `shipped` of `LineItem` to select those orders that have at least one line item that has not yet shipped. (Note that this query does not select orders that have no line items.)

Although reserved identifiers, such as `DISTINCT`, `FROM`, `AS`, `JOIN`, `WHERE`, and `FALSE` appear in upper case in this example, reserved identifiers are case insensitive.^[2]

The `SELECT` clause of this example designates the return type of this query to be of type `Order`.

Because the same persistence unit defines the abstract persistence schema of the related entities, the developer can also specify a query over orders that utilizes the abstract schema type for products, and hence the state fields and association fields of both the abstract schema types `Order` and `Product`. For example, if the abstract schema type `Product` has a state field named `productType`, a query over orders can be specified using this state field. Such a query might be to find all orders for products with product type office supplies. A query for this might be as follows.

```

SELECT DISTINCT o
FROM Order o JOIN o.lineItems l JOIN l.product p
WHERE p.productType = 'office_supplies'
  
```

Because `Order` is related to `Product` by means of the relationships between `Order` and `LineItem` and between `LineItem` and `Product`, navigation using the association fields `lineItems` and `product` is used to express the query. This query is specified by using the entity name `Order`, which designates the abstract schema type over which the query ranges. The basis for the navigation is provided by the association fields `lineItems` and `product` of the abstract schema types `Order` and `LineItem` respectively.

4.4. The FROM Clause and Navigational Declarations

The `FROM` clause of a query defines the *domain* of the query:

- one or more named entity abstract schema types, as specified below in [Section 4.4.3](#), together with
- zero or more joined associations and collections, as specified below in [Section 4.4.5](#).

An *identification variable* is an identifier declared in the `FROM` clause of a query. Each identification variable is assigned an abstract schema type. Each element of the domain may declare an identification variable.

- If the domain has exactly one named entity abstract schema type and no joins, then the named entity does not require an explicit identification variable, and its identification variable defaults to the *implicit identification variable*, `this`.
- Otherwise, every element of the `FROM` clause—that is, every named entity abstract schema types and every join—

must declare an identification variable.

```
from_clause ::=
    FROM {this_implicit_variable | identification_variable_declarations}

this_implicit_variable ::= entity_name

identification_variable_declarations ::=
    identification_variable_declaration
    {, {identification_variable_declaration | collection_member_declaration}}*

identification_variable_declaration ::= range_variable_declaration {join | fetch_join}*

range_variable_declaration ::= entity_name [AS] identification_variable

join ::= range_join | path_join

range_join ::= join_spec range_variable_declaration [join_condition]

path_join ::=
    join_spec join_association_path_expression [AS] identification_variable [join_condition]

fetch_join ::= join_spec FETCH join_association_path_expression

join_spec ::= [INNER | LEFT [OUTER]] JOIN

join_association_path_expression ::=
    join_collection_valued_path_expression |
    join_single_valued_path_expression |
    TREAT(join_collection_valued_path_expression AS subtype) |
    TREAT(join_single_valued_path_expression AS subtype)

join_collection_valued_path_expression ::=
    [identification_variable.]{single_valued_embeddable_object_field.}*collection_valued_field

join_single_valued_path_expression ::=
    [identification_variable.]{single_valued_embeddable_object_field.}*single_valued_object_field

join_condition ::= ON conditional_expression

collection_member_declaration ::= IN (collection_valued_path_expression) [AS] identification_variable
```

The following subsections discuss the constructs used in the FROM clause.

4.4.1. Identifiers

An identifier is a character sequence of unlimited length. The character sequence must begin with a Java identifier start character, and all other characters must be Java identifier part characters. An identifier start character is any character for which the method `Character.isJavaIdentifierStart` returns true. This includes the underscore (`_`) character and the dollar sign (`$`) character. An identifier part character is any character for which the method `Character.isJavaIdentifierPart` returns true. The question mark (`?`) character is reserved for use by the Jakarta Persistence query language.

The following^[9] are reserved identifiers: ABS, ALL, AND, ANY, AS, ASC, AVG, BETWEEN, BIT_LENGTH, BOTH, BY, CASE, CEILING, CHAR_LENGTH, CHARACTER_LENGTH, CLASS, COALESCE, CONCAT, COUNT, CURRENT_DATE, CURRENT_TIME, CURRENT_TIMESTAMP, DELETE, DESC, DISTINCT, ELSE, EMPTY, END, ENTRY, ESCAPE, EXISTS, EXP, EXTRACT, FALSE, FETCH, FIRST, FLOOR, FROM, FUNCTION, GROUP, HAVING, IN, INDEX, INNER, IS, JOIN, KEY, LEADING, LAST, LEFT, LENGTH, LIKE, LOCAL, LN, LOCATE, LOWER, MAX, MEMBER, MIN, MOD, NEW, NOT, NULL, NULLS, NULLIF, OBJECT, OF, ON, OR, ORDER, OUTER, POSITION, POWER, REPLACE, RIGHT, ROUND, SELECT, SET, SIGN, SIZE, SOME, SQRT, SUBSTRING, SUM, THEN, TRAILING, TREAT, TRIM, TRUE, TYPE, UNKNOWN, UPDATE, UPPER, VALUE, WHEN, WHERE.

Reserved identifiers are case-insensitive. Reserved identifiers must not be used as identification variables or result variables (see [Section 4.9](#)).



It is recommended that SQL keywords other than those listed above not be used as identification variables in queries because they may be used as reserved identifiers in future releases of this specification.

4.4.2. Identification Variables

An identification variable is a valid identifier declared in the `FROM` clause of a query.

Every identification variable must be declared in the `FROM` clause, except for the implicit identification variable `this`. Identification variables are never declared in other clauses.

An identification variable must not be a reserved identifier.

An identification variable may have the same name as an entity.

Identification variables are case-insensitive.

An identification variable evaluates to a value of the type of the expression used in declaring the variable. For example, consider the previous query:

```
SELECT DISTINCT o
FROM Order o JOIN o.lineItems l JOIN l.product p
WHERE p.productType = 'office_supplies'
```

In the `FROM` clause declaration `o.lineItems l`, the identification variable `l` evaluates to any `LineItem` value directly reachable from `Order`. The association field `lineItems` is a collection of instances of the abstract schema type `LineItem` and the identification variable `l` refers to an element of this collection. The type of `l` is the abstract schema type of `LineItem`.

An identification variable can range over an entity, embeddable, or basic abstract schema type. An identification variable designates an instance of an abstract schema type or an element of a collection of abstract schema type instances.

Note that for identification variables referring to an instance of an association or collection represented as a `java.util.Map`, the identification variable is of the abstract schema type of the `map` value.

An identification variable always designates a reference to a single value. It is declared in one of three ways: in a range variable declaration, in a join clause, or in a collection member declaration. The identification variable declarations are evaluated from left to right in the `FROM` clause, and an identification variable declaration can use the result of a preceding identification variable declaration of the query string.

All identification variables used in the `SELECT`, `WHERE`, `ORDER BY`, `GROUP BY`, or `HAVING` clause of a `SELECT` or `DELETE` statement must be declared in the `FROM` clause. The identification variables used in the `WHERE` clause of an `UPDATE` statement must be declared in the `UPDATE` clause.

Identification variables are existentially quantified in these clauses. This means that an identification variable represents a member of a collection or an instance of an entity's abstract schema type. An identification variable never designates a collection in its entirety.

An identification variable is scoped to the query (or subquery) in which it is defined and is also visible to any subqueries within that query scope that do not define an identification variable of the same name.

4.4.3. Range Variable Declarations

A range variable declaration introduces a query domain element ranging over a given named entity abstract schema type, with an associated identification variable.

The syntax for declaring an identification variable as a range variable is similar to that of SQL; optionally, it may use the AS keyword. A range variable declaration designates an entity abstract schema type by its entity name, as defined above in [Section 4.3.1](#).^[4]

```
range_variable_declaration ::= entity_name [AS] identification_variable
```

The entity name in a range variable declaration is case-sensitive.

Range variable declarations allow the developer to designate a “root” for objects which may not be reachable by navigation.

In order to select values by comparing more than one instance of an entity abstract schema type, more than one identification variable ranging over the abstract schema type is needed in the FROM clause.

The following query returns orders whose quantity is greater than the order quantity for John Smith. This example illustrates the use of two different identification variables in the FROM clause, both of the abstract schema type `Order`. The SELECT clause of this query determines that it is the orders with quantities larger than John Smith’s that are returned.

```
SELECT DISTINCT o1
FROM Order o1, Order o2
WHERE o1.quantity > o2.quantity AND
      o2.customer.lastname = 'Smith' AND
      o2.customer.firstname= 'John'
```

If the query domain is a single entity abstract schema type, the range variable declaration is optional. These queries are equivalent:

```
SELECT quantity
FROM Order
WHERE customer.lastname = 'Smith'
      AND customer.firstname= 'John'

SELECT this.quantity
FROM Order
WHERE this.customer.lastname = 'Smith'
      AND this.customer.firstname= 'John'

SELECT ord.quantity
FROM Order AS ord
WHERE ord.customer.lastname = 'Smith'
      AND ord.customer.firstname= 'John'
```

Otherwise, if the query domain has more than one element, each named entity abstract schema type listed in the FROM clause must be a range variable declaration, and the implicit identification variable is not implicitly assigned an abstract schema type.

4.4.4. Path Expressions

A path expression is a sequence of identifiers uniquely identifying a state field or association field of an element of the query domain.

A path expression may begin with a reference to an identification variable, followed by the navigation operator (.). If the first element of a path expression is not an identification variable, then the path expression is interpreted exactly as if it began with the implicit identification variable `this`.

The remaining elements of the path expression are interpreted as references to state fields or association fields in the context of the abstract schema type assigned to the identification variable—or to `this`, if the path expression does not begin with an identification variable.

A reference to a state field or association field in a path expression is case-sensitive.

The type of the path expression is the type computed as the result of navigation; that is, the type of the state field or association field to which the expression navigates. The type of a path expression that navigates to an association field may be specified as a subtype of the declared type of the association field by means of the `TREAT` operator. See [Section 4.4.9](#).

An identification variable qualified by the `KEY`, `VALUE`, or `ENTRY` operator is a path expression. The `KEY`, `VALUE`, and `ENTRY` operators may only be applied to identification variables that correspond to map-valued associations or map-valued element collections. The type of the path expression is the type computed as the result of the operation; that is, the abstract schema type of the field that is the value of the `KEY`, `VALUE`, or `ENTRY` operator (the map key, map value, or map entry respectively).^[5]

In the following query, `photos` is a map from photo label to filename.

```
SELECT i.name, VALUE(p)
FROM Item i JOIN i.photos p
WHERE KEY(p) LIKE '%egret'
```

In the above query the identification variable `p` designates an abstract schema type corresponding to the map value. The results of `VALUE(p)` and `KEY(p)` are the map value and the map key associated with `p`, respectively. The following query is equivalent:

```
SELECT i.name, p
FROM Item i JOIN i.photos p
WHERE KEY(p) LIKE '%egret'
```

A path expression using the `KEY` or `VALUE` operator can be further composed. A path expression using the `ENTRY` operator is terminal. It cannot be further composed and can only appear in the `SELECT` list of a query.

The syntax for qualified identification variables is as follows.

```
qualified_identification_variable ::=
    map_field_identification_variable |
    ENTRY(identification_variable)

map_field_identification_variable ::=
    KEY(identification_variable) |
    VALUE(identification_variable)
```

Depending on navigability, a path expression that leads to an association field or to a field whose type is an embeddable class may be further composed. Path expressions can be composed from other path expressions if the original path expression evaluates to a single-valued type (not a collection).

In the following example, simple data model with `Employee`, `ContactInfo`, `Address` and `Phone` classes is used:

```
@Entity
public class Employee {
    @Id int id;
```

```

    @Embedded
    private ContactInfo contactInfo;
}

@Entity
public class Phone {
    @Id
    private int id;
    private String vendor;
}

@Embeddable
public class ContactInfo {
    @Embedded
    private Address address;
    @ManyToMany
    private List<Phone> phones;
}

@Embeddable
public class Address {
    private String street;
    private String city;
    private String state;
    private String zipcode;
}

```

The `contactInfo` field denotes an embeddable class consisting of an address and set of phones.

```

SELECT p.vendor
FROM Employee e JOIN e.contactInfo.phones p
WHERE e.contactInfo.address.zipcode = '95054'

```

Path expression navigability is composed using “inner join” semantics. That is, if the value of a non-terminal field in the path expression is null, the path is considered to have no value, and does not participate in the determination of the result.

The following query is equivalent to the query above:

```

SELECT p.vendor
FROM Employee e JOIN e.contactInfo c JOIN c.phones p
WHERE e.contactInfo.address.zipcode = '95054'

```

4.4.4.1. Path Expression Syntax

The syntax for single-valued path expressions and collection-valued path expressions is as follows.

An identification variable used in a `single_valued_object_path_expression` or in a `collection_valued_path_expression` may be an unqualified identification variable or an identification variable to which the `KEY` or `VALUE` function has been applied.

```

general_identification_variable ::=
    identification_variable |
    map_field_identification_variable

```

The type of an entity-valued path expression or an entity-valued subpath of a path expression used in a `WHERE` clause may be specified as a subtype of the corresponding declared type by means of the `TREAT` operator. See [Section 4.4.9](#).

```

general_subpath ::= simple_subpath | treated_subpath{.single_valued_object_field}*

simple_subpath ::=
    general_identification_variable |

```

```

    general_identification_variable{.single_valued_object_field}*
treated_subpath ::= TREAT(general_subpath AS subtype)

single_valued_path_expression ::=
    qualified_identification_variable |
    TREAT(qualified_identification_variable AS subtype) |
    state_field_path_expression |
    single_valued_object_path_expression

state_field_path_expression ::= [general_subpath.]state_field

state_valued_path_expression ::= state_field_path_expression | general_identification_variable

single_valued_object_path_expression ::= general_subpath.single_valued_object_field

collection_valued_path_expression ::= general_subpath.collection_valued_field

```

A `single_valued_object_field` is designated by the name of an association field in a one-to-one or many-to-one relationship or a field of embeddable class type. The type of a `single_valued_object_field` is the abstract schema type of the related entity or embeddable class.

A `single_valued_embeddable_object_field` is designated by the name of a field of embeddable class type.

A `state_field` is designated by the name of an entity or embeddable class state field that corresponds to a basic type.

A `collection_valued_field` is designated by the name of an association field in a one-to-many or a many-to-many relationship or by the name of an element collection field. The type of a `collection_valued_field` is a collection of values of the abstract schema type of the related entity or element type.

It is syntactically illegal to compose a path expression from a path expression that evaluates to a collection. For example, if `o` designates `Order`, the path expression `o.lineItems.product` is illegal since navigation to `lineItems` results in a collection. This case should produce an error when the query string is verified. To handle such a navigation, an identification variable must be declared in the `FROM` clause to range over the elements of the `lineItems` collection. Another path expression must be used to navigate over each such element in the `WHERE` clause of the query, as in the following:

```

SELECT DISTINCT l.product
FROM Order AS o JOIN o.lineItems l

```

A `collection_valued_path_expression` may only occur in:

- the `FROM` clause of a query,
- an `empty_collection_comparison_expression`,
- a `collection_member_expression`, or
- as an argument to the `SIZE` operator.

See [Section 4.6.8](#), [Section 4.6.9](#), and [Section 4.7.7.2](#).

4.4.5. Joins

JPQL defines the following varieties of join:

- inner joins, and
- left outer joins.^[6]

The semantics of each variety of join is identical to SQL, and the syntax is borrowed from ANSI SQL.

Every join has a target, either:

- an entity-valued path expression, or
- an entity type (that is, range variable declaration, as already specified in [Section 4.4.3](#)).

An inner join may be implicitly specified by the use of a cartesian product in the FROM clause and a join condition in the WHERE clause. In the absence of a join condition, this reduces to the cartesian product.

The main use case for this generalized style of join is when a join condition does not involve a foreign key relationship mapped to an association between entities.

Example:

```
SELECT c FROM Customer c, Employee e WHERE c.hatsize = e.shoesize
```

This style of inner join (sometimes called a "theta" join) is less typical than explicitly defined joins over relationships.

The syntax for explicit join operations is given by:

```
join ::= range_join | path_join
range_join ::= join_spec range_variable_declaration [join_condition]
path_join ::=
    join_spec join_association_path_expression [AS] identification_variable [join_condition]
fetch_join ::= join_spec FETCH join_association_path_expression
join_spec ::= [INNER | LEFT [OUTER]] JOIN
join_association_path_expression ::=
    join_collection_valued_path_expression |
    join_single_valued_path_expression |
    TREAT(join_collection_valued_path_expression `AS` subtype) |
    TREAT(join_single_valued_path_expression AS subtype)
join_collection_valued_path_expression ::=
    [identification_variable.]{single_valued_embeddable_object_field.}*collection_valued_field
join_single_valued_path_expression ::=
    [identification_variable.]{single_valued_embeddable_object_field.}*single_valued_object_field
join_condition ::= ON conditional_expression
```

The inner and outer join operation types described in [Section 4.4.5.1](#), [Section 4.4.5.2](#), and [Section 4.4.5.3](#) are supported.

4.4.5.1. Inner Joins

The syntax for an inner join to an entity type is given by:

```
[INNER] JOIN range_variable_declaration [join_condition]
```

The keyword INNER is optional and does not affect the semantics of the query.

```
SELECT c
FROM Customer c
    JOIN Order o ON o.customer.id = c.id
WHERE c.status = 1
```

Or, equivalently:

```

SELECT c
FROM Customer c
     INNER JOIN Order o ON o.customer.id = c.id
WHERE c.status = 1

```

These queries are equivalent to the following query involving an implicit "theta" join:

```

SELECT c
FROM Customer c, Order o
WHERE o.customer.id = c.id AND c.status = 1

```

The syntax for an inner join over an association is given by:

```

[INNER] JOIN join_association_path_expression [AS] identification_variable [join_condition]

```

For example, the query below joins over the relationship between customers and orders. This type of join typically equates to a join over a foreign key relationship in the database.

```

SELECT c
FROM Customer c
     JOIN c.orders o
WHERE c.status = 1

```

Equivalently:

```

SELECT c
FROM Customer c
     INNER JOIN c.orders o
WHERE c.status = 1

```

This is equivalent to the following query using the earlier IN construct, defined in [4]. It selects those customers of status 1 for which at least one order exists:

```

SELECT OBJECT(c)
FROM Customer c, IN(c.orders) o
WHERE c.status = 1

```

The query below joins over Employee, ContactInfo and Phone. ContactInfo is an embeddable class that consists of an address and set of phones. Phone is an entity.

```

SELECT p.vendor
FROM Employee e JOIN e.contactInfo c JOIN c.phones p
WHERE c.address.zipcode = '95054'

```

A join condition may be specified for an inner join. This is equivalent to specification of the same condition in the WHERE clause.

4.4.5.2. Outer Joins

The syntax for an outer join to an entity type is given by:

```

LEFT [OUTER] JOIN range_variable_declaration [join_condition]

```

The keyword OUTER is optional and does not affect the semantics of the query.

```

SELECT c

```

```

FROM Customer c
  LEFT JOIN Order o ON o.customer.id = c.id
WHERE c.status = 1

```

Or, equivalently:

```

SELECT c
FROM Customer c
  LEFT OUTER JOIN Order o ON o.customer.id = c.id
WHERE c.status = 1

```

Outer joins enable the retrieval of a set of entities where matching values in the join condition may be absent. For example, the queries above return `Customer` instances with no matching `Order`.

The syntax for an outer join over an association is given by:

```

LEFT [OUTER] JOIN join_association_path_expression [AS] identification_variable [join_condition]

```

An association outer join without no explicit `join_condition` has an implicit join condition inferred from the foreign key relationship mapped by the `join_association_path_expression`. Typically, a JPQL join of this form is translated to a SQL outer join with an `ON` condition specifying the foreign key relationship, as in the following examples.

Jakarta Persistence query language:

```

SELECT s.name, COUNT(p)
FROM Suppliers s LEFT JOIN s.products p
GROUP BY s.name

```

SQL:

```

SELECT s.name, COUNT(p.id)
FROM Suppliers s LEFT JOIN Products p
  ON s.id = p.supplierId
GROUP BY s.name

```

An explicit `join_condition` (that is, an `ON` condition in the `JOIN`) results in an additional restriction in the `ON` condition of the generated SQL.

Jakarta Persistence query language:

```

SELECT s.name, COUNT(p)
FROM Suppliers s LEFT JOIN s.products p
  ON p.status = 'inStock'
GROUP BY s.name

```

SQL:

```

SELECT s.name, COUNT(p.id)
FROM Suppliers s LEFT JOIN Products p
  ON s.id = p.supplierId AND p.status = 'inStock'
GROUP BY s.name

```

Note that the result of this query will be different from that of the following query:

```

SELECT s.name, COUNT(p)
FROM Suppliers s LEFT JOIN s.products p
WHERE p.status = 'inStock'
GROUP BY s.name

```


The result of the latter query will exclude suppliers who have no products in stock whereas the former query will include them.

An important use case for `LEFT JOIN` is in enabling the prefetching of related data items as a side effect of a query. This is accomplished by specifying the `LEFT JOIN` as a fetch join, that is, `LEFT JOIN FETCH`, as described below.

4.4.5.3. Fetch Joins

A *fetch join* clause in a query results in eager fetching of an association or element collection as a side effect of execution of the query.

The syntax for a fetch join is given by:

```
fetch_join ::= [LEFT [OUTER] | INNER] JOIN FETCH join_association_path_expression
```

A fetch join must be an `INNER` or `LEFT (OUTER)` join. A fetch join does not have an explicit join condition or identification variable.

The association referenced by the right side of the fetch join clause must be an association or element collection that is referenced from an entity or embeddable that is returned as a result of the query. It is not permitted to specify an identification variable for the objects referenced by the right side of the fetch join clause, and hence references to the implicitly fetched entities or elements cannot appear elsewhere in the query.

The following query returns a set of departments. As a side effect, the associated employees for those departments are also retrieved, even though they are not part of the explicit query result. The initialization of the persistent state or relationship fields or properties of the objects that are retrieved as a result of a fetch join is determined by the metadata for that class—in this example, the `Employee` entity class.

```
SELECT d
FROM Department d LEFT JOIN FETCH d.employees
WHERE d.deptno = 1
```

A fetch join has the same join semantics as the corresponding inner or outer join, except that the related objects specified on the right-hand side of the join operation are not returned in the query result or otherwise referenced in the query. Hence, for example, if department 1 has five employees, the above query returns five references to the department 1 entity.

The fetch join construct must not be used in the `FROM` clause of a subquery.

4.4.6. Collection Member Declarations

An identification variable declared by a `collection_member_declaration` ranges over values of a collection obtained by navigation using a path expression.

An identification variable of a collection member declaration is declared using a special operator, the reserved identifier `IN`. The argument to the `IN` operator is a collection-valued path expression. The path expression evaluates to a collection type specified as a result of navigation to a collection-valued association field of an entity or embeddable class abstract schema type.

The syntax for declaring a collection member identification variable is as follows:

```
collection_member_declaration ::=
    IN (collection_valued_path_expression) [AS] identification_variable
```

For example, the query

```
SELECT DISTINCT o
FROM Order o JOIN o.lineItems l
WHERE l.product.productType = 'office_supplies'
```

can equivalently be expressed as follows, using the IN operator:

```
SELECT DISTINCT o
FROM Order o, IN(o.lineItems) l
WHERE l.product.productType = 'office_supplies'
```

In this example, `lineItems` is the name of an association field whose value is a collection of instances of the abstract schema type `LineItem`. The identification variable `l` designates a member of this collection, a single `LineItem` abstract schema type instance. In this example, `o` is an identification variable of the abstract schema type `Order`.

4.4.7. FROM Clause and SQL

The Jakarta Persistence query language treats the `FROM` clause similarly to SQL in that the declared identification variables affect the results of the query even if they are not used in the `WHERE` clause. Application developers should use caution in defining identification variables because the domain of the query can depend on whether there are any values of the declared type.

For example, the `FROM` clause below defines a query over all orders that have line items and existing products. If there are no `Product` instances in the database, the domain of the query is empty and no order is selected.

```
SELECT o
FROM Order AS o JOIN o.lineItems l JOIN l.product p
```

4.4.8. Polymorphism

Jakarta Persistence queries are automatically polymorphic. The `FROM` clause of a query designates not only instances of the specific entity class(es) to which it explicitly refers but instances of subclasses of those classes as well. The instances returned by a query thus include instances of the subclasses that satisfy the query criteria.

Non-polymorphic queries or queries whose polymorphism is restricted can be specified using entity type expressions in the `WHERE` clause to restrict the domain of the query. See [Section 4.7.12](#).

4.4.9. Downcasting

The use of the `TREAT` operator is supported for downcasting within path expressions in the `FROM` and `WHERE` clauses. Use of the `TREAT` operator allows access to subclass-specific state.

If during query execution the first argument to the `TREAT` operator is not a subtype (proper or improper) of the target type, the path is considered to have no value, and does not participate in the determination of the result. That is, in the case of a join, the referenced object does not participate in the result, and in the case of a restriction, the associated predicate is false. Use of the `TREAT` operator therefore also has the effect of filtering on the specified type (and its subtypes) as well as performing the downcast. If the target type is not a subtype (proper or improper) of the static type of the first argument, the query is invalid.

Examples:

```
SELECT b.name, b.ISBN
FROM Order o JOIN TREAT(o.product AS Book) b

SELECT e FROM Employee e JOIN TREAT(e.projects AS LargeProject) lp
WHERE lp.budget > 1000
```

```

SELECT e FROM Employee e JOIN e.projects p
WHERE TREAT(p AS LargeProject).budget > 1000
      OR TREAT(p AS SmallProject).name LIKE 'Persist%'
      OR p.description LIKE "cost overrun"

SELECT e FROM Employee e
WHERE TREAT(e AS Exempt).vacationDays > 10
      OR TREAT(e AS Contractor).hours > 100

```

4.5. WHERE Clause

The WHERE clause of a query consists of a conditional expression used to select objects or values that satisfy the expression. The WHERE clause restricts the result of a select statement or the scope of an update or delete operation.

A WHERE clause is defined as follows:

```
where_clause ::= WHERE conditional_expression
```

The GROUP BY construct enables the aggregation of values according to the properties of an entity class. The HAVING construct enables conditions to be specified that further restrict the query result as restrictions upon the groups.

The syntax of the HAVING clause is as follows:

```
having_clause ::= HAVING conditional_expression
```

The GROUP BY and HAVING constructs are further discussed in [Section 4.8](#).

4.6. Conditional Expressions

The following sections describe language constructs that can be used in a conditional expression of the WHERE clause, the HAVING clause, or in an ON condition.

State fields that are mapped in serialized form or as lobbs cannot be portably used in conditional ^[7].

4.6.1. Conditional Expression Composition

Conditional expressions are composed of other conditional expressions, comparison operations, logical operations, path expressions that evaluate to boolean values, boolean literals, and boolean input parameters.

The scalar expressions described in [Section 4.7](#) can be used in conditional expressions.

Aggregate functions can only be used in conditional expressions in a HAVING clause. See [Section 4.8](#).

Standard bracketing () for ordering expression evaluation is supported.

Conditional expressions are defined as follows:

```

conditional_expression ::= conditional_term | conditional_expression OR conditional_term
conditional_term ::= conditional_factor | conditional_term AND conditional_factor
conditional_factor ::= [NOT] conditional_primary
conditional_primary ::= simple_cond_expression | (conditional_expression)
simple_cond_expression ::=
    comparison_expression |
    between_expression |
    in_expression |
    like_expression |
    null_comparison_expression |

```

```
empty_collection_comparison_expression |
collection_member_expression |
exists_expression
```

4.6.2. Operators and Operator Precedence

The operators are listed below in order of decreasing precedence.

- Navigation operator (.)
- Arithmetic operators:
 - +, - unary
 - *, / multiplication and division
 - +, - addition and subtraction
- String concatenation (||)
- Comparison operators: =, >, >=, <, <=, <> (not equal), [NOT] BETWEEN, [NOT] LIKE, [NOT] IN, IS [NOT] NULL, IS [NOT] EMPTY, [NOT] MEMBER [OF], [NOT] EXISTS
- Logical operators:
 - NOT
 - AND
 - OR

The following sections describe operators used in specific expressions.

4.6.3. Comparison Expressions

The syntax for the use of comparison expressions in a conditional expression is as follows^[8]:

```
comparison_expression ::=
  string_expression comparison_operator {string_expression | all_or_any_expression} |
  boolean_expression {= | <>} {boolean_expression | all_or_any_expression} |
  enum_expression {= | <>} {enum_expression | all_or_any_expression} |
  datetime_expression comparison_operator
    {datetime_expression | all_or_any_expression} |
  entity_expression {= | <>} {entity_expression | all_or_any_expression} |
  arithmetic_expression comparison_operator
    {arithmetic_expression | all_or_any_expression} |
  entity_id_or_version_function {= | <>} input_parameter |
  entity_type_expression {= | <>} entity_type_expression

comparison_operator ::= = | > | >= | < | <= | <>
```

Examples:

```
item.cost * 1.08 <= 100.00
CONCAT(person.lastName, ' ', person.firstName) = 'Jones, Sam'
TYPE(e) = ExemptEmployee
```

4.6.4. Between Expressions

The syntax for the use of the comparison operator [NOT] BETWEEN in a conditional expression is as follows:

```
between_expression ::=
  arithmetic_expression [NOT] BETWEEN arithmetic_expression AND arithmetic_expression |
  string_expression [NOT] BETWEEN string_expression AND string_expression |
  datetime_expression [NOT] BETWEEN datetime_expression AND datetime_expression
```

The BETWEEN expression

```
x BETWEEN y AND z
```

is semantically equivalent to:

```
y <= x AND x <= z
```

The rules for unknown and NULL values in comparison operations apply. See [Section 4.6.13](#).

Examples:

- p.age BETWEEN 15 and 19 is equivalent to p.age >= 15 AND p.age <= 19
- p.age NOT BETWEEN 15 and 19 is equivalent to p.age < 15 OR p.age > 19

In the following example, transactionHistory is a list of credit card transactions defined using an order column.

```
SELECT t
FROM CreditCard c JOIN c.transactionHistory t
WHERE c.holder.name = 'John Doe' AND INDEX(t) BETWEEN 0 AND 9
```

4.6.5. In Expressions

The syntax for the use of the comparison operator [NOT] IN in a conditional expression is as follows:

```
in_expression ::=
  {state_valued_path_expression | type_discriminator} [NOT] IN
  {(in_item {, in_item}*) | (subquery) | collection_valued_input_parameter}
in_item ::= literal | single_valued_input_parameter
```

The state_valued_path_expression must have a string, numeric, date, time, timestamp, or enum value.

The literal and/or input parameter values must be *like* the abstract schema type of the state_valued_path_expression in type. (See [Section 4.6.14](#).)

The results of the subquery must be *like* the abstract schema type of the state_valued_path_expression in type. Subqueries are discussed in [Section 4.6.12](#).

Example 1:

```
o.country IN ('UK', 'US', 'France')
```

is true for UK and false for Peru, and is equivalent to the expression

```
(o.country = 'UK') OR (o.country = 'US') OR (o.country = 'France')
```

Example 2:

```
o.country NOT IN ('UK', 'US', 'France')
```

is false for UK and true for Peru, and is equivalent to the expression

```
NOT ((o.country = 'UK') OR (o.country = 'US') OR (o.country = 'France'))
```

If an IN or NOT IN expression has a list of in_item expressions, there must be at least one item in the list. The value of such expressions is determined according to the following rules:

- If the `state_valued_path_expression` in an `IN` or `NOT IN` expression evaluates to `NULL` or `unknown`, then the whole `IN` or `NOT IN` expression evaluates to `NULL` or `unknown`.
- Otherwise, if the `state_valued_path_expression` and at least one `in_item` evaluate to the same value, the whole `IN` or `NOT IN` expression evaluates to `true`.
- Otherwise, if the value of a `state_valued_path_expression` evaluates to a value distinct from the value of every `in_item` expression, the whole `IN` or `NOT IN` expression evaluates to:
 - `false`, if every `in_item` expression evaluates to a non-null value, or
 - `NULL` or `unknown` if at least one `in_item` expression evaluates to `null`.

The list of values may be parameterized by a collection-valued input parameter. ^[9] (See [Section 4.7.4](#).)

```
o.country NOT IN :countries
```

4.6.6. Like Expressions

The syntax for the use of the comparison operator `[NOT] LIKE` in a conditional expression is as follows:

```
like_expression ::=
  string_expression [NOT] LIKE pattern_value [ESCAPE escape_character]
```

The `string_expression` must have a string value. The `pattern_value` is a string literal or a string-valued input parameter in which an underscore (`_`) stands for any single character, a percent (`%`) character stands for any sequence of characters (including the empty sequence), and all other characters stand for themselves. The optional `escape_character` is a single-character string literal or a character-valued input parameter (i.e., `char` or `Character`) and is used to escape the special meaning of the underscore and percent characters in `pattern_value`. ^[10]

Examples:

- `address.phone LIKE '123'` is true for `'123'`, `'12993'` and false for `'1234'`
- `asentence.word LIKE 'l_se'` is true for `'lose'` and false for `'loose'`
- `aword.underscored LIKE '_%' ESCAPE '\'` is true for `'_foo'` and false for `'bar'`
- `address.phone NOT LIKE '123'` is false for `'123'` and `'12993'` and true for `'1234'`

If the value of the `string_expression` or `pattern_value` is `NULL` or `unknown`, the value of the `LIKE` expression is `unknown`. If the `escape_character` is specified and is `NULL`, the value of the `LIKE` expression is `unknown`.

4.6.7. Null Comparison Expressions

The syntax for the use of the comparison operator `IS NULL` in a conditional expression is as follows:

```
null_comparison_expression ::=
  {single_valued_path_expression | input_parameter} IS [NOT] NULL
```

A null comparison expression tests whether or not the single-valued path expression or input parameter is a `NULL` value.

Null comparisons over instances of embeddable class types are not supported. Support for comparisons over embeddables may be added in a future release of this specification.

4.6.8. Empty Collection Comparison Expressions

The syntax for the use of the comparison operator `IS EMPTY` in an `empty_collection_comparison_expression` is as follows:

```
empty_collection_comparison_expression ::=
```

```
collection_valued_path_expression IS [NOT] EMPTY
```

This expression tests whether or not the collection designated by the collection-valued path expression is empty (i.e., has no elements).

Example:

```
SELECT o
FROM Order o
WHERE o.lineItems IS EMPTY
```

If the value of the collection-valued path expression in an empty collection comparison expression is unknown, the value of the empty comparison expression is unknown.

4.6.9. Collection Member Expressions

The syntax for the use of the comparison operator `MEMBER OF` ^[11] in a `collection_member_expression` is as follows:

```
collection_member_expression ::=
    entity_or_value_expression [NOT] MEMBER [OF] collection_valued_path_expression
entity_or_value_expression ::=
    single_valued_object_path_expression |
    state_valued_path_expression |
    simple_entity_or_value_expression
simple_entity_or_value_expression ::=
    identification_variable |
    input_parameter |
    literal
```

This expression tests whether the designated value is a member of the collection specified by the collection-valued path expression.

Expressions that evaluate to embeddable types are not supported in collection member expressions. Support for use of embeddables in collection member expressions may be added in a future release of this specification.

If the collection valued path expression designates an empty collection, the value of the `MEMBER OF` expression is `FALSE` and the value of the `NOT MEMBER OF` expression is `TRUE`. Otherwise, if the value of the `collection_valued_path_expression` or `entity_or_value_expression` in the collection member expression is `NULL` or unknown, the value of the collection member expression is unknown.

Example:

```
SELECT p
FROM Person p
WHERE 'Joe' MEMBER OF p.nicknames
```

4.6.10. Exists Expressions

An `EXISTS` expression is a predicate that is true only if the result of the subquery consists of one or more values and that is false otherwise.

The syntax of an exists expression is

```
exists_expression ::= [NOT] EXISTS (subquery)
```

Example:

```

SELECT DISTINCT emp
FROM Employee emp
WHERE EXISTS (
    SELECT spouseEmp
    FROM Employee spouseEmp
    WHERE spouseEmp = emp.spouse)

```

The result of this query consists of all employees whose spouses are also employees.

4.6.11. All or Any Expressions

An ALL conditional expression is a predicate over a subquery that is true if the comparison operation is true for all values in the result of the subquery or the result of the subquery is empty. An ALL conditional expression is false if the result of the comparison is false for at least one value of the result of the subquery, and is unknown if neither true nor false.

An ANY conditional expression is a predicate over a subquery that is true if the comparison operation is true for some value in the result of the subquery. An ANY conditional expression is false if the result of the subquery is empty or if the comparison operation is false for every value in the result of the subquery, and is unknown if neither true nor false. The keyword SOME is synonymous with ANY.

The comparison operators used with ALL or ANY conditional expressions are =, <, <=, >, >=, <>. The result of the subquery must be like that of the other argument to the comparison operator in type. See [Section 4.6.14](#).

The syntax of an ALL or ANY expression is specified as follows:

```
all_or_any_expression ::= {ALL | ANY | SOME} (subquery)
```

Example:

```

SELECT emp
FROM Employee emp
WHERE emp.salary > ALL (
    SELECT m.salary
    FROM Manager m
    WHERE m.department = emp.department)

```

The result of this query consists of all employees whose salaries exceed the salaries of all managers in their department.

4.6.12. Subqueries

Subqueries may be used in the WHERE or HAVING clause.^[12]

The syntax for subqueries is as follows:

```

subquery ::= simple_select_clause subquery_from_clause [where_clause]
           [groupby_clause] [having_clause]
simple_select_clause ::= SELECT [DISTINCT] simple_select_expression
subquery_from_clause ::=
    FROM subselect_identification_variable_declaration
         {, subselect_identification_variable_declaration |
          collection_member_declaration}*
subselect_identification_variable_declaration ::=
    identification_variable_declaration |
    derived_path_expression [AS] identification_variable {join}* |
    derived_collection_member_declaration
simple_select_expression ::=

```



```

single_valued_path_expression |
scalar_expression |
aggregate_expression |
identification_variable
derived_path_expression ::=
  general_derived_path.single_valued_object_field |
  general_derived_path.collection_valued_field
general_derived_path ::=
  simple_derived_path |
  treated_derived_path{.single_valued_object_field}*
simple_derived_path ::= superquery_identification_variable{.single_valued_object_field}*
treated_derived_path ::= TREAT(general_derived_path AS subtype)
derived_collection_member_declaration ::=
  IN superquery_identification_variable.{single_valued_object_field.*}collection_valued_field

```

Examples:

```

SELECT DISTINCT emp
FROM Employee emp
WHERE EXISTS (
  SELECT spouseEmp
  FROM Employee spouseEmp
  WHERE spouseEmp = emp.spouse)

```

Note that some contexts in which a subquery can be used require that the subquery be a scalar subquery (i.e., produce a single result). This is illustrated in the following examples using numeric comparisons.

```

SELECT c
FROM Customer c
WHERE (SELECT AVG(o.price) FROM c.orders o) > 100

SELECT goodCustomer
FROM Customer goodCustomer
WHERE goodCustomer.balanceOwed < (
  SELECT AVG(c.balanceOwed)/2.0 FROM Customer c)

```

4.6.13. Null Values

When the target of a reference does not exist in the database, its value is regarded as NULL. SQL NULL semantics [2] defines the evaluation of conditional expressions containing NULL values.

The following is a brief description of these semantics:

- Comparison or arithmetic operations with a NULL value always yield an unknown value.
- Two NULL values are not considered to be equal, the comparison yields an unknown value.
- Comparison or arithmetic operations with an unknown value always yield an unknown value.
- The IS NULL and IS NOT NULL operators convert a NULL state field or single-valued object field value into the respective TRUE or FALSE value.
- Boolean operators use three valued logic, defined by Table 1, Table 2, and Table 3.

Table 1. Definition of the AND Operator

| AND | T | F | U |
|-----|---|---|---|
| T | T | F | U |
| F | F | F | F |

| AND | T | F | U |
|-----|---|---|---|
| U | U | F | U |

Table 2. Definition of the OR Operator

| OR | T | F | U |
|----|---|---|---|
| T | T | T | T |
| F | T | F | U |
| U | T | U | U |

Table 3. Definition of the NOT Operator

| NOT | T | F | U |
|-----|---|---|---|
| T | F | | |
| F | T | | |
| U | U | | |



The Jakarta Persistence query language defines the empty string, '', as a string with length zero, which is not equal to a NULL value. However, NULL values and empty strings may not always be distinguished when queries are mapped to some databases. Application developers should therefore not rely on the semantics of query comparisons involving the empty string and NULL value.

4.6.14. Equality and Comparison Semantics

Only the values of *like* types are permitted to be compared. A type is *like* another type if they correspond to the same Java language type, or if one is a primitive Java language type and the other is the wrapped Java class type equivalent (e.g., `int` and `Integer` are like types in this sense). There is one exception to this rule: it is valid to compare numeric values for which the rules of numeric promotion apply. Conditional expressions attempting to compare non-like type values are disallowed except for this numeric case.



Note that the arithmetic operators, the string concatenation operator, and comparison operators are permitted to be applied to state fields and input parameters of the wrapped Java class equivalents to the primitive numeric Java types.

Two entities of the same abstract schema type are equal if and only if they have the same primary key value.

Only equality/inequality comparisons over enums are required to be supported.

Comparisons over instances of embeddable class or map entry types are not supported.

The following examples illustrate the syntax and semantics of the Jakarta Persistence query language. These examples are based on the example presented in [Section 4.3.2](#).

Find all orders:

```
SELECT o
```

```
FROM Order o
```

Find all orders that need to be shipped to California:

```
SELECT o
FROM Order o
WHERE o.shippingAddress.state = 'CA'
```

Find all states for which there are orders:

```
SELECT DISTINCT o.shippingAddress.state
FROM Order o
```

Find all orders that have line items:

```
SELECT DISTINCT o
FROM Order o JOIN o.lineItems l
```

Note that the result of this query does not include orders with no associated line items. This query can also be written as:

```
SELECT o
FROM Order o
WHERE o.lineItems IS NOT EMPTY
```

Find all orders that have no line items:

```
SELECT o
FROM Order o
WHERE o.lineItems IS EMPTY
```

Find all pending orders:

```
SELECT DISTINCT o
FROM Order o JOIN o.lineItems l
WHERE l.shipped = FALSE
```

Find all orders in which the shipping address differs from the billing address. This example assumes that the application developer uses two distinct entity types to designate shipping and billing addresses.

```
SELECT o
FROM Order o
WHERE
  NOT (o.shippingAddress.state = o.billingAddress.state AND
       o.shippingAddress.city = o.billingAddress.city AND
       o.shippingAddress.street = o.billingAddress.street)
```

If the application developer uses a single entity type in two different relationships for both the shipping address and the billing address, the above expression can be simplified based on the equality rules defined in [Section 4.6.14](#). The query can then be written as:

```
SELECT o
FROM Order o
WHERE o.shippingAddress <> o.billingAddress
```

The query checks whether the same entity abstract schema type instance (identified by its primary key) is related to an order through two distinct relationships.

4.6.14.1. Queries Using Input Parameters

The following query finds the orders for a product whose name is designated by an input parameter:

```
SELECT DISTINCT o
FROM Order o JOIN o.lineItems l
WHERE l.product.name = ?1
```

For this query, the input parameter must be of the type of the state field name, i.e., a string.

4.7. Scalar Expressions

Numeric, string, datetime, case, and entity type expressions result in scalar values.

Scalar expressions may be used in the SELECT clause of a query as well as in the WHERE ^[13] and HAVING clauses.

```
scalar_expression ::=
    arithmetic_expression |
    string_expression |
    enum_expression |
    datetime_expression |
    boolean_expression |
    case_expression |
    entity_type_expression |
    entity_id_or_version_function
```

4.7.1. Literals

A string literal is enclosed in single quotes—for example: 'literal'. A string literal that includes a single quote is represented by two single quotes—for example: 'literal's'. String literals in queries, like Java String literals, use unicode character encoding. The use of Java escape notation is not supported in query string literals.

A numeric literal may be either:

- a decimal Java integer (int or long) literal
- a Java floating point (float or double) literal, or
- a literal BigInteger or BigDecimal.

A suffix L, D, or F may be used to indicate the specific numeric type, in accordance with the Java Language Specification. The suffix is not case-sensitive. The literal numeric value preceding the suffix must conform to the rules for Java numeric literals established by the Java Language Specification.

A suffix BI or BD may be used to indicate a literal BigInteger or BigDecimal, respectively. The literal numeric value preceding the suffix must be an exact or approximate SQL numeric literal. For a BigInteger literal, the numeric value must be an exact integer literal.

Just as in Java, when a numeric literal has no suffix:

- an integer literal is interpreted as a Java int, and
- a floating point literal is interpreted as a Java double.

Support for hexadecimal and octal numeric literals is not required by this specification.

Enum literals support the use of Java enum literal syntax. The fully qualified enum class name must be specified.

The JDBC escape syntax may be used for the specification of date, time, and timestamp literals. For example:

```
SELECT o
FROM Customer c JOIN c.orders o
WHERE c.name = 'Smith'
AND o.submissionDate < {d '2008-12-31'}
```

The portability of this syntax for date, time, and timestamp literals is dependent upon the JDBC driver in use. Persistence providers are not required to translate from this syntax into the native syntax of the database or driver.

The boolean literals are TRUE and FALSE.

Entity type literals are specified by entity names—for example: Customer.

Although reserved literals appear in upper case, they are case-insensitive.

4.7.2. Identification Variables

All identification variables used in the WHERE or HAVING clause of a SELECT or DELETE statement must be declared in the FROM clause, as described in [Section 4.4.2](#). The identification variables used in the WHERE clause of an UPDATE statement must be declared in the UPDATE clause.

Identification variables are existentially quantified in the WHERE and HAVING clause. This means that an identification variable represents a member of a collection or an instance of an entity's abstract schema type. An identification variable never designates a collection in its entirety.

4.7.3. Path Expressions

It is illegal to use a `collection_valued_path_expression` within a WHERE or HAVING clause as part of a conditional expression except in an `empty_collection_comparison_expression`, in a `collection_member_expression`, or as an argument to the SIZE operator.

4.7.4. Input Parameters

An input parameter allows a value in the Java program to be safely interpolated into the text of the parameterized query.

In a given query, either positional or named parameters may be used. Positional and named parameters must not be mixed in a single query.

The persistence provider is required to support input parameters which occur in the WHERE clause or HAVING clause of a query, or as the new value for an update item in the SET clause of an update statement.



Note that if an input parameter value is null, comparison operations or arithmetic operations involving the input parameter will result in an unknown value. See [Section 4.6.13](#).

An input parameter might be *single-valued* or *collection-valued*. An input parameter which occurs directly to the right of the IN keyword in an IN predicate, as defined in [Section 4.6.5](#), is collection-valued. Every other input parameter is single-valued.

The API for the binding concrete arguments to query parameters is described in [Section 3.11](#).

4.7.4.1. Positional Parameters

The following rules apply to positional input parameters.

- A positional parameter is designated by an integer, and prefixed with a ? symbol (question mark) in the text of the query string. For example: ?1.
- Input parameters are numbered starting from 1.
- A given positional parameter may occur more than once in the query string.
- The ordering of the use of parameters within the text of the query string need not match the numbering of the positional parameters.

4.7.4.2. Named Parameters

A named parameter is denoted by an identifier, and prefixed by the : symbol (colon) in the text of the query string. The identifier name must follow the usual rules for identifiers specified in [Section 4.4.1](#). Named parameters are case-sensitive.

Example:

```
SELECT c
FROM Customer c
WHERE c.status = :stat
```

A given named parameter may occur more than once in the query string.

4.7.5. Arithmetic Expressions

The arithmetic operators are:

- +, - unary
- *, / multiplication and division
- +, - addition and subtraction

Arithmetic operations use numeric promotion.

Arithmetic functions are described in [Section 4.7.7.2](#).

4.7.6. String concatenation operator

The binary concatenation operator is ||. Its operands must be string expressions.

4.7.7. Built-in String, Arithmetic, and Datetime Functional Expressions

The Jakarta Persistence query language includes the built-in functions described in [Section 4.7.7.1](#), [Section 4.7.7.2](#), [Section 4.7.7.3](#), which may be used in the SELECT, WHERE or HAVING clause of a query. The invocation of predefined database functions and user-defined database functions is described in [Section 4.7.9](#).

If the value of any argument to a functional expression is null or unknown, the value of the functional expression is unknown.

4.7.7.1. String Functions

```
functions_returning_strings ::=
    CONCAT(string_expression, string_expression {, string_expression}*) |
    SUBSTRING(string_expression,
        arithmetic_expression [, arithmetic_expression]) |
    TRIM([[trim_specification] [trim_character] FROM] string_expression) |
    LOWER(string_expression) |
```

```

UPPER(string_expression) |
REPLACE(string_expression, string_expression, string_expression) |
LEFT(string_expression, arithmetic_expression) |
RIGHT(string_expression, arithmetic_expression)
trim_specification ::= LEADING | TRAILING | BOTH

functions_returning_numerics ::=
LENGTH(string_expression) |
LOCATE(string_expression, string_expression[, arithmetic_expression])

```

The CONCAT function returns a string that is a concatenation of its arguments.

The second and third arguments of the SUBSTRING function denote the starting position and length of the substring to be returned. These arguments are integers. The third argument is optional. If it is not specified, the substring from the start position to the end of the string is returned. The first position of a string is denoted by 1. The SUBSTRING function returns a string.

The TRIM function trims the specified character from a string. If the character to be trimmed is not specified, it will be assumed to be space (or blank). The optional trim_character is a single-character string literal or a character-valued input parameter (i.e., char or Character)^[14]. If a trim specification is not provided, it defaults to BOTH. The TRIM function returns the trimmed string.

The LOWER and UPPER functions convert a string to lower and upper case, respectively, with regard to the locale of the database. They return a string.

The LEFT and RIGHT functions return the leftmost or rightmost substring, respectively, of the first argument whose length is given by the second argument.

The REPLACE function replaces all occurrences within the first argument string of the second argument string with the third argument string.

The LOCATE function returns the position at which one string occurs within a second string, optionally ignoring any occurrences that begin before a specified character position in the second string. It returns the first character position within the second string (after the specified character position, if any) at which the first string occurs, as an integer, where the first character of the second string is denoted by 1. That is, the first argument is the string to be searched for; the second argument is the string to be searched in; the optional third argument is an integer representing the character position at which the search starts (by default, 1, the first character of the second string). If the first string does not occur within the second string, 0 is returned.^[15]

The LENGTH function returns the length of the string in characters as an integer.

4.7.7.2. Arithmetic Functions

```

functions_returning_numerics ::=
ABS(arithmetic_expression) |
CEILING(arithmetic_expression) |
EXP(arithmetic_expression) |
FLOOR(arithmetic_expression) |
LN(arithmetic_expression) |
MOD(arithmetic_expression, arithmetic_expression) |
POWER(arithmetic_expression, arithmetic_expression) |
ROUND(arithmetic_expression, arithmetic_expression) |
SIGN(arithmetic_expression) |
SQRT(arithmetic_expression) |
SIZE(collection_valued_path_expression) |
INDEX(identification_variable) |
extract_datetime_field

```

The ABS, CEILING, and FLOOR functions accept a numeric argument and return a number (integer, float, or double) of the same type as the argument.

The SIGN function accepts a numeric argument and returns an integer.

The SQRT, EXP, and LN functions accept a numeric argument and return a double.

The MOD function accepts two integer arguments and returns an integer.

The ROUND function accepts a numeric argument and an integer argument and returns a number of the same type as the first argument.

The POWER function accepts two numeric arguments and returns a double.

Numeric arguments to these functions may correspond to the numeric Java object types as well as the primitive numeric types.

The SIZE function returns an integer value, the number of elements of the collection. If the collection is empty, the SIZE function evaluates to zero.

The INDEX function returns an integer value corresponding to the position of its argument in an ordered list. The INDEX function can only be applied to identification variables denoting types for which an order column has been specified.

In the following example, `studentWaitlist` is a list of students for which an order column has been specified:

```
SELECT w.name
FROM Course c JOIN c.studentWaitlist w
WHERE c.name = 'Calculus'
AND INDEX(w) = 0
```

4.7.7.3. Datetime Functions

```
functions_returning_datetime :=
    CURRENT_DATE |
    CURRENT_TIME |
    CURRENT_TIMESTAMP |
    LOCAL_DATE |
    LOCAL_TIME |
    LOCAL_DATETIME |
    extract_datetime_part
```

The functions LOCAL DATE, LOCAL TIME, and LOCAL DATETIME return the value of the current date, time, or timestamp on the database server, respectively. Their types are `java.time.LocalDate`, `java.time.LocalTime`, and `java.time.LocalDateTime` respectively.

The functions CURRENT_DATE, CURRENT_TIME, and CURRENT_TIMESTAMP return the value of the current date, time, or timestamp on the database server, respectively. Their types are `java.sql.Date`, `java.sql.Time`, and `java.sql.Timestamp` respectively.

The EXTRACT function takes a datetime argument and one of the following field type identifiers: YEAR, QUARTER, MONTH, WEEK, DAY, HOUR, MINUTE, SECOND, DATE, TIME.

EXTRACT returns the value of the corresponding field or part of the datetime.

```
extract_datetime_field :=
    EXTRACT(datetime_field FROM datetime_expression)

datetime_field := identification_variable
```

For the following field type identifiers, EXTRACT returns an integer value:

- YEAR means the calendar year.
- QUARTER means the calendar quarter, numbered from 1 to 4.
- MONTH means the calendar month of the year, numbered from 1.
- WEEK means the ISO-8601 week number.
- DAY means the calendar day of the month, numbered from 1.
- HOUR means the hour of the day in 24-hour time, numbered from 0 to 23.
- MINUTE means the minute of the hour, numbered from 0 to 59.

For the SECOND field type identifier, EXTRACT returns a floating point value:

- SECOND means the second of the minute, numbered from 0 to 59, including a fractional part representing fractions of a second.

It is illegal to pass a datetime argument which does not have the given field type to EXTRACT.

```
extract_datetime_part :=
    EXTRACT(datetime_part FROM datetime_expression)

datetime_part := identification_variable
```

For the following field type identifiers, EXTRACT returns a part of the datetime value:

- DATE means the date part of a datetime.
- TIME means the time part of a datetime.

It is illegal to pass a datetime argument which does not have the given part to EXTRACT.

```
FROM Course c WHERE c.year = EXTRACT(YEAR FROM LOCAL DATE)
```

4.7.8. Typecasts

The CAST function converts an expression of one type to an expression of a different type.

```
string_cast_function ::=
    CAST(scalar_expression AS STRING)
arithmetic_cast_function ::=
    CAST(string_expression AS {INTEGER | LONG | FLOAT | DOUBLE})
```

The persistence provider is required to accept typecasts of the following forms:

- any scalar expression to STRING
- any string expression to INTEGER, LONG, FLOAT, or DOUBLE

Typecast expressions are evaluated by the database, with semantics that vary somewhat between different databases.

When a typecast occurs as a select expression, the result type of the select expression is:

- java.lang.String for a cast to STRING
- java.lang.Integer, java.lang.Long, java.lang.Float, or java.lang.Double for a cast to INTEGER, LONG, FLOAT, or DOUBLE, respectively

4.7.9. Invocation of Predefined and User-defined Database Functions

The invocation of functions other than the built-in functions of the Jakarta Persistence query language is supported by means of the function_invocation syntax. This includes the invocation of predefined database functions and user-

defined database functions.

```
function_invocation ::= FUNCTION(function_name {, function_arg}*)

function_arg ::=
    literal |
    state_valued_path_expression |
    input_parameter |
    scalar_expression
```

The `function_name` argument is a string that denotes the database function that is to be invoked. The arguments must be suitable for the database function that is to be invoked. The result of the function must be suitable for the invocation context.

The function may be a database-defined function or a user-defined function. The function may be a scalar function or an aggregate function.

Applications that use the `function_invocation` syntax will not be portable across databases.

Example:

```
SELECT c
FROM Customer c
WHERE FUNCTION('hasGoodCredit', c.balance, c.creditLimit)
```

4.7.10. Case Expressions

The following forms of case expressions are supported: general case expressions, simple case expressions, coalesce expressions, and nullif expressions.^[16]

```
case_expression ::=
    general_case_expression |
    simple_case_expression |
    coalesce_expression |
    nullif_expression

general_case_expression ::=
    CASE when_clause {when_clause}* ELSE scalar_expression END
when_clause ::= WHEN conditional_expression THEN scalar_expression

simple_case_expression ::=
    CASE case_operand simple_when_clause {simple_when_clause}*
    ELSE scalar_expression
    END
case_operand ::= state_valued_path_expression | type_discriminator
simple_when_clause ::= WHEN scalar_expression THEN scalar_expression

coalesce_expression ::= COALESCE(scalar_expression {, scalar_expression}+)

nullif_expression ::= NULLIF(scalar_expression, scalar_expression)
```

Examples:

```
UPDATE Employee e
SET e.salary =
    CASE WHEN e.rating = 1 THEN e.salary * 1.1
         WHEN e.rating = 2 THEN e.salary * 1.05
         ELSE e.salary * 1.01
    END

UPDATE Employee e
```

```

SET e.salary =
  CASE e.rating WHEN 1 THEN e.salary * 1.1
               WHEN 2 THEN e.salary * 1.05
               ELSE e.salary * 1.01
  END

SELECT e.name,
  CASE TYPE(e) WHEN Exempt THEN 'Exempt'
             WHEN Contractor THEN 'Contractor'
             WHEN Intern THEN 'Intern'
             ELSE 'NonExempt'
  END
FROM Employee e
WHERE e.dept.name = 'Engineering'

SELECT e.name,
  f.name,
  CONCAT(CASE WHEN f.annualMiles > 50000 THEN 'Platinum '
             WHEN f.annualMiles > 25000 THEN 'Gold '
             ELSE ''
  END,
  'Frequent Flyer')
FROM Employee e JOIN e.frequentFlierPlan f

```

4.7.11. Identifier and Version Functions

The ID and VERSION functions evaluate to the primary key or version, respectively, of their argument, which must be an identification variable assigned an entity abstract schema type or a path expression resolving to a one-to-one or many-to-one relationship field. For example, if Person has a primary key field named ssn, then ID(person) is a synonym for person.ssn.

```

entity_id_or_version_function ::= id_function | version_function
id_function ::=
  ID(general_identification_variable |
    single_valued_object_path_expression)
version_function ::=
  VERSION(general_identification_variable |
    single_valued_object_path_expression)

```

The result type of an ID or VERSION function expression is the primary key type or version type of the argument entity, respectively.

The result may be compared to an input parameter:

```

DELETE from Employee
WHERE id(this) = :id
  AND version(this) = :version

```

A persistence provider is not required to support the use of the ID function for entities with composite primary keys.

4.7.12. Entity Type Expressions and Literal Entity Types

An *entity type expression* can be used to restrict query polymorphism. The syntax of an entity type expression is as follows:

```

entity_type_expression ::=
  type_discriminator |
  entity_type_literal |
  input_parameter
type_discriminator ::=

```

```
TYPE(general_identification_variable |
     single_valued_object_path_expression |
     input_parameter)
```

The `TYPE` operator returns the exact type of its argument, which must be an identification variable assigned an entity abstract schema type, a path expression resolving to a one-to-one or many-to-one relationship field, or an input parameter.

An `entity_type_literal` specifies a literal entity type by its entity name defined above in [Section 4.3.1](#).

For an input parameter, the entity type must be specified by calling `Query.setParameter()` with the `java.lang.Class` object representing the entity class.

Examples:

```
SELECT e
FROM Employee e
WHERE TYPE(e) IN (Exempt, Contractor)

SELECT e
FROM Employee e
WHERE TYPE(e) IN (:empType1, :empType2)

SELECT e
FROM Employee e
WHERE TYPE(e) IN :empTypes

SELECT TYPE(e)
FROM Employee e
WHERE TYPE(e) <> Exempt
```

4.7.13. Numeric Expressions and Type Promotion

Every numeric expression in a query is assigned a Java numeric type according to the following rules:

- An expression that corresponds to a persistent state field is of the same type as that persistent state field.
- An expression that corresponds to one of arithmetic functions described in [Section 4.7.7.2](#) is of the type defined by [Section 4.7.7.2](#).
- An expression that corresponds to one of an aggregate functions described in [Section 4.9.5](#) is of the type defined by [Section 4.9.5](#).

For a `CASE` expression, `COALESCE` expression, `NULLIF` expression, or arithmetic operator expression (+, -, *, /), the numeric type is determined by its operand types, and by the following rules^[17].

- If there is an operand of type `Double` or `double`, the expression is of type `Double`;
- otherwise, if there is an operand of type `Float` or `float`, the expression is of type `Float`;
- otherwise, if there is an operand of type `BigDecimal`, the expression is of type `BigDecimal`;
- otherwise, if there is an operand of type `BigInteger`, the expression is of type `BigInteger`, unless the operator is / (division), in which case the expression type is not defined here;
- otherwise, if there is an operand of type `Long` or `long`, the expression is of type `Long`, unless the operator is / (division), in which case the expression type is not defined here;
- otherwise, if there is an operand of integral type, the expression is of type `Integer`, unless the operator is / (division), in which case the expression type is not defined here.



Users should note that the semantics of the SQL division operation are not standard across databases. In particular, when both operands are of integral types, the result of the division operation will be an

integral type in some databases, and a non-integral type in others. Portable applications should not assume a particular result type.

For numeric expressions occurring in the `SELECT` clause, these rules determine the Java object type returned in the query result list.

4.8. GROUP BY, HAVING

The `GROUP BY` construct enables the aggregation of result values according to a set of properties. The `HAVING` construct enables conditions to be specified that further restrict the query result. Such conditions are restrictions upon the groups.

The syntax of the `GROUP BY` and `HAVING` clauses is as follows:

```
groupby_clause ::= GROUP BY groupby_item {, groupby_item}*
groupby_item  ::= single_valued_path_expression | identification_variable

having_clause ::= HAVING conditional_expression
```

If a query contains both a `WHERE` clause and a `GROUP BY` clause, the effect is that of first applying the `WHERE` clause, and then forming the groups and filtering them according to the `HAVING` clause. The `HAVING` clause causes those groups to be retained that satisfy the condition of the `HAVING` clause.

The requirements for the `SELECT` clause when `GROUP BY` is used follow those of SQL: namely, any item that appears in the `SELECT` clause (other than as an aggregate function or as an argument to an aggregate function) must also appear in the `GROUP BY` clause. In forming the groups, null values are treated as the same for grouping purposes.

Grouping by an entity is permitted. In this case, the entity must contain no serialized state fields or lob-valued state fields that are eagerly fetched. Grouping by an entity that contains serialized state fields or lob-valued state fields is not portable, since the implementation is permitted to eagerly fetch fields or properties that have been specified as `LAZY`.

Grouping by embeddables is not supported.

The `HAVING` clause is used to filter over the groups, and can contain aggregate functions over attributes included in the groups and/or functions or other query language operators over the attributes that are used for grouping. It is not required that an aggregate function used in the `HAVING` clause also be used in the `SELECT` clause.

If there is no `GROUP BY` clause and the `HAVING` clause is used, the result is treated as a single group, and the select list can only consist of aggregate functions. The use of `HAVING` in the absence of `GROUP BY` is not required to be supported by an implementation of this specification. Portable applications should not rely on `HAVING` without the use of `GROUP BY`.

Examples:

```
SELECT c.status, AVG(c.filledOrderCount), COUNT(c)
FROM Customer c
GROUP BY c.status
HAVING c.status IN (1, 2)
```

```
SELECT c.country, COUNT(c)
FROM Customer c
GROUP BY c.country
HAVING COUNT(c) > 30
```

```
SELECT c, COUNT(o)
FROM Customer c JOIN c.orders o
GROUP BY c
HAVING COUNT(o) >= 5
```

4.9. SELECT Clause

The SELECT clause specifies the query result, as a list of items to be returned by the query.

The SELECT clause can contain one or more of the following elements:

- an identification variable that ranges over an abstract schema type,
- a single-valued path expression,
- a scalar expression,
- an aggregate expression,
- a constructor expression.

The SELECT clause has the following syntax:

```
select_clause ::= SELECT [DISTINCT] select_item {, select_item}*
select_item  ::= select_expression [[AS] result_variable]
select_expression ::=
  single_valued_path_expression |
  scalar_expression |
  aggregate_expression |
  identification_variable |
  OBJECT(identification_variable) |
  constructor_expression
constructor_expression ::=
  NEW constructor_name (constructor_item {, constructor_item}*)
constructor_item ::=
  single_valued_path_expression |
  scalar_expression |
  aggregate_expression |
  identification_variable
aggregate_expression ::=
  {AVG | MAX | MIN | SUM} ([DISTINCT] state_valued_path_expression) |
  COUNT ([DISTINCT] identification_variable | state_valued_path_expression |
  single_valued_object_path_expression) |
  function_invocation
```

For example:

```
SELECT c.id, c.status
FROM Customer c JOIN c.orders o
WHERE o.count > 100
```

In the following example, videoInventory is a Map from the entity Movie to the number of copies in stock:

```
SELECT v.location.street, KEY(i).title, VALUE(i)
FROM VideoStore v JOIN v.videoInventory i
WHERE v.location.zipcode = '94301' AND VALUE(i) > 0
```

Note that the SELECT clause must be specified to return only single-valued expressions. The query below is therefore not valid:

```
SELECT o.lineItems FROM Order AS o
```

The DISTINCT keyword is used to specify that duplicate values must be eliminated from the query result.

If DISTINCT is not specified, duplicate values are not eliminated.

The result of DISTINCT over embeddable objects or map entry results is undefined.

Standalone identification variables in the `SELECT` clause may optionally be qualified by the `OBJECT` operator.^[18] The `SELECT` clause must not use the `OBJECT` operator to qualify path expressions.

A `result_variable` assigns a name to a `select_item` in the query result. The `result_variable` must be a valid identifier, as defined in [Section 4.4.1](#), must not be a reserved identifier, and must not collide with any identification variable declared in the `FROM` clause. A result variable may be used to refer to an element of the `select` clause from an item in the `ORDER BY` clause, as specified in [Section 4.10](#). Like identification variables, result variables are case-insensitive.

Example:

```
SELECT c, COUNT(1) AS itemCount
FROM Customer c JOIN c.orders o JOIN o.lineItems l
WHERE c.address.state = 'CA'
GROUP BY c
ORDER BY itemCount
```

The `SELECT` clause is optional. A query with a missing `SELECT` clause is interpreted as if it had the following single-item `SELECT` clause: `select this`, where `this` is the implicit identification variable.

Thus, the following queries are equivalent:

```
FROM Order
WHERE customer.lastname = 'Smith'
AND customer.firstname= 'John'

SELECT this
FROM Order
WHERE this.customer.lastname = 'Smith'
AND this.customer.firstname= 'John'

SELECT ord
FROM Order AS ord
WHERE ord.customer.lastname = 'Smith'
AND ord.customer.firstname= 'John'
```

If the implicit identification variable has not been assigned an abstract schema type, the `SELECT` clause is required.

4.9.1. Result Type of the `SELECT` Clause

The type of the query result specified by the `SELECT` clause of a query is an entity abstract schema type, a state field type, the result of a scalar expression, the result of an aggregate function, the result of a construction operation, or some sequence of these.

The result type of the `SELECT` clause is defined by the result types of the `select` expressions contained in it. When multiple `select` expressions are used in the `SELECT` clause, the elements in this result correspond in order to the order of their specification in the `SELECT` clause and in type to the result types of each of the `select` expressions.

The type of the result of a `select_expression` is as follows:

- The result type of an `identification_variable` is the type of the entity object or embeddable object to which the identification variable corresponds. The type of an `identification_variable` that refers to an entity abstract schema type is the type of the entity to which that identification variable corresponds or a subtype as determined by the object/relational mapping.
- The result type of a `single_valued_path_expression` that is a `state_field_path_expression` is the same type as the corresponding state field of the entity or embeddable class. If the state field of the entity is a primitive type, the result type is the corresponding object type.

- The result type of a `single_valued_path_expression` that is a `single_valued_object_path_expression` is the type of the entity object or embeddable object to which the path expression corresponds. A `single_valued_object_path_expression` that results in an entity object will result in an entity of the type of the relationship field or the subtype of the relationship field of the entity object as determined by the object/relational mapping.
- The result type of a `single_valued_path_expression` that is an `identification_variable` to which the `KEY` or `VALUE` function has been applied is determined by the type of the map key or value respectively, as defined by the above rules.
- The result type of a `single_valued_path_expression` that is an `identification_variable` to which the `ENTRY` function has been applied is `java.util.Map.Entry`, where the key and value types of the map entry are determined by the above rules as applied to the map key and map value respectively.
- The result type of a `scalar_expression` is the type of the scalar value to which the expression evaluates. The result type of a numeric `scalar_expression` is defined in [Section 4.7.13](#).
- The result type of an `entity_type_expression` scalar expression is the Java class to which the resulting abstract schema type corresponds.
- The result type of `aggregate_expression` is defined in [Section 4.9.5](#).
- The result type of a `constructor_expression` is the type of the class for which the constructor is defined. The types of the arguments to the constructor are defined by the above rules.

4.9.2. Constructor Expressions in the SELECT Clause

A constructor may be used in the `SELECT` list to return an instance of a Java class. The specified class is not required to be an entity or to be mapped to the database. The constructor name must be fully qualified.

If an entity class name is specified as the constructor name in the `SELECT NEW` clause, the resulting entity instances will be in either the new or the detached state, depending on whether a primary key is retrieved for the constructed object.

If a `single_valued_path_expression` or `identification_variable` that is an argument to the constructor references an entity, the resulting entity instance referenced by that `single_valued_path_expression` or `identification_variable` will be in the managed state.

For example,

```
SELECT NEW com.acme.example.CustomerDetails(c.id, c.status, o.count)
FROM Customer c JOIN c.orders o
WHERE o.count > 100
```

4.9.3. Null Values in the Query Result

If the result of a query corresponds to an association field or state field whose value is null, that null value is returned in the result of the query method. The `IS NOT NULL` construct can be used to eliminate such null values from the result set of the query.

Note, however, that state field types defined in terms of Java numeric primitive types cannot produce `NULL` values in the query result. A query that returns such a state field type as a result type must not return a null value.

4.9.4. Embeddables in the Query Result

If the result of a query corresponds to an `identification_variable` or state field whose value is an embeddable, the embeddable instance returned by the query will not be in the managed state (i.e., it will not be part of the state of any managed entity).

In the following example, the `Address` instances returned by the query will reference `Phone` instances. While the `Phone` instances will be managed, the `Address` instances referenced by the `addr` result variable will not be. Modifications to

these embeddable instances will have no effect on persistent state.

```
@Entity
public class Employee {
    @Id
    int id;

    Address address;

    // ...
}

@Embeddable
public class Address {
    String street;

    // ...

    @OneToOne
    Phone phone; // fetch=EAGER
}

@Entity
public class Phone {
    @Id
    int id;

    // ...

    @OneToOne(mappedBy="address.phone")
    Employee emp; // fetch=EAGER
}

SELECT e.address AS addr
FROM Employee e
```

4.9.5. Aggregate Functions in the SELECT Clause

The result of a query may be the result of an aggregate function applied to a path expression.

The following aggregate functions can be used in the SELECT clause of a query: AVG, COUNT, MAX, MIN, SUM, aggregate functions defined in the database.

For all aggregate functions except COUNT, the path expression that is the argument to the aggregate function must terminate in a state field. The path expression argument to COUNT may terminate in either a state field or a association field, or the argument to COUNT may be an identification variable.

Arguments to the functions SUM and AVG must be numeric. Arguments to the functions MAX and MIN must correspond to orderable state field types (i.e., numeric types, string types, character types, or date types).

The Java type that is contained in the result of a query using an aggregate function is as follows:

- COUNT returns Long.
- MAX, MIN return the type of the state field to which they are applied.
- AVG returns Double.
- SUM returns Long when applied to state fields of integral types (other than BigInteger); Double when applied to state fields of floating point types; BigInteger when applied to state fields of type BigInteger; and BigDecimal when applied to state fields of type BigDecimal.

Null values are eliminated before the aggregate function is applied, regardless of whether the keyword DISTINCT is

specified.

If SUM, AVG, MAX, or MIN is used, and there are no values to which the aggregate function can be applied, the result of the aggregate function is NULL.

If COUNT is used, and there are no values to which COUNT can be applied, the result of the aggregate function is 0.

The argument to an aggregate function may be preceded by the keyword DISTINCT to specify that duplicate values are to be eliminated before the aggregate function is applied.^[19]

The use of DISTINCT with COUNT is not supported for arguments of embeddable types or map entry types.

The invocation of aggregate database functions, including user defined functions, is supported by means of the FUNCTION operator. See [Section 4.7.9](#).

The following query returns the average order quantity:

```
SELECT AVG(o.quantity) FROM Order o
```

The following query returns the total cost of the items that John Smith has ordered.

```
SELECT SUM(l.price)
FROM Order o JOIN o.lineItems l JOIN o.customer c
WHERE c.lastname = 'Smith' AND c.firstname = 'John'
```

The following query returns the total number of orders.

```
SELECT COUNT(o) FROM Order o
```

The following query counts the number of items in John Smith's order for which prices have been specified.

```
SELECT COUNT(l.price)
FROM Order o JOIN o.lineItems l JOIN o.customer c
WHERE c.lastname = 'Smith' AND c.firstname = 'John'
```

Note that this is equivalent to:

```
SELECT COUNT(l)
FROM Order o JOIN o.lineItems l JOIN o.customer c
WHERE c.lastname = 'Smith' AND c.firstname = 'John' AND l.price IS NOT NULL
```

4.10. ORDER BY Clause

The ORDER BY clause specifies how the results of a query should be sorted. The syntax of the ORDER BY clause is:

```
orderby_clause ::= ORDER BY orderby_item {, orderby_item}*
orderby_item ::= orderby_expression [ASC | DESC] [NULLS {FIRST | LAST}]
orderby_expression ::=
    state_field_path_expression |
    general_identification_variable |
    result_variable |
    scalar_expression
```

The ORDER BY clause specifies a list of items. Each orderby_expression must be one of the following:

1. A state_field_path_expression evaluating to an orderable state field of an entity or embeddable class abstract schema type designated in the SELECT clause by either:

- a `general_identification_variable`, or
 - a `single_valued_object_path_expression`.
2. A `state_field_path_expression` evaluating to the same state field of the same entity or embeddable abstract schema type as a `state_field_path_expression` in the `SELECT` clause.
 3. A `general_identification_variable` evaluating to the same map field of the same entity or embeddable abstract schema type as a `general_identification_variable` in the `SELECT` clause.
 4. A reference to a `result_variable` declared by an orderable item in the `SELECT` clause. The orderable item must be an `aggregate_expression`, a `scalar_expression`, or a `state_field_path_expression`.
 5. Any `scalar_expression` involving only `state_field_path_expressions` which would be allowed according to items 1 or 2 above.

Depending on the database, arbitrary scalar expressions may not be allowed in the `ORDER BY` clause. Therefore, applications which require portability between databases should not depend on the use of a scalar expression in `ORDER BY` if it is only permitted by item 5.

For example, the four queries below are legal.

```
SELECT o
FROM Customer c JOIN c.orders o JOIN c.address a
WHERE a.state = 'CA'
ORDER BY o.quantity DESC, o.totalcost

SELECT o.quantity, a.zipcode
FROM Customer c JOIN c.orders o JOIN c.address a
WHERE a.state = 'CA'
ORDER BY o.quantity, a.zipcode

SELECT o.quantity, o.cost*1.08 AS taxedCost, a.zipcode
FROM Customer c JOIN c.orders o JOIN c.address a
WHERE a.state = 'CA' AND a.county = 'Santa Clara'
ORDER BY o.quantity, taxedCost, a.zipcode

SELECT AVG(o.quantity) as q, a.zipcode
FROM Customer c JOIN c.orders o JOIN c.address a
WHERE a.state = 'CA'
GROUP BY a.zipcode
ORDER BY q DESC
```

The following query is legal, but might not be supported on every database.

```
SELECT c, o
FROM Customer c JOIN c.orders o JOIN c.address a
WHERE a.state = 'CA'
ORDER BY UPPER(c.lastname), UPPER(c.firstname)
```

The following two queries are *not* legal because the `orderby_item` is not reflected in the `SELECT` clause of the query.

```
SELECT p.product_name
FROM Order o JOIN o.lineItems l JOIN l.product p JOIN o.customer c
WHERE c.lastname = 'Smith' AND c.firstname = 'John'
ORDER BY p.price

SELECT p.product_name
FROM Order o, IN(o.lineItems) l JOIN o.customer c
WHERE c.lastname = 'Smith' AND c.firstname = 'John'
ORDER BY o.quantity
```

The keyword `ASC` specifies that ascending ordering is used for the associated `orderby_item`; the keyword `DESC` specifies

that descending ordering is used. If neither keyword is explicitly specified, ascending ordering is the default.

The interpretation of ascending or descending order is determined by the database, but, in general:

- ascending order for numeric values means smaller values first, while descending order means larger values first, and
- strings are sorted lexicographically, using a database-dependent collation.

The keyword `NULLS` specifies the ordering of null values, either `FIRST` or `LAST`.

- `FIRST` means that results are sorted so that all null values occur before all non-null values.
- `LAST` means that results are sorted so that all null values occur after all non-null values.

If `NULLS` is not specified, the database determines whether null values occur first or last.

Items occurring earlier in the `ORDER BY` clause take precedence. That is, an item occurring later in the `ORDER BY` clause is only used to resolve "ties" between results which cannot be unambiguously ordered using only earlier items.

The order of query results must be preserved in the result list or stream returned by a query execution method when an `ORDER BY` clause is specified.

4.11. Bulk Update and Delete Operations

Bulk update and delete operations apply to entities of a single entity class (together with its subclasses, if any). Only one entity abstract schema type may be specified in the `FROM` or `UPDATE` clause.

The syntax of these operations is as follows:

```
update_statement ::= update_clause [where_clause]
update_clause ::= UPDATE entity_name [[AS] identification_variable]
                SET update_item {, update_item}*
update_item ::= [identification_variable.]{single_valued_embeddable_object_field.}*
              {state_field | single_valued_object_field} = new_value
new_value ::=
  scalar_expression |
  simple_entity_expression |
  NULL

delete_statement ::= delete_clause [where_clause]
delete_clause ::= DELETE FROM entity_name [[AS] identification_variable]
```

The syntax of the `WHERE` clause is described in [Section 4.5](#).

A delete operation only applies to entities of the specified class and its subclasses. It does not cascade to related entities.

The `new_value` specified for an update operation must be compatible in type with the field to which it is assigned.

Bulk update maps directly to a database update operation, bypassing optimistic locking checks. Portable applications must manually update the value of the version column, if desired, and/or manually validate the value of the version column.

The persistence context is not synchronized with the result of the bulk update or delete.



Caution should be used when executing bulk update or delete operations because they may result in inconsistencies between the database and the entities in the active persistence context. In general, bulk update and delete operations should only be performed within a transaction in a new persistence context or before fetching or accessing entities whose state might be affected by such operations.

Examples:

```
DELETE
FROM Customer c
WHERE c.status = 'inactive'

DELETE
FROM Customer c
WHERE c.status = 'inactive'
      AND c.orders IS EMPTY

UPDATE Customer c
SET c.status = 'outstanding'
WHERE c.balance < 10000

UPDATE Employee e
SET e.address.building = 22
WHERE e.address.building = 14
      AND e.address.city = 'Santa Clara'
      AND e.project = 'Jakarta EE'
```

4.12. BNF

BNF notation summary:

- { ... } grouping
- [...] optional constructs
- * zero or more
- + one or more
- | alternates

The following is the BNF for the Jakarta Persistence query language.

```
QL_statement ::= select_statement | update_statement | delete_statement
select_statement ::= union
union ::= intersection | union {UNION [ALL] | EXCEPT [ALL]} intersection
intersection ::= query_expression | intersection INTERSECT [ALL] query_expression
query_expression ::= select_query | (union)
select_query ::= [select_clause] from_clause [where_clause] [groupby_clause]
               [having_clause] [orderby_clause]
update_statement ::= update_clause [where_clause]
delete_statement ::= delete_clause [where_clause]
from_clause ::=
    FROM {this_implicit_variable | identification_variable_declarations}
this_implicit_variable ::= entity_name
identification_variable_declarations ::=
    identification_variable_declaration
    {, {identification_variable_declaration | collection_member_declaration}}*
identification_variable_declaration ::= range_variable_declaration {join | fetch_join}*
range_variable_declaration ::= entity_name [AS] identification_variable
join ::= range_join | path_join
range_join ::= join_spec range_variable_declaration [join_condition]
path_join ::=
    join_spec join_association_path_expression [AS] identification_variable [join_condition]
fetch_join ::= join_spec FETCH join_association_path_expression
join_spec ::= [INNER | LEFT [OUTER]] JOIN
join_condition ::= ON conditional_expression
join_association_path_expression ::=
    join_collection_valued_path_expression |
    join_single_valued_path_expression |
    TREAT(join_collection_valued_path_expression AS subtype) |
    TREAT(join_single_valued_path_expression AS subtype)
```

```

join_collection_valued_path_expression ::=
    [identification_variable.]{single_valued_embeddable_object_field.*} collection_valued_field
join_single_valued_path_expression ::=
    [identification_variable.]{single_valued_embeddable_object_field.*} single_valued_object_field
collection_member_declaration ::=
    IN (collection_valued_path_expression) [AS] identification_variable
qualified_identification_variable ::=
    map_field_identification_variable |
    ENTRY(identification_variable)
map_field_identification_variable ::=
    KEY(identification_variable) |
    VALUE(identification_variable)
single_valued_path_expression ::=
    qualified_identification_variable |
    TREAT(qualified_identification_variable AS subtype) |
    state_field_path_expression |
    single_valued_object_path_expression
general_identification_variable ::=
    identification_variable |
    map_field_identification_variable
general_subpath ::= simple_subpath | treated_subpath{.single_valued_object_field}*
simple_subpath ::=
    general_identification_variable |
    general_identification_variable{.single_valued_object_field}*
treated_subpath ::= TREAT(general_subpath AS subtype)
state_field_path_expression ::= [general_subpath.]state_field
state_valued_path_expression ::=
    state_field_path_expression | general_identification_variable
single_valued_object_path_expression ::=
    general_subpath.single_valued_object_field
collection_valued_path_expression ::= general_subpath.{collection_valued_field}
update_clause ::= UPDATE entity_name [[AS] identification_variable]
    SET update_item {, update_item}*
update_item ::= [identification_variable.]{single_valued_embeddable_object_field.*}
    {state_field | single_valued_object_field} = new_value
new_value ::=
    scalar_expression |
    simple_entity_expression |
    NULL
delete_clause ::= DELETE FROM entity_name [[AS] identification_variable]
select_clause ::= SELECT [DISTINCT] select_item {, select_item}*
select_item ::= select_expression [[AS] result_variable]
select_expression ::=
    single_valued_path_expression |
    scalar_expression |
    aggregate_expression |
    identification_variable |
    OBJECT(identification_variable) |
    constructor_expression
constructor_expression ::=
    NEW constructor_name (constructor_item {, constructor_item}*)
constructor_item ::=
    single_valued_path_expression |
    scalar_expression |
    aggregate_expression |
    identification_variable
aggregate_expression ::=
    {AVG | MAX | MIN | SUM} ([DISTINCT] state_valued_path_expression) |
    COUNT ([DISTINCT] identification_variable | state_valued_path_expression |
        single_valued_object_path_expression) |
    function_invocation
where_clause ::= WHERE conditional_expression
groupby_clause ::= GROUP BY groupby_item {, groupby_item}*
groupby_item ::= single_valued_path_expression | identification_variable
having_clause ::= HAVING conditional_expression
orderby_clause ::= ORDER BY orderby_item {, orderby_item}*
orderby_item ::= orderby_expression [ASC | DESC] [NULLS {FIRST | LAST}]

```

```

orderby_expression ::=
    state_field_path_expression |
    general_identification_variable |
    result_variable |
    scalar_expression
subquery ::= simple_select_clause subquery_from_clause [where_clause]
    [groupby_clause] [having_clause]
subquery_from_clause ::=
    FROM subselect_identification_variable_declaration
        {, subselect_identification_variable_declaration | collection_member_declaration}*
subselect_identification_variable_declaration ::=
    identification_variable_declaration |
    derived_path_expression [AS] identification_variable {join}* |
    derived_collection_member_declaration
derived_path_expression ::=
    general_derived_path.single_valued_object_field |
    general_derived_path.collection_valued_field
general_derived_path ::=
    simple_derived_path |
    treated_derived_path{.single_valued_object_field}*
simple_derived_path ::= superquery_identification_variable{.single_valued_object_field}*
treated_derived_path ::= TREAT(general_derived_path AS subtype)
derived_collection_member_declaration ::=
    IN superquery_identification_variable.{single_valued_object_field.}*collection_valued_field
simple_select_clause ::= SELECT [DISTINCT] simple_select_expression
simple_select_expression ::=
    single_valued_path_expression |
    scalar_expression |
    aggregate_expression |
    identification_variable
scalar_expression ::=
    arithmetic_expression |
    string_expression |
    enum_expression |
    datetime_expression |
    boolean_expression |
    case_expression |
    entity_type_expression |
    entity_id_or_version_function
conditional_expression ::= conditional_term | conditional_expression OR conditional_term
conditional_term ::= conditional_factor | conditional_term AND conditional_factor
conditional_factor ::= [NOT] conditional_primary
conditional_primary ::= simple_cond_expression | (conditional_expression)
simple_cond_expression ::=
    comparison_expression |
    between_expression |
    in_expression |
    like_expression |
    null_comparison_expression |
    empty_collection_comparison_expression |
    collection_member_expression |
    exists_expression
between_expression ::=
    arithmetic_expression [NOT] BETWEEN
        arithmetic_expression AND arithmetic_expression |
    string_expression [NOT] BETWEEN string_expression AND string_expression |
    datetime_expression [NOT] BETWEEN datetime_expression AND datetime_expression
in_expression ::=
    {state_valued_path_expression | type_discriminator} [NOT] IN
        {(in_item{, in_item}*) | (subquery) | collection_valued_input_parameter}
in_item ::= literal | single_valued_input_parameter
like_expression ::=
    string_expression [NOT] LIKE pattern_value [ESCAPE escape_character]
null_comparison_expression ::=
    {single_valued_path_expression | input_parameter} IS [NOT] NULL
empty_collection_comparison_expression ::=
    collection_valued_path_expression IS [NOT] EMPTY

```

```

collection_member_expression ::= entity_or_value_expression
    [NOT] MEMBER [OF] collection_valued_path_expression
entity_or_value_expression ::=
    single_valued_object_path_expression |
    state_field_path_expression |
    simple_entity_or_value_expression
simple_entity_or_value_expression ::=
    identification_variable |
    input_parameter |
    literal
exists_expression ::= [NOT] EXISTS (subquery)
all_or_any_expression ::= {ALL | ANY | SOME} (subquery)
comparison_expression ::=
    string_expression comparison_operator {string_expression | all_or_any_expression} |
    boolean_expression {= | <>} {boolean_expression | all_or_any_expression} |
    enum_expression {= | <>} {enum_expression | all_or_any_expression} |
    datetime_expression comparison_operator
        {datetime_expression | all_or_any_expression} |
    entity_expression {= | <>} {entity_expression | all_or_any_expression} |
    arithmetic_expression comparison_operator {arithmetic_expression | all_or_any_expression} |
    entity_id_or_version_function {= | <>} input_parameter |
    entity_type_expression {= | <>} entity_type_expression}
comparison_operator ::= = | > | >= | < | <= | <>
arithmetic_expression ::=
    arithmetic_term | arithmetic_expression {+ | -} arithmetic_term
arithmetic_term ::= arithmetic_factor | arithmetic_term {*} | /} arithmetic_factor
arithmetic_factor ::= [{+ | -}] arithmetic_primary
arithmetic_primary ::=
    state_valued_path_expression |
    numeric_literal |
    (arithmetic_expression) |
    input_parameter |
    functions_returning_numerics |
    aggregate_expression |
    case_expression |
    function_invocation |
    arithmetic_cast_function |
    (subquery)
string_expression ::=
    state_valued_path_expression |
    string_literal |
    input_parameter |
    functions_returning_strings |
    aggregate_expression |
    case_expression |
    function_invocation |
    string_cast_function |
    string_expression || string_expression |
    (subquery)
datetime_expression ::=
    state_valued_path_expression |
    input_parameter |
    functions_returning_datetime |
    aggregate_expression |
    case_expression |
    function_invocation |
    date_time_timestamp_literal |
    (subquery)
boolean_expression ::=
    state_valued_path_expression |
    boolean_literal |
    input_parameter |
    case_expression |
    function_invocation |
    (subquery)
enum_expression ::=
    state_valued_path_expression |

```



```

enum_literal |
input_parameter |
case_expression |
(subquery)
entity_expression ::= single_valued_object_path_expression | simple_entity_expression
simple_entity_expression ::= identification_variable | input_parameter
entity_type_expression ::=
type_discriminator |
entity_type_literal |
input_parameter
type_discriminator ::=
TYPE(general_identification_variable |
single_valued_object_path_expression |
input_parameter)
arithmetic_cast_function ::=
CAST(string_expression AS {INTEGER | LONG | FLOAT | DOUBLE})
functions_returning_numerics ::=
LENGTH(string_expression) |
LOCATE(string_expression, string_expression[, arithmetic_expression]) |
ABS(arithmetic_expression) |
CEILING(arithmetic_expression) |
EXP(arithmetic_expression) |
FLOOR(arithmetic_expression) |
LN(arithmetic_expression) |
SIGN(arithmetic_expression) |
SQRT(arithmetic_expression) |
MOD(arithmetic_expression, arithmetic_expression) |
POWER(arithmetic_expression, arithmetic_expression) |
ROUND(arithmetic_expression, arithmetic_expression) |
SIZE(collection_valued_path_expression) |
INDEX(identification_variable) |
extract_datetime_field
functions_returning_datetime ::=
CURRENT_DATE |
CURRENT_TIME |
CURRENT_TIMESTAMP |
LOCAL_DATE |
LOCAL_TIME |
LOCAL_DATETIME |
extract_datetime_part
string_cast_function ::=
CAST(scalar_expression AS STRING)
functions_returning_strings ::=
CONCAT(string_expression, string_expression[, string_expression]*) |
SUBSTRING(string_expression, arithmetic_expression[, arithmetic_expression]) |
TRIM([[trim_specification] [trim_character] FROM] string_expression) |
LOWER(string_expression) |
UPPER(string_expression)
trim_specification ::= LEADING | TRAILING | BOTH
function_invocation ::= FUNCTION(function_name[, function_arg]*)
extract_datetime_field :=
EXTRACT(datetime_field FROM datetime_expression)
datetime_field := identification_variable
extract_datetime_part :=
EXTRACT(datetime_part FROM datetime_expression)
datetime_part := identification_variable
function_arg ::=
literal |
state_valued_path_expression |
input_parameter |
scalar_expression
entity_id_or_version_function ::= id_function | version_function
id_function ::=
ID(general_identification_variable |
single_valued_object_path_expression)
version_function ::=
VERSION(general_identification_variable |

```

```

        single_valued_object_path_expression)
case_expression ::=
    general_case_expression |
    simple_case_expression |
    coalesce_expression |
    nullif_expression
general_case_expression ::= CASE when_clause {when_clause}* ELSE scalar_expression END
when_clause ::= WHEN conditional_expression THEN scalar_expression
simple_case_expression ::=
    CASE case_operand simple_when_clause {simple_when_clause}*
    ELSE scalar_expression
    END
case_operand ::= state_valued_path_expression | type_discriminator
simple_when_clause ::= WHEN scalar_expression THEN scalar_expression
coalesce_expression ::= COALESCE(scalar_expression{, scalar_expression}+)
nullif_expression ::= NULLIF(scalar_expression, scalar_expression)

```

- [1] As in SQL, the INTERSECT and INTERSECT ALL operations have higher precedence than UNION, UNION ALL, EXCEPT, and EXCEPT ALL.
- [2] This chapter uses the convention that reserved identifiers appear in upper case in the examples and BNF for the language.
- [3] BIT_LENGTH, CHAR_LENGTH, CHARACTER_LENGTH, POSITION, and UNKNOWN are not currently used: they are reserved for future use.
- [4] A range variable never designates an embeddable class abstract schema type.
- [5] Note that use of VALUE is optional, as an identification variable referring to an association of type `java.util.Map` is of the abstract schema type of the map value. (See [Section 4.4.2](#).)
- [6] Support for right outer joins and full outer joins is under consideration for inclusion in a future version of this specification.
- [7] The implementation is not expected to perform such query operations involving such fields in memory rather than in the database.
- [8] Note that queries that contain subqueries on both sides of a comparison operation will not be portable across all databases.
- [9] Note that use of a collection-valued input parameter might prevent precompilation of the query.
- [10] Refer to [2] for a more precise characterization of these rules.
- [11] The use of the reserved word OF is optional in this expression.
- [12] Subqueries are restricted to the WHERE and HAVING clauses in this release. Support for subqueries in the FROM clause will be considered in a later release of this specification.
- [13] Note that expressions involving aggregate operators must not be used in the WHERE clause.
- [14] Note that not all databases support the use of a trim character other than the space character; use of this argument may result in queries that are not portable.
- [15] Note that not all databases support the use of the third argument to LOCATE; use of this argument may result in queries that are not portable.
- [16] Note that not all databases support the use of SQL case expressions. The use of case expressions may result in queries that are not portable to such databases.
- [17] For a general or simple CASE expression, the operands are the scalar expressions in the THEN and ELSE clauses.
- [18] Note that the keyword OBJECT is not required. It is preferred that it be omitted for new queries.
- [19] It is legal to specify DISTINCT with MAX or MIN, but it does not affect the result.

Chapter 5. Metamodel API

This specification provides a set of interfaces for dynamically accessing a metamodel representing the managed classes of a persistence unit. Instances of metamodel types may be obtained either:

- via programmatic lookup using an instance of the interface `Metamodel` (found in [Section D.1](#)) obtained from the `EntityManagerFactory` or `EntityManager` by calling `getMetamodel()`, or
- in a typesafe way, using *static metamodel classes*.

A static metamodel class is a class with static members providing direct typesafe access to metamodel objects representing the persistent members of a given managed class.

5.1. Static Metamodel Classes

A set of static metamodel classes corresponding to the managed classes of a persistence unit can be generated using an annotation processor or may be created by the application developer.

In the typical case, an annotation processor is used to generate static metamodel classes corresponding to the entities, mapped superclasses, and embeddable classes in the persistence unit. A static metamodel class models the persistent state and relationships of the corresponding managed class. For portability, an annotation processor should generate a *canonical metamodel* as specified in the next section.

5.1.1. Canonical Metamodel

This specification defines as follows a canonical metamodel and the structure of canonical metamodel classes.

For every managed class in the persistence unit, a corresponding metamodel class is produced as follows:

- For each managed class `X` in package `p`, a metamodel class `X_` in package `p` is created.^[1]
- The name of the metamodel class is derived from the name of the managed class by appending “_” to the name of the managed class.
- The metamodel class `X_` must be annotated with the `StaticMetamodel` annotation found in [Section D.2](#).^[2]
- If the managed class `X` extends another class `S`, where `S` is the most derived managed class (i.e., entity or mapped superclass) extended by `X`, then the metamodel class `X_` must extend the metamodel class `S_` created for `S`.
- The metamodel class must contain a field declaration as follows:

```
public static volatile jakarta.persistence.metamodel.T<X> class_;
```

where `T` is `EntityType`, `EmbeddableType`, or `MappedSuperclassType` depending on whether `X` is an entity, embeddable, or mapped superclass.

- For every persistent attribute `y` declared by class `X`, the metamodel class must contain a field declaration as follows:

```
public static final String Y = "y";
```

where the field name `Y` is obtained by transforming each lowercase character in the attribute name `y` to uppercase, inserting an underscore if the character following the transformed character is uppercase, and then replacing each character which is not a legal Java identifier character with an underscore.

- For every persistent non-collection-valued attribute `y` declared by class `X`, where the type of `y` is `Y`, the metamodel class must contain a declaration as follows:

```
public static volatile SingularAttribute<X, Y> y;
```

- For every persistent collection-valued attribute *z* declared by class *X*, where the element type of *z* is *Z*, the metamodel class must contain a declaration as follows:

- if the collection type of *z* is `java.util.Collection`, then

```
public static volatile CollectionAttribute<X, Z> z;
```

- if the collection type of *z* is `java.util.Set`, then

```
public static volatile SetAttribute<X, Z> z;
```

- if the collection type of *z* is `java.util.List`, then

```
public static volatile ListAttribute<X, Z> z;
```

- if the collection type of *z* is `java.util.Map`, then

```
public static volatile MapAttribute<X, K, Z> z;
```

where *K* is the type of the key of the map in class *X*

- For every named query, named entity graph, or SQL result set mapping with name "*n*" declared by annotations of the class *X*, the metamodel class must contain a declaration as follows:

```
public static final String T_N = "n";
```

where the prefix *T* is the string `QUERY`, `GRAPH`, or `MAPPING`, as appropriate, depending on the annotation type, and the suffix *N* is obtained by transforming each lowercase character in the name *n* to uppercase, inserting an underscore if the character following the transformed character is uppercase, and then replacing each character which is not a legal Java identifier character with an underscore.

- For every named query with name "*n*" and query result class *R* declared by annotations of the class *X*, the metamodel class must contain a declaration as follows:

```
public static volatile TypedQueryReference<R> _n_;
```

where *n* is the name "*n*" with every character which is not a legal Java identifier character replaced with an underscore.

- For every named entity graph with name "*n*" declared by annotations of the class *X*, the metamodel class must contain a declaration as follows:

```
public static volatile EntityGraph<X> _n_;
```

where *n* is the name "*n*" with every character which is not a legal Java identifier character replaced with an underscore.

Import statements must be included for the needed `jakarta.persistence` and `jakarta.persistence.metamodel` types as appropriate and all classes *X*, *Y*, *Z*, *R*, and *K*.



Implementations of this specification are not required to resolve naming collisions resulting from the rules above when generating canonical metamodel classes.



Implementations of this specification are not required to support the use of non-canonical metamodel

classes. Applications that use non-canonical metamodel classes will not be portable.

5.1.1.1. Example Canonical Metamodel

Assume the `Order` entity below.

```
package com.example;

import java.util.Set;
import java.math.BigDecimal;
import jakarta.persistence.Entity;
import jakarta.persistence.Id;
import jakarta.persistence.ManyToOne;
import jakarta.persistence.OneToMany;

@Entity
public class Order {
    @Id
    Integer orderId;

    @ManyToOne
    Customer customer;

    @OneToMany
    Set<Item> lineItems;

    Address shippingAddress;

    BigDecimal totalCost;

    // ...
}
```

The corresponding canonical metamodel class, `Order_`, is as follows:

```
package com.example;

import java.math.BigDecimal;
import jakarta.persistence.metamodel.EntityType;
import jakarta.persistence.metamodel.SingularAttribute;
import jakarta.persistence.metamodel.SetAttribute;
import jakarta.persistence.metamodel.StaticMetamodel;

@StaticMetamodel(Order.class)
public class Order_ {
    public static volatile EntityType<Order> class_;

    public static volatile SingularAttribute<Order, Integer> orderId;
    public static volatile SingularAttribute<Order, Customer> customer;
    public static volatile SetAttribute<Order, Item> lineItems;
    public static volatile SingularAttribute<Order, Address> shippingAddress;
    public static volatile SingularAttribute<Order, BigDecimal> totalCost;

    public static final String LINE_ITEMS = "lineItems";
    public static final String ORDER_ID = "orderId";
    public static final String SHIPPING_ADDRESS = "shippingAddress";
    public static final String TOTAL_COST = "totalCost";
    public static final String CUSTOMER = "customer";
}
```

5.1.2. Bootstrapping the Static Metamodel

When the entity manager factory for a persistence unit is created, it is the responsibility of the persistence provider to initialize the state of the static metamodel classes representing managed classes belonging to the persistence unit. Any generated metamodel classes must be accessible on the classpath.

Persistence providers must support the use of canonical metamodel classes. Persistence providers may, but are not required to, support the use of non-canonical metamodel classes.

5.2. Runtime Access to Metamodel

The interfaces defined in `jakarta.persistence.metamodel` provide for dynamic access to a metamodel of the persistent state and relationships of the managed classes of a persistence unit.

An instance of `Metamodel` may be obtained by calling the `getMetamodel()` method of `EntityManagerFactory` or `EntityManager`.

The complete metamodel API may be found in [Appendix D](#).

[1] We expect that the option of different packages will be provided in a future release of this specification.

[2] If the class was generated, it should also be annotated with either `javax.annotation.processing.Generated` or `jakarta.annotation.Generated`. The use of any other annotations on static metamodel classes is undefined.

Chapter 6. Criteria API

The Jakarta Persistence Criteria API is used to define queries through the construction of object-based query definition objects, rather than use of the string-based approach of the Jakarta Persistence query language described in [Chapter 4](#).

This chapter provides the full definition of the Criteria API.

6.1. Overview

The Jakarta Persistence Criteria API, like the Jakarta Persistence query language is based on the abstract persistence schema of entities, their embedded objects, and their relationships as its data model. This abstract persistence schema is materialized in the form of metamodel objects over which the Criteria API operates. The semantics of criteria queries are designed to reflect those of Jakarta Persistence query language queries.

The complete criteria query API may be found in [Appendix C](#).

The syntax of the Criteria API is designed to allow the construction of an object-based query “graph”, whose nodes correspond to the semantic query elements.

Java language variables can be used to reference individual nodes in a criteria query object as it is constructed and/or modified. Such variables, when used to refer to the entities and embeddable types that constitute the query domain, play a role analogous to that of the identification variables of the Jakarta Persistence query language.

These concepts are further described in the sections that follow. Sections [Section 6.2](#) through [Section 6.6](#) describe the construction and modification of criteria query objects. Additional requirements on the persistence provider are described in [Section 6.7](#).

The metamodel on which criteria queries are based was already presented in [Chapter 5](#). The static metamodel classes which are used to construct strongly-typed criteria queries are described in [Section 5.1](#).

6.2. Criteria Query API Usage

The `jakarta.persistence.criteria` API interfaces are designed both to allow criteria queries to be constructed in a strongly-typed manner, using metamodel objects to provide type safety, and to allow for string-based use as an alternative:

Metamodel objects are used to specify navigation through joins and through path expressions^[1]. Typesafe navigation is achieved by specification of the source and target types of the navigation.

Strings may be used as an alternative to metamodel objects, whereby joins and navigation are specified by use of strings that correspond to attribute names.

Using either the approach based on metamodel objects or the string-based approach, queries can be constructed both statically and dynamically. Both approaches are equivalent in terms of the range of queries that can be expressed and operational semantics.

[Section 6.3](#) provides a description of the use of the criteria API interfaces. This section is illustrated on the basis of the construction of strongly-typed queries using static metamodel classes. [Section 6.4](#) describes how the `jakarta.persistence.metamodel` API can be used to construct strongly-typed queries in the absence of such classes. String-based use of the criteria API is described in [Section 6.5](#).

6.3. Constructing Criteria Queries

A criteria query is constructed through the creation and modification of an instance of the `CriteriaQuery` interface found in [Section C.3](#).

The `CriteriaBuilder` interface found in [Section C.1](#) is used to construct `CriteriaQuery`, `CriteriaUpdate`, and `CriteriaDelete` objects. The `CriteriaBuilder` implementation is accessed through the `getCriteriaBuilder` method of the `EntityManager` or `EntityManagerFactory` interface.

For example:

```
@PersistenceUnit
EntityManagerFactory emf;

CriteriaBuilder cb = emf.getCriteriaBuilder();
```

6.3.1. CriteriaQuery Creation

A `CriteriaQuery` object is created by means of one of the `createQuery` methods or the `createTupleQuery` method of the `CriteriaBuilder` interface. A `CriteriaQuery` object is typed according to its expected result type when the `CriteriaQuery` object is created. A `TypedQuery` instance created from the `CriteriaQuery` object by means of the `EntityManager` `createQuery` method will result in instances of this type when the resulting query is executed.

The following methods are provided for the creation of `CriteriaQuery` objects:

```
<T> CriteriaQuery<T> createQuery(Class<T> resultClass);

CriteriaQuery<Tuple> createTupleQuery();

CriteriaQuery<Object> createQuery();
```

Methods for the creation of update and delete queries are described in [Section 6.3.15](#).

The methods `<T> CriteriaQuery<T> createQuery(Class<T> resultClass)` and `createTupleQuery` provide for typing of criteria query results and for typesafe query execution using the `TypedQuery` API.

The effect of the `createTupleQuery` method is semantically equivalent to invoking the `createQuery` method with the `Tuple.class` argument. The `Tuple` interface supports the extraction of multiple selection items in a strongly typed manner. See [Section B.9](#) and [Section B.10](#).

The `CriteriaQuery<Object> createQuery()` method supports both the case where the `select` or `multiselect` method specifies only a single selection item and where the `multiselect` method specifies multiple selection items. If only a single item is specified, an instance of type `Object` will be returned for each result of the query execution. If multiple selection items are specified, an instance of type `Object[]` will be instantiated and returned for each result of the execution.

See [Section 6.3.11](#) for further discussion of the specification of selection items.

6.3.2. Query Roots

A `CriteriaQuery` object defines a query over one or more entity, embeddable, or basic abstract schema types. The root objects of the query are entities, from which the other types are reached by navigation. A query root plays a role analogous to that of a range variable in the Jakarta Persistence query language and forms the basis for defining the domain of the query.

A query root is created and added to the query by use of the `from` method of the `AbstractQuery` interface (from which both the `CriteriaQuery` and `Subquery` interfaces inherit). The argument to the `from` method is the entity class or `EntityType`

instance for the entity. The result of the `from` method is a `Root` object. The `Root` interface extends the `From` interface, which represents objects that may occur in the `from` clause of a query.

A `CriteriaQuery` object may have more than one root. The addition of a query root has the semantic effect of creating a cartesian product between the entity type referenced by the added root and those of the other roots.

The following query illustrates the definition of a query root. When executed, this query causes all instances of the `Customer` entity to be returned.

```
CriteriaBuilder cb = ...
CriteriaQuery<Customer> q = cb.createQuery(Customer.class);
Root<Customer> customer = q.from(Customer.class);
q.select(customer);
```

6.3.3. Joins

The `join` methods of the `From` interface extend the query domain by creating a join with a related class that can be navigated to or that is an element of the given class of the query domain.

The target of the join is specified by the corresponding `SingularAttribute` or collection-valued attribute (`CollectionAttribute`, `SetAttribute`, `ListAttribute`, or `MapAttribute`) of the corresponding metamodel class.^{[2] [3]}

The `join` methods may be applied to instances of the `Root` and `Join` types.

The result of a `join` method is a `Join` object (instance of the `Join`, `CollectionJoin`, `SetJoin`, `ListJoin`, or `MapJoin` types) that captures the source and target types of the join.

For example, given the `Order` entity and corresponding `Order_` metamodel class shown in [Section 5.1.1.1](#), a join to the `lineItems` of the order would be expressed as follows:

```
CriteriaQuery<Order> q = cb.createQuery(Order.class);
Root<Order> order = q.from(Order.class);
Join<Order, Item> item = order.join(Order_.lineItems);
q.select(order);
```

The argument to the `join` method, `Order_.lineItems`, is of type `jakarta.persistence.metamodel.SetAttribute<Order, Item>`.

The `join` methods have the same semantics as the corresponding Jakarta Persistence query language operations, as described in [Section 4.4.7](#).

Example:

```
CriteriaBuilder cb = ...
CriteriaQuery<String> q = cb.createQuery(String.class);
Root<Customer> customer = q.from(Customer.class);
Join<Customer, Order> order = customer.join(Customer_.orders);
Join<Order, Item> item = order.join(Order_.lineItems);
q.select(customer.get(Customer_.name)
    .where(cb.equal(item.get(Item_.product).get(Product_.productType), "printer")));
```

This query is equivalent to the following Jakarta Persistence query language query:

```
SELECT c.name
FROM Customer c JOIN c.orders o JOIN o.lineItems i
WHERE i.product.productType = 'printer'
```

Joins can be chained, thus allowing this query to be written more concisely:

```
CriteriaQuery<String> q = cb.createQuery(String.class);
Root<Customer> customer = q.from(Customer.class);
Join<Order, Item> item = customer.join(Customer_.orders).join(Order_.lineItems);
q.select(customer.get(Customer_.name))
    .where(cb.equal(item.get(Item_.product).get(Product_.productType), "printer"));
```

By default, the join method defines an inner join. Outer joins are defined by explicitly specifying a JoinType argument.

The following query uses a left outer join:

```
CriteriaQuery<Customer> q = cb.createQuery(Customer.class);
Root<Customer> customer = q.from(Customer.class);
Join<Customer, Order> order = customer.join(Customer_.orders, JoinType.LEFT);
q.where(cb.equal(customer.get(Customer_.status), 1))
    .select(customer);
```

This query is equivalent to the following Jakarta Persistence query language query:

```
SELECT c FROM Customer c LEFT JOIN c.orders o WHERE c.status = 1
```

On-conditions can be specified for joins. The following query uses an on-condition with a left outer join:

```
CriteriaQuery<Tuple> q = cb.createTupleQuery();
Root<Supplier> s = q.from(Supplier.class);
Join<Supplier, Product> p = s.join(Supplier_.products, JoinType.LEFT);
p.on(cb.equal(p.get(Product_.status), "inStock"));
q.groupBy(s.get(Supplier_.name));
q.multiselect(s.get(Supplier_.name), cb.count(p));
```

This query is equivalent to the following Jakarta Persistence query language query:

```
SELECT s.name, COUNT(p)
FROM Suppliers s LEFT JOIN s.products p ON p.status = 'inStock'
GROUP BY s.name
```

6.3.4. Fetch Joins

Fetch joins are specified by means of the fetch method. The fetch method specifies that the referenced association or attribute is to be fetched as a side effect of the execution of the query. The fetch method can be applied to a Root or Join instance.

An association or attribute referenced by the fetch method must be referenced from an entity or embeddable that is returned as the result of the query. A fetch join has the same join semantics as the corresponding inner or outer join, except that the related objects are not top-level objects in the query result and cannot be referenced elsewhere by the query. See [Section 4.4.5.3](#).

The fetch method must not be used in a subquery.

Multiple levels of fetch joins are not required to be supported by an implementation of this specification. Applications that use multi-level fetch joins will not be portable.

Example:

```
CriteriaQuery<Department> q = cb.createQuery(Department.class);
Root<Department> d = q.from(Department.class);
d.fetch(Department.employees, JoinType.LEFT);
q.where(cb.equal(d.get(Department_.deptno), 1)).select(d);
```

This query is equivalent to the following Jakarta Persistence query language query:

```
SELECT d
FROM Department d LEFT JOIN FETCH d.employees
WHERE d.deptno = 1
```

6.3.5. Path Navigation

A Path instance can be a Root instance, a Join instance, a Path instance that has been derived from another Path instance by means of the `get` navigation method, or a Path instance derived from a map-valued association or element collection by use of the `key` or `value` method.

When a criteria query is executed, path navigation—like path navigation using the Jakarta Persistence query language—is obtained using “inner join” semantics. That is, if the value of a non-terminal Path instance is null, the path is considered to have no value, and does not participate in the determination of the query result. See [Section 4.4.4](#).

The `get` method is used for path navigation. The argument to the `get` method is specified by the corresponding SingularAttribute or collection-valued attribute (CollectionAttribute, SetAttribute, ListAttribute, or MapAttribute) of the corresponding metamodel class^[4].

Example 1:

In the following example, `ContactInfo` is an embeddable class consisting of an address and set of phones. `Phone` is an entity.

```
CriteriaQuery<Vendor> q = cb.createQuery(Vendor.class);
Root<Employee> emp = q.from(Employee.class);
Join<ContactInfo, Phone> phone =
    emp.join(Employee_.contactInfo).join(ContactInfo_.phones);
q.where(cb.equal(emp.get(Employee_.contactInfo)
    .get(ContactInfo_.address)
    .get(Address_.zipcode), "95054"))
    .select(phone.get(Phone_.vendor));
```

The following Jakarta Persistence query language query is equivalent:

```
SELECT p.vendor
FROM Employee e JOIN e.contactInfo.phones p
WHERE e.contactInfo.address.zipcode = '95054'
```

Example 2:

In this example, the `photos` attribute corresponds to a map from photo label to filename. The map key is a string, the value an object. The result of this query will be returned as a `Tuple` object whose elements are of types `String` and `Object`. The `multiselect` method, described further in [Section 6.3.11](#), is used to specify that the query returns multiple selection items.

```
CriteriaQuery<Tuple> q = cb.createTupleQuery();
Root<Item> item = q.from(Item.class);
MapJoin<Item, String, Object> photo = item.join(Item_.photos);
q.multiselect(item.get(Item_.name), photo)
    .where(cb.like(photo.key(), "%egret%"));
```

This query is equivalent to the following Jakarta Persistence query language query:

```
SELECT i.name, p
FROM Item i JOIN i.photos p
```

```
WHERE KEY(p) LIKE '%egret%'
```

6.3.6. Restricting the Query Result

The result of a query can be restricted by specifying one or more predicate conditions. Restriction predicates are applied to the `CriteriaQuery` object by means of the `where` method. Invocation of the `where` method results in the modification of the `CriteriaQuery` object with the specified restriction(s).

The argument to the `where` method can be either an `Expression<Boolean>` instance or zero or more `Predicate` instances. A predicate can be either simple or compound.

A simple predicate is created by invoking one of the conditional methods of the `CriteriaBuilder` interface, or by the `isNull`, `isNotNull`, and `in` methods of the `Expression` interface. The semantics of the conditional methods—e.g., `equal`, `notEqual`, `gt`, `ge`, `lt`, `le`, `between`, and `like`—mirror those of the corresponding Jakarta Persistence query language operators as described in [Chapter 4](#).

Compound predicates are constructed by means of the `and`, `or`, and `not` methods of the `CriteriaBuilder` interface.

The restrictions upon the types to which conditional operations are permitted to be applied are the same as the respective operators of the Jakarta Persistence query language as described in subsections [Section 4.6.3](#) through [Section 4.7](#). The same null value semantics as described in [Section 4.6.13](#) and the subsections of [Section 4.6](#) apply. The equality and comparison semantics described in [Section 4.6.14](#) likewise apply.

Example 1:

```
CriteriaQuery<TransactionHistory> q = cb.createQuery(TransactionHistory.class);
Root<CreditCard> cc = q.from(CreditCard.class);
ListJoin<CreditCard,TransactionHistory> t = cc.join(CreditCard_.transactionHistory);
q.select(t)
    .where(cb.equal(cc.get(CreditCard_.customer)
        .get(Customer_.accountNum), 321987),
        cb.between(t.index(), 0, 9));
```

This query is equivalent to the following Jakarta Persistence query language query:

```
SELECT t
FROM CreditCard c JOIN c.transactionHistory t
WHERE c.customer.accountNum = 321987 AND INDEX(t) BETWEEN 0 AND 9
```

Example 2:

```
CriteriaQuery<Order> q = cb.createQuery(Order.class);
Root<Order> order = q.from(Order.class);
q.where(cb.isEmpty(order.get(Order_.lineItems)))
    .select(order);
```

This query is equivalent to the following Jakarta Persistence query language query:

```
SELECT o
FROM Order o
WHERE o.lineItems IS EMPTY
```

6.3.7. Downcasting

Downcasting by means of the `treat` method is supported in joins and in the construction of `where` conditions.

Example 1:

```
CriteriaQuery<String> q = cb.createQuery(String.class);
Root<Order> order = q.from(Order.class);
Join<Order, Book> book = cb.treat(order.join(Order_.product), Book.class);
q.select(book.get(Book_.isbn));
```

This query is equivalent to the following Jakarta Persistence query language query.

```
SELECT b.ISBN
FROM Order o JOIN TREAT(o.product AS Book) b
```

Example 2:

```
CriteriaQuery<Customer> q = cb.createQuery(Customer.class);
Root<Customer> customer = q.from(Customer.class);
Join<Customer, Order> order = customer.join(Customer_.orders);
q.where(
    cb.equal(cb.treat(order.get(Order_.product), Book.class).get(Book_.name), "Iliad"));
q.select(customer);
```

This query is equivalent to the following Jakarta Persistence query language query:

```
SELECT c
FROM Customer c JOIN c.orders o
WHERE TREAT(o.product AS Book).name = 'Iliad'
```

Example 3:

```
CriteriaQuery<Employee> q = cb.createQuery(Employee.class);
Root<Employee> e = q.from(Employee.class);
q.where(
    cb.or(cb.gt(cb.treat(e, Exempt.class).get(Exempt_.vacationDays), 10),
        cb.gt(cb.treat(e, Contractor.class).get(Contractor_.hours), 100)));
```

This query is equivalent to the following Jakarta Persistence query language query:

```
SELECT e
FROM Employee e
WHERE TREAT(e AS Exempt).vacationDays > 10
    OR TREAT(e AS Contractor).hours > 100
```

6.3.8. Expressions

An `Expression` or one of its subtypes can be used in the construction of the query's select list or in the construction of where or having method conditions.

Paths and boolean predicates are expressions.

Other expressions are created by means of the methods of the `CriteriaBuilder` interface. The `CriteriaBuilder` interface provides methods corresponding to the built-in arithmetic, string, datetime, and case operators and functions of the Jakarta Persistence query language.

Example 1:

```
CriteriaQuery<Tuple> q = cb.createTupleQuery();
Root<Customer> cust = q.from(Customer.class);
Join<Customer, Order> order = cust.join(Customer_.orders);
Join<Customer, Address> addr = cust.join(Customer_.address);
q.where(cb.equal(addr.get(Address_.state), "CA"),
        cb.equal(addr.get(Address_.county), "Santa Clara"));
```

```
q.multiselect(order.get(Order_.quantity),
    cb.prod(order.get(Order_.totalCost), 1.08),
    addr.get(Address_.zipcode));
```

The following Jakarta Persistence query language query is equivalent:

```
SELECT o.quantity, o.totalCost*1.08, a.zipcode
FROM Customer c JOIN c.orders o JOIN c.address a
WHERE a.state = 'CA' AND a.county = 'Santa Clara'
```

Example 2:

```
CriteriaQuery<Employee> q = cb.createQuery(Employee.class);
Root<Employee> emp = q.from(Employee.class);
q.select(emp)
    .where(cb.notEqual(emp.type(), Exempt.class));
```

The type method can only be applied to a path expression. Its result denotes the type navigated to by the path.

The following Jakarta Persistence query language query is equivalent:

```
SELECT e
FROM Employee e
WHERE TYPE(e) <> Exempt
```

Example 3:

```
CriteriaQuery<String> q = cb.createQuery(String.class);
Root<Course> c = q.from(Course.class);
ListJoin<Course, Student> w = c.join(Course_.studentWaitlist);
q.where(cb.equal(c.get(Course_.name), "Calculus"),
    cb.equal(w.index(), 0))
    .select(w.get(Student_.name));
```

The index method can be applied to a ListJoin object that corresponds to a list for which an order column has been specified. Its result denotes the position of the item in the list.

The following Jakarta Persistence query language query is equivalent:

```
SELECT w.name
FROM Course c JOIN c.studentWaitlist w
WHERE c.name = 'Calculus' AND INDEX(w) = 0
```

Example 4:

```
CriteriaQuery<BigDecimal> q = cb.createQuery(BigDecimal.class);
Root<Order> order = q.from(Order.class);
Join<Order, Item> item = order.join(Order_.lineItems);
Join<Order, Customer> cust = order.join(Order_.customer);

q.where(
    cb.equal(cust.get(Customer_.lastName), "Smith"),
    cb.equal(cust.get(Customer_.firstName), "John"));
q.select(cb.sum(item.get(Item_.price)));
```

The aggregation methods avg, max, min, sum, count can only be used in the construction of the select list or in having method conditions.

The following Jakarta Persistence query language query is equivalent:

```
SELECT SUM(i.price)
FROM Order o JOIN o.lineItems i JOIN o.customer c
WHERE c.lastName = 'Smith' AND c.firstName = 'John'
```

Example 5:

```
CriteriaQuery<Integer> q = cb.createQuery(Integer.class);
Root<Department> d = q.from(Department.class);
q
    .where(cb.equal(d.get(Department_.name), "Sales"))
    .select(cb.size(d.get(Department_.employees)));
```

The size method can be applied to a path expression that corresponds to an association or element collection. Its result denotes the number of elements in the association or element collection.

The following Jakarta Persistence query language query is equivalent:

```
SELECT SIZE(d.employees)
FROM Department d
WHERE d.name = 'Sales'
```

Example 6:

Both simple and general case expressions are supported. The query below illustrates use of a general case expression.

```
CriteriaQuery<Tuple> q = cb.createTupleQuery();
Root<Employee> e = q.from(Employee.class);
q.where(
    cb.equal(e.get(Employee_.department).get(Department_.name), "Engineering"));
q.multiselect(
    e.get(Employee_.name),
    cb.selectCase()
        .when(
            cb.equal(e.get(Employee_.rating), 1),
            cb.prod(e.get(Employee_.salary), 1.1))
        .when(
            cb.equal(e.get(Employee_.rating), 2),
            cb.prod(e.get(Employee_.salary), 1.2))
        .otherwise(cb.prod(e.get(Employee_.salary), 1.01)));
```

The following Jakarta Persistence query language query is equivalent:

```
SELECT e.name,
CASE
    WHEN e.rating = 1 THEN e.salary * 1.1
    WHEN e.rating = 2 THEN e.salary * 1.2
    ELSE e.salary * 1.01
END
FROM EMPLOYEE e
WHERE e.department.name = 'Engineering'
```

6.3.8.1. Result Types of Expressions

The `getJavaType` method, as defined in the `TupleElement` interface, returns the runtime type of the object on which it is invoked.

In the case of the `In`, `Case`, `SimpleCase`, and `Coalesce` builder interfaces, the runtime results of the `getJavaType` method may differ from the `Expression` type and may vary as the expression is incrementally constructed. For non-numerical

operands, the implementation must return the most specific common superclass of the types of the operands used to form the result.

In the case of the two-argument `sum`, `prod`, `diff`, `quot`, `coalesce`, and `nullif` methods, and the `In`, `Case`, `SimpleCase`, and `Coalesce` builder methods, the runtime result types will differ from the `Expression` type when the latter is `Number`. The following rules must be observed by the implementation when materializing the results of numeric expressions involving these methods. These rules correspond to those specified for the Jakarta Persistence query language as defined in [Section 4.7.13](#).

- If there is an operand of type `Double`, the result of the operation is of type `Double`;
- otherwise, if there is an operand of type `Float`, the result of the operation is of type `Float`;
- otherwise, if there is an operand of type `BigDecimal`, the result of the operation is of type `BigDecimal`;
- otherwise, if there is an operand of type `BigInteger`, the result of the operation is of type `BigInteger`, unless the method is `quot`, in which case the numeric result type is not further defined;
- otherwise, if there is an operand of type `Long`, the result of the operation is of type `Long`, unless the method is `quot`, in which case the numeric result type is not further defined;
- otherwise, if there is an operand of integral type, the result of the operation is of type `Integer`, unless the method is `quot`, in which case the numeric result type is not further defined.



Users should note that the semantics of the SQL division operation are not standard across databases. In particular, when both operands are of integral types, the result of the division operation will be an integral type in some databases, and a non-integral type in others. Portable applications should not assume a particular result type.

6.3.9. Literals

An `Expression` literal instance is obtained by passing a value to the `literal` method of the `CriteriaBuilder` interface. An `Expression` instance representing a null is created by the `nullLiteral` method of the `CriteriaBuilder` interface.

Example:

```
CriteriaQuery<String> q = cb.createQuery(String.class);
Root<Employee> emp = q.from(Employee.class);
Join<Employee, FrequentFlierPlan> fp = emp.join(Employee_.frequentFlierPlan);

q.select(
    cb.<String>selectCase()
        .when(
            cb.gt(fp.get(FrequentFlierPlan_.annualMiles), 50000),
            cb.literal("Platinum"))
        .when(
            cb.gt(fp.get(FrequentFlierPlan_.annualMiles), 25000),
            cb.literal("Silver"))
        .otherwise(cb.nullLiteral(String.class)));
```

The following Jakarta Persistence query language query is equivalent:

```
SELECT
  CASE
    WHEN fp.annualMiles > 50000 THEN 'Platinum'
    WHEN fp.annualMiles > 25000 THEN 'Gold'
    ELSE NULL
  END
```


6.3.10. Parameter Expressions

A `ParameterExpression` instance is an expression that corresponds to a parameter whose value will be supplied before the query is executed. Parameter expressions can only be used in the construction of conditional predicates.

Example:

```
CriteriaQuery<Customer> q = cb.createQuery(Customer.class);
Root<Customer> c = q.from(Customer.class);
ParameterExpression<Integer> param = cb.parameter(Integer.class);

q.select(c)
  .where(cb.equal(c.get(Customer_.status), param));
```

If a name is supplied when the `ParameterExpression` instance is created, the parameter may also be treated as a named parameter when the query is executed:

```
CriteriaQuery<Customer> q =
  cb.createQuery(Customer.class);

Root<Customer> c = q.from(Customer.class);
ParameterExpression<Integer> param = cb.parameter(Integer.class, "stat");
q.select(c).where(cb.equal(c.get(Customer_.status), param));
```

This is equivalent to the following query in the Jakarta Persistence query language:

```
SELECT c FROM Customer c WHERE c.status = :stat
```

6.3.11. Specifying the Select List

The select list of a query is specified by use of the `select` or `multiselect` methods of the `CriteriaQuery` interface. The arguments to the `select` and `multiselect` methods are `Selection` instances.



Portable applications should use the `select` or `multiselect` method to specify the query's selection list. Applications that do not use one of these methods will not be portable.

The `select` method takes a single `Selection` argument, which can be either an `Expression` instance or a `CompoundSelection` instance. The type of the `Selection` item must be assignable to the defined `CriteriaQuery` result type, as described in [Section 6.3.1](#).

The `construct`, `tuple` and `array` methods of the `CriteriaBuilder` interface are used to aggregate multiple selection items into a `CompoundSelection` instance.

The `multiselect` method also supports the specification and aggregation of multiple selection items. When the `multiselect` method is used, the aggregation of the selection items is determined by the result type of the `CriteriaQuery` object as described in [Section 6.3.1](#).

A `Selection` instance passed to the `construct`, `tuple`, `array`, or `multiselect` methods can be one of the following:

- An `Expression` instance.
- A `Selection` instance obtained as the result of the invocation of the `CriteriaBuilder` `construct` method.

The `distinct` method of the `CriteriaQuery` interface is used to specify that duplicate values must be eliminated from the query result. If the `distinct` method is not used or `distinct(false)` is invoked on the criteria query object, duplicate values are not eliminated. When `distinct(true)` is used, and the select items include embeddable objects or map entry results, the elimination of duplicates is undefined.

The semantics of the `construct` method used in the selection list is as described in [Section 4.9.2](#). The semantics of embeddables returned by the selection list areas described in [Section 4.9.4](#).

Example 1:

In the following example, `videoInventory` is a `Map` from the entity `Movie` to the number of copies in stock.

```
CriteriaQuery<Tuple> q = cb.createTupleQuery();
Root<VideoStore> v = q.from(VideoStore.class);
MapJoin<VideoStore, Movie, Integer> inv = v.join(VideoStore_.videoInventory);

q.multiselect(
    v.get(VideoStore_.location).get(Address_.street),
    inv.key().get(Movie_.title),
    inv);
q.where(cb.equal(v.get(VideoStore_.location).get(Address_.zipcode), "94301"),
    cb.gt(inv, 0));
```

This query is equivalent to the following, in which the `tuple` method is used:

```
CriteriaQuery<Tuple> q = cb.createTupleQuery();
Root<VideoStore> v = q.from(VideoStore.class);
MapJoin<VideoStore, Movie, Integer> inv = v.join(VideoStore_.videoInventory);

q.select(cb.tuple(
    v.get(VideoStore_.location).get(Address_.street),
    inv.key().get(Movie_.title),
    inv));
q.where(cb.equal(v.get(VideoStore_.location).get(Address_.zipcode), "94301"),
    cb.gt(inv, 0));
```

Both are equivalent to the following Jakarta Persistence query language query:

```
SELECT v.location.street, KEY(i).title, VALUE(i)
FROM VideoStore v JOIN v.videoInventory i
WHERE v.location.zipcode = '94301' AND VALUE(i) > 0
```

Example 2:

The following two queries are equivalent to the Jakarta Persistence query language query above. Because the result type is not specified by the `createQuery` method, an `Object[]` is returned as a result of the query execution:

```
CriteriaQuery<Object> q = cb.createQuery();
Root<VideoStore> v = q.from(VideoStore.class);
MapJoin<VideoStore, Movie, Integer> inv = v.join(VideoStore_.videoInventory);

q.multiselect(
    v.get(VideoStore_.location).get(Address_.street),
    inv.key().get(Movie_.title),
    inv);

q.where(cb.equal(v.get(VideoStore_.location).get(Address_.zipcode), "94301"),
    cb.gt(inv, 0));
```

Equivalently:

```
CriteriaQuery<Object> q = cb.createQuery();
Root<VideoStore> v = q.from(VideoStore.class);
MapJoin<VideoStore, Movie, Integer> inv = v.join(VideoStore_.videoInventory);

q.select(cb.array(
    v.get(VideoStore_.location).get(Address_.street),
```

```

        inv.key().get(Movie_.title),
        inv));
q.where(cb.equal(v.get(VideoStore_.location).get(Address_.zipcode), "94301"),
        cb.gt(inv, 0));

```

Example 3:

The following example illustrates the specification of a constructor.

```

CriteriaQuery<CustomerDetails> q = cb.createQuery(CustomerDetails.class);
Root<Customer> c = q.from(Customer.class);
Join<Customer, Order> o = c.join(Customer_.orders);

q.where(cb.gt(o.get(Order_.quantity), 100));
q.select(cb.construct(
    CustomerDetails.class,
    c.get(Customer_.id),
    c.get(Customer_.status),
    o.get(Order_.quantity)));

```

The following Jakarta Persistence query language query is equivalent:

```

SELECT NEW com.acme.example.CustomerDetails(c.id, c.status, o.quantity)
FROM Customer c JOIN c.orders o
WHERE o.quantity > 100

```

6.3.11.1. Assigning Aliases to Selection Items

The `alias` method of the `Selection` interface can be used to assign an alias to a selection item. The alias may then later be used to extract the corresponding item from the query result when the query is executed. The `alias` method assigns the given alias to the `Selection` item. Once assigned, the alias cannot be changed.

Example:

```

CriteriaQuery<Tuple> q = cb.createTupleQuery();
Root<Customer> c = q.from(Customer.class);
Join<Customer, Order> o = c.join(Customer_.orders);
Join<Customer, Address> a = c.join(Customer_.address);

q.where(cb.equal(c.get(Customer_.id), 97510));
q.multiselect(
    o.get(Order_.quantity).alias("quantity"),
    cb.prod(o.get(Order_.totalCost), 1.08).alias("taxedCost"),
    a.get(Address_.zipcode).alias("zipcode"));

TypedQuery<Tuple> typedQuery = em.createQuery(q);
Tuple result = typedQuery.getSingleResult();
Double cost = (Double)result.get("taxedCost");

```

6.3.12. Subqueries

Both correlated and non-correlated subqueries can be used in restriction predicates. A subquery is constructed through the creation and modification of a `Subquery` object.

A `Subquery` instance can be passed as an argument to the `all`, `any`, or `some` methods of the `CriteriaBuilder` interface for use in conditional expressions.

A `Subquery` instance can be passed to the `CriteriaBuilder` `exists` method to create a conditional predicate.

Example 1: Non-correlated subquery

The query below contains a non-correlated subquery. A non-correlated subquery does not reference objects of the query of which it is a subquery. In particular, Root, Join, and Path instances are not shared between the subquery and the criteria query instance of which it is a subquery.

```
// create criteria query instance, with root Customer
CriteriaQuery<Customer> q = cb.createQuery(Customer.class);
Root<Customer> goodCustomer = q.from(Customer.class);

// create subquery instance, with root Customer
// the Subquery object is typed according to its return type
Subquery<Double> sq = q.subquery(Double.class);
Root<Customer> customer = sq.from(Customer.class);

// the result of the first query depends on the subquery
q.where(cb.lt(
    goodCustomer.get(Customer_.balanceOwed),
    sq.select(cb.avg(customer.get(Customer_.balanceOwed))))));
q.select(goodCustomer);
```

This query corresponds to the following Jakarta Persistence query language query.

```
SELECT goodCustomer
FROM Customer goodCustomer
WHERE goodCustomer.balanceOwed < (SELECT AVG(c.balanceOwed) FROM Customer c)
```

Example 2: Correlated subquery

```
// create CriteriaQuery instance, with root Employee
CriteriaQuery<Employee> q = cb.createQuery(Employee.class);
Root<Employee> emp = q.from(Employee.class);

// create Subquery instance, with root Employee
Subquery<Employee> sq = q.subquery(Employee.class);
Root<Employee> spouseEmp = sq.from(Employee.class);

// the subquery references the root of the containing query
sq.where(cb.equal(spouseEmp, emp.get(Employee_.spouse)))
    .select(spouseEmp);

// an exists condition is applied to the subquery result:
q.where(cb.exists(sq));
q.select(emp).distinct(true);
```

The above query corresponds to the following Jakarta Persistence query language query.

```
SELECT DISTINCT emp
FROM Employee emp
WHERE EXISTS (
    SELECT spouseEmp
    FROM Employee spouseEmp
    WHERE spouseEmp = emp.spouse)
```

Example 3: Subquery qualified by all()

```
// create CriteriaQuery instance, with root Employee
CriteriaQuery<Employee> q = cb.createQuery(Employee.class);
Root<Employee> emp = q.from(Employee.class);

// create Subquery instance, with root Manager
Subquery<BigDecimal> sq = q.subquery(BigDecimal.class);
Root<Manager> manager = sq.from(Manager.class);
```

```

sq.select(manager.get(Manager_.salary));
sq.where(cb.equal(
    manager.get(Manager_.department),
    emp.get(Employee_.department)));

// an all expression is applied to the subquery result
q.select(emp)
    .where(cb.gt(emp.get(Employee_.salary), cb.all(sq)));

```

This query corresponds to the following Jakarta Persistence query language query:

```

SELECT emp
FROM Employee emp
WHERE emp.salary > ALL (
    SELECT m.salary
    FROM Manager m
    WHERE m.department = emp.department)

```

Example 4: A Special case

In order to express some correlated subqueries involving unidirectional relationships, it may be useful to correlate the domain of the subquery with the domain of the containing query. This is performed by using the `correlate` method of the Subquery interface.

For example:

```

CriteriaQuery<Customer> q = cb.createQuery(Customer.class);
Root<Customer> customer = q.from(Customer.class);
Subquery<Long> sq = q.subquery(Long.class);
Root<Customer> customerSub = sq.correlate(customer);
Join<Customer,Order> order = customerSub.join(Customer_.orders);

q.where(cb.gt(sq.select(cb.count(order)), 10))
    .select(customer);

```

This query corresponds to the following Jakarta Persistence query language query:

```

SELECT c
FROM Customer c
WHERE (SELECT COUNT(o) FROM c.orders o) > 10

```

Note that joins involving the derived subquery root do not affect the join conditions of the containing query. The following two query definitions thus differ in semantics:

```

CriteriaQuery<Order> q = cb.createQuery(Order.class);
Root<Order> order = q.from(Order.class);
Subquery<Integer> sq = q.subquery(Integer.class);
Root<Order> orderSub = sq.correlate(order);
Join<Order,Customer> customer = orderSub.join(Order_.customer);
Join<Customer,Account> account = customer.join(Customer_.accounts);

sq.select(account.get(Account_.balance));
q.where(cb.lt(cb.literal(10000), cb.all(sq)));

```

and

```

CriteriaQuery<Order> q = cb.createQuery(Order.class);
Root<Order> order = q.from(Order.class);
Join<Order,Customer> customer = order.join(Order_.customer);
Subquery<Integer> sq = q.subquery(Integer.class);
Join<Order,Customer> customerSub = sq.correlate(customer);

```

```

Join<Customer,Account> account = customerSub.join(Customer_.accounts);

sq.select(account.get(Account_.balance));
q.where(cb.lt(cb.literal(10000), cb.all(sq)));

```

The first of these queries will return orders that are not associated with customers, whereas the second will not. The corresponding Jakarta Persistence query language queries are the following:

```

SELECT o
FROM Order o
WHERE 10000 < ALL (
    SELECT a.balance
    FROM o.customer c JOIN c.accounts a)

```

and

```

SELECT o
FROM Order o JOIN o.customer c
WHERE 10000 < ALL (
    SELECT a.balance
    FROM c.accounts a)

```

6.3.13. GroupBy and Having

The `groupBy` method of the `CriteriaQuery` interface is used to define a partitioning of the query results into groups. The `having` method of the `CriteriaQuery` interface can be used to filter over the groups.

The arguments to the `groupBy` method are `Expression` instances.

When the `groupBy` method is used, each selection item that is not the result of applying an aggregate method must correspond to a path expression that is used for defining the grouping. Requirements on the types that correspond to the elements of the grouping and having constructs and their relationship to the select items are as specified in [Section 4.8](#).

Example:

```

CriteriaQuery<Tuple> q = cb.createTupleQuery();
Root<Customer> customer = q.from(Customer.class);

q.groupBy(customer.get(Customer_.status));
q.having(cb.in(customer.get(Customer_.status)).value(1).value(2));
q.select(cb.tuple(
    customer.get(Customer_.status),
    cb.avg(customer.get(Customer_.filledOrderCount)),
    cb.count(customer)));

```

This query is equivalent to the following Jakarta Persistence query language query:

```

SELECT c.status, AVG(c.filledOrderCount), COUNT(c)
FROM Customer c
GROUP BY c.status
HAVING c.status IN (1, 2)

```

6.3.14. Ordering the Query Results

The ordering of the results of a query is defined by use of the `orderBy` method of the `CriteriaQuery` instance. The arguments to the `orderBy` method are `Order` instances.

An `Order` instance is created by means of the `asc` and `desc` methods of the `CriteriaBuilder` interface. An argument to either of these methods must be one of the following:

- Any `Expression` instance that corresponds to an orderable state field of an entity or embeddable class abstract schema type that is specified as an argument to the `select` or `multiselect` method or that is an argument to a tuple or array constructor that is passed as an argument to the `select` method.
- Any `Expression` instance that corresponds to the same state field of the same entity or embeddable abstract schema type as an `Expression` instance that is specified as an argument to the `select` or `multiselect` method or that is an argument to a tuple or array constructor that is passed as an argument to the `select` method.
- An `Expression` instance that is specified as an argument to the `select` or `multiselect` method or that is an argument to a tuple or array constructor that is passed as an argument to the `select` method or that is semantically equivalent to such an `Expression` instance.

If more than one `Order` instance is specified, the order in which they appear in the argument list of the `orderBy` method determines the precedence, whereby the first item has highest precedence.

SQL rules for the ordering of null values apply, as described in [Section 4.10](#).

Example 1:

```
CriteriaQuery<Order> q = cb.createQuery(Order.class);
Root<Customer> c = q.from(Customer.class);
Join<Customer,Order> o = c.join(Customer_.orders);
Join<Customer,Address> a = c.join(Customer_.address);

q.where(cb.equal(a.get(Address_.state), "CA"));
q.select(o);
q.orderBy(cb.desc(o.get(Order_.quantity)),
          cb.asc(o.get(Order_.totalCost)));
```

This query corresponds to the following Jakarta Persistence query language query:

```
SELECT o
FROM Customer c JOIN c.orders o JOIN c.address a
WHERE a.state = 'CA'
ORDER BY o.quantity DESC, o.totalcost
```

Example 2:

```
CriteriaQuery<Tuple> q = cb.createTupleQuery();
Root<Customer> c = q.from(Customer.class);
Join<Customer, Order> o = c.join(Customer_.orders);
Join<Customer, Address> a = c.join(Customer_.address);

q.where(cb.equal(a.get(Address_.state), "CA"));
q.orderBy(cb.asc(o.get(Order_.quantity)),
          cb.asc(a.get(Address_.zipcode)));
q.multiselect(o.get(Order_.quantity),
              a.get(Address_.zipcode));
```

This query corresponds to the following Jakarta Persistence query language query:

```
SELECT o.quantity, a.zipcode
FROM Customer c JOIN c.orders o JOIN c.address a
WHERE a.state = 'CA'
ORDER BY o.quantity, a.zipcode
```

It can be equivalently expressed as follows:

```
CriteriaQuery<Tuple> q = cb.createTupleQuery();
Root<Customer> c = q.from(Customer.class);
Join<Customer, Order> o = c.join(Customer_.orders);
Join<Customer, Address> a = c.join(Customer_.address);

q.where(cb.equal(a.get(Address_.state), "CA"));
q.orderBy(cb.asc(o.get(Order_.quantity)),
    cb.asc(a.get(Address_.zipcode)));
q.select(cb.tuple(o.get(Order_.quantity),
    a.get(Address_.zipcode)));
```

Example 3:

```
CriteriaQuery<Object[]> q = cb.createQuery(Object[].class);
Root<Customer> c = q.from(Customer.class);
Join<Customer, Order> o = c.join(Customer_.orders);
Join<Customer, Address> a = c.join(Customer_.address);

q.where(cb.equal(a.get(Address_.state), "CA"),
    cb.equal(a.get(Address_.county), "Santa Clara"));
q.select(cb.array(o.get(Order_.quantity),
    cb.prod(o.get(Order_.totalCost), 1.08),
    a.get(Address_.zipcode)));
q.orderBy(cb.asc(o.get(Order_.quantity)),
    cb.asc(cb.prod(o.get(Order_.totalCost), 1.08)),
    cb.asc(a.get(Address_.zipcode)));
```

This query corresponds to the following Jakarta Persistence query language query:

```
SELECT o.quantity, o.totalCost * 1.08 AS taxedCost, a.zipcode
FROM Customer c JOIN c.orders o JOIN c.address a
WHERE a.state = 'CA' AND a.county = 'Santa Clara'
ORDER BY o.quantity, taxedCost, a.zipcode
```

6.3.15. Bulk Update and Delete Operations

A bulk update query is constructed through the creation and modification of a `jakarta.persistence.criteria.CriteriaUpdate` object.

A `CriteriaUpdate` object is created by means of one of the `createCriteriaUpdate` methods of the `CriteriaBuilder` interface. A `CriteriaUpdate` object is typed according to the entity type that is the target of the update. A `CriteriaUpdate` object has a single root, the entity that is being updated.

A bulk delete query is constructed through the creation and modification of a `jakarta.persistence.criteria.CriteriaDelete` object.

A `CriteriaDelete` object is created by means of one of the `createCriteriaDelete` methods of the `CriteriaBuilder` interface. A `CriteriaDelete` object is typed according to the entity type that is the target of the delete. A `CriteriaDelete` object has a single root, the entity that is being deleted.

Example 1:

```
CriteriaUpdate<Customer> q = cb.createCriteriaUpdate(Customer.class);
Root<Customer> c = q.from(Customer.class);

q.set(c.get(Customer_.status), "outstanding")
    .where(cb.lt(c.get(Customer_.balance), 10000));
```

The following Jakarta Persistence query language update statement is equivalent.


```

UPDATE Customer c
SET c.status = 'outstanding'
WHERE c.balance < 10000

```

Example 2:

```

CriteriaUpdate<Employee> q = cb.createCriteriaUpdate(Employee.class);
Root<Employee> e = q.from(Employee.class);

q.set(e.get(Employee_.address).get(Address_.building), 22)
  .where(
    cb.equal(e.get(Employee_.address).get(Address_.building), 14),
    cb.equal(e.get(Employee_.address).get(Address_.city), "Santa Clara"),
    cb.equal(e.get(Employee_.project).get(Project_.name), "Jakarta EE"));

```

Address is an embeddable class. Note that updating across implicit joins is not supported.

The following Jakarta Persistence query language update statement is equivalent.

```

UPDATE Employee e
SET e.address.building = 22
WHERE e.address.building = 14
  AND e.address.city = 'Santa Clara'
  AND e.project.name = 'Jakarta EE'

```

Example 3:

The following update query causes multiple attributes to be updated.

```

CriteriaUpdate<Employee> q = cb.createCriteriaUpdate(Employee.class);
Root<Employee> e = q.from(Employee.class);

q.set(e.get(Employee_.salary), cb.prod(e.get(Employee_.salary), 1.1f))
  .set(e.get(Employee_.commission), cb.prod(e.get(Employee_.commission), 1.1f))
  .set(e.get(Employee_.bonus), cb.sum(e.get(Employee_.bonus), 5000))
  .where(cb.equal(e.get(Employee_.dept).get(Department_.name), "Sales"));

```

The following Jakarta Persistence query language update statement is equivalent.

```

UPDATE Employee e
SET e.salary = e.salary * 1.1,
    e.commission = e.commission * 1.1,
    e.bonus = e.bonus + 5000
WHERE e.dept.name = 'Sales'

```

Example 4:

```

CriteriaDelete<Customer> q = cb.createCriteriaDelete(Customer.class);
Root<Customer> c = q.from(Customer.class);

q.where(
  cb.equal(c.get(Customer_.status), "inactive"),
  cb.isEmpty(c.get(Customer_.orders)));

```

The following Jakarta Persistence query language delete statement is equivalent.

```

DELETE
FROM Customer c
WHERE c.status = 'inactive'
  AND c.orders IS EMPTY

```

Like bulk update and delete operations made through the Jakarta Persistence query language, criteria API bulk update and delete operations map directly to database operations, bypassing any optimistic locking checks. Portable applications using bulk update operations must manually update the value of the version column, if desired, and/or manually validate the value of the version column.

The persistence context is not synchronized with the result of the bulk update or delete. See [Section 4.11](#).

6.4. Constructing Strongly-typed Queries using the `jakarta.persistence.metamodel` Interfaces

Strongly-typed queries can also be constructed, either statically or dynamically, in the absence of generated metamodel classes. The `jakarta.persistence.metamodel` interfaces are used to access the metamodel objects that correspond to the managed classes.

The following examples illustrate this approach. These are equivalent to the example queries shown in [Section 6.3.5](#).

The `Metamodel` interface is obtained from the `EntityManager` or `EntityManagerFactory` for the persistence unit, and then used to obtain the corresponding metamodel objects for the managed types referenced by the queries.

Example 1:

```
EntityManager em = ...;

Metamodel mm = em.getMetamodel();
EntityType<Employee> emp_ = mm.entity(Employee.class);
EmbeddableType<ContactInfo> cinfo_ = mm.embeddable(ContactInfo.class);
EntityType<Phone> phone_ = mm.entity(Phone.class);
EmbeddableType<Address> addr_ = mm.embeddable(Address.class);

CriteriaQuery<Vendor> q = cb.createQuery(Vendor.class);
Root<Employee> emp = q.from(Employee.class);
Join<Employee, ContactInfo> cinfo =
    emp.join(emp_.getSingularAttribute("contactInfo", ContactInfo.class));
Join<ContactInfo, Phone> p =
    cinfo.join(cinfo_.getSingularAttribute("phones", Phone.class));
q.where(
    cb.equal(emp.get(emp_.getSingularAttribute("contactInfo", ContactInfo.class))
        .get(cinfo_.getSingularAttribute("address", Address.class))
        .get(addr_.getSingularAttribute("zipcode", String.class)), "95054"))
    .select(p.get(phone_.getSingularAttribute("vendor", Vendor.class)));
```

Example 2:

```
EntityManager em = ...;
Metamodel mm = em.getMetamodel();

EntityType<Item> item_ = mm.entity(Item.class);
CriteriaQuery<Tuple> q = cb.createTupleQuery();
Root<Item> item = q.from(Item.class);
MapJoin<Item, String, Object> photo =
    item.join(item_.getMap("photos", String.class, Object.class));
q.multiselect(
    item.get(item_.getSingularAttribute("name", String.class)), photo)
    .where(cb.like(photo.key(), "%egret%"));
```

6.5. Use of the Criteria API with Strings to Reference Attributes

The Criteria API provides the option of specifying the attribute references used in joins and navigation by attribute names used as arguments to the various `join`, `fetch`, and `get` methods.

The resulting queries have the same semantics as described in [Section 6.3](#), but do not provide the same level of type safety.

The examples in this section illustrate this approach. These examples are derived from among those of sections [Section 6.3.3](#) and [Section 6.3.5](#).

Example 1:

```
CriteriaBuilder cb = ...
CriteriaQuery<String> q = cb.createQuery(String.class);
Root<Customer> cust = q.from(Customer.class);
Join<Order, Item> item = cust.join("orders").join("lineItems");
q.select(cust.<String>get("name"))
    .where(cb.equal(item.get("product").get("productType"), "printer"));
```

This query is equivalent to the following Jakarta Persistence query language query:

```
SELECT c.name
FROM Customer c JOIN c.orders o JOIN o.lineItems i
WHERE i.product.productType = 'printer'
```

It is not required that type parameters be used. However, their omission may result in compiler warnings, as with the below version of the same query:

```
CriteriaBuilder cb = ...
CriteriaQuery q = cb.createQuery();
Root cust = q.from(Customer.class);
Join item = cust.join("orders").join("lineItems");
q.select(cust.get("name")).where(
    cb.equal(item.get("product").get("productType"), "printer"));
```

Example 2:

The following query uses an outer join:

```
CriteriaQuery<Customer> q = cb.createQuery(Customer.class);
Root<Customer> cust = q.from(Customer.class);
Join<Customer, Order> order = cust.join("orders", JoinType.LEFT);
q.where(cb.equal(cust.get("status"), 1))
    .select(cust);
```

This query is equivalent to the following Jakarta Persistence query language query:

```
SELECT c FROM Customer c LEFT JOIN c.orders o
WHERE c.status = 1
```

Example 3:

In the following example, `ContactInfo` is an embeddable class consisting of an address and set of phones. `Phone` is an entity.

```
CriteriaQuery<Vendor> q = cb.createQuery(Vendor.class);
Root<Employee> emp = q.from(Employee.class);
Join<ContactInfo, Phone> phone = emp.join("contactInfo").join("phones");
q.where(cb.equal(emp.get("contactInfo")
    .get("address")
    .get("zipcode"), "95054"));
q.select(phone.<Vendor>get("vendor"));
```

The following Jakarta Persistence query language query is equivalent:

```
SELECT p.vendor
FROM Employee e JOIN e.contactInfo.phones p
WHERE e.contactInfo.address.zipcode = '95054'
```

Example 4:

In this example, the photos attribute corresponds to a map from photo label to filename. The map key is a string, the value an object.

```
CriteriaQuery<Object> q = cb.createQuery();
Root<Item> item = q.from(Item.class);
MapJoin<Item, String, Object> photo = item.joinMap("photos");
q.multiselect(item.get("name"), photo)
    .where(cb.like(photo.key(), "%egret%"));
```

This query is equivalent to the following Jakarta Persistence query language query:

```
SELECT i.name, p
FROM Item i JOIN i.photos p
WHERE KEY(p) LIKE 'egret%'
```

6.6. Query Modification

A `CriteriaQuery`, `CriteriaUpdate`, or `CriteriaDelete` object may be modified, either before or after `Query` or `TypedQuery` objects have been created and executed from it. For example, such modification may entail replacement of the where predicate or the select list. Modifications may thus result in the same query object “base” being reused for several query instances.

For example, the user might create and execute a query from the following `CriteriaQuery` object:

```
CriteriaQuery<Customer> q = cb.createQuery(Customer.class);
Root<Customer> c = q.from(Customer.class);

Predicate pred = cb.equal(c.get(Customer_.address).get(Address_.city), "Chicago");

q.select(c);
q.where(pred);
```

The `CriteriaQuery` object might then be modified to reflect a different predicate condition, for example:

```
Predicate pred2 = cb.gt(c.get(Customer_.balanceOwed), 1000);
q.where(pred2);
```

Note, however, that query elements—in this example, predicate conditions—are dependent on the `CriteriaQuery`, `CriteriaUpdate`, or `CriteriaDelete` instance, and are thus not portably reusable with different instances.

6.7. Query Execution

A criteria query is executed by passing the `CriteriaQuery`, `CriteriaUpdate`, or `CriteriaDelete` object to the `createQuery` method of the `EntityManager` interface to create an executable `TypedQuery` object (or, in the case of `CriteriaUpdate` and `CriteriaDelete`, a `Query` object), which can then be passed to one of the query execution methods of the `TypedQuery` or `Query` interface.

A `CriteriaQuery`, `CriteriaUpdate`, or `CriteriaDelete` object may be further modified after an executable query object has

been created from it. The modification of the `CriteriaQuery`, `CriteriaUpdate`, or `CriteriaDelete` object does not have any impact on the already created executable query object. If the modified `CriteriaQuery`, `CriteriaUpdate`, or `CriteriaDelete` object is passed to the `createQuery` method, the persistence provider must insure that a new executable query object is created and returned that reflects the semantics of the changed query definition.

`CriteriaQuery`, `CriteriaUpdate`, and `CriteriaDelete` objects must be serializable. A persistence vendor is required to support the subsequent deserialization of such an object into a separate JVM instance of that vendor's runtime, where both runtime instances have access to any required vendor implementation classes. `CriteriaQuery`, `CriteriaUpdate`, and `CriteriaDelete` objects are not required to be interoperable across vendors.

[1] The attributes of these metamodel objects play a role analogous to that which would be played by member literals.

[2] Metamodel objects are used to specify typesafe navigation through joins and through path expressions. These metamodel objects capture both the source and target types of the attribute through which navigation occurs, and are thus the mechanism by which typesafe navigation is achieved.

[3] Attribute names serve this role for string-based queries. See [Section 6.5](#).

[4] Attribute names serve this role for string-based queries. See [Section 6.5](#).

Chapter 7. Entity Managers and Persistence Contexts

7.1. Persistence Contexts

A persistence context is a set of managed entity instances in which for any persistent entity identity there is a unique entity instance. Within the persistence context, the entity instances and their lifecycle are managed by the entity manager.

In Jakarta EE environments, a JTA transaction typically involves calls across multiple components. Such components may often need to access the same persistence context within a single transaction. To facilitate such use of entity managers in Jakarta EE environments, when an entity manager is injected into a component or looked up directly in the JNDI naming context, its persistence context will automatically be propagated with the current JTA transaction, and the `EntityManager` references that are mapped to the same persistence unit will provide access to this same persistence context within the JTA transaction. This propagation of persistence contexts by the Jakarta EE container avoids the need for the application to pass references to `EntityManager` instances from one component to another. An entity manager for which the container manages the persistence context in this manner is termed a *container-managed entity manager*. A container-managed entity manager's lifecycle is managed by the Jakarta EE container.

In less common use cases within Jakarta EE environments, applications may need to access a persistence context that is “stand-alone”—i.e. not propagated along with the JTA transaction across the `EntityManager` references for the given persistence unit. Instead, each instance of creating an entity manager causes a new isolated persistence context to be created that is not accessible through other `EntityManager` references within the same transaction. These use cases are supported through the `createEntityManager` methods of the `EntityManagerFactory` interface. An entity manager that is used by the application to create and destroy a persistence context in this manner is termed an *application-managed entity manager*. An application-managed entity manager's lifecycle is managed by the application.

Both container-managed entity managers and application-managed entity managers and their persistence contexts are required to be supported in Jakarta EE web containers and EJB containers. Within an EJB environment, container-managed entity managers are typically used.

In Java SE environments and in Jakarta EE application client containers, only application-managed entity managers are required to be ^[1].

7.2. Obtaining an EntityManager

The entity manager for a persistence context is obtained from an entity manager factory.

When container-managed entity managers are used (in Jakarta EE environments), the application does not interact with the entity manager factory. The entity managers are obtained directly through dependency injection or from JNDI, and the container manages interaction with the entity manager factory transparently to the application.

When application-managed entity managers are used, the application must use the entity manager factory to manage the entity manager and persistence context lifecycle.

An entity manager must not be shared among multiple concurrently executing threads, as the entity manager and persistence context are not required to be threadsafe. Entity managers must only be accessed in a single-threaded manner.

7.2.1. Obtaining an Entity Manager in the Jakarta EE Environment

A container-managed entity manager is obtained by the application through dependency injection or through direct lookup of the entity manager in the JNDI namespace. The container manages the persistence context lifecycle and the

creation and the closing of the entity manager instance transparently to the application.

The `PersistenceContext` annotation is used for entity manager injection. The `type` element specifies whether a transaction-scoped or extended persistence context is to be used, as described in [Section 7.7](#). The `synchronization` element specifies whether the persistence context is always automatically joined to the current transaction (the default) or is not joined to the current transaction unless the `joinTransaction` method is invoked by the application. The `unitName` element may optionally be specified to designate the persistence unit whose entity manager factory is used by the container. The semantics of the persistence context synchronization type are further described in [Section 7.7.1](#). [Section 10.5.2](#) provides further information about the `unitName` element.

For example,

```
@PersistenceContext
EntityManager em;

@PersistenceContext(type=PersistenceContextType.EXTENDED)
EntityManager orderEM;
```

The JNDI lookup of an entity manager is illustrated below:

```
@Stateless
@PersistenceContext(name="OrderEM")
public class MySessionBean implements MyInterface {
    @Resource
    SessionContext ctx;

    public void doSomething() {
        EntityManager em = (EntityManager)ctx.lookup("OrderEM");

        // ...
    }
}
```

7.2.2. Obtaining an Application-managed Entity Manager

An application-managed entity manager is obtained by the application from an entity manager factory.

The `EntityManagerFactory` API used to obtain an application-managed entity manager is the same independent of whether this API is used in Jakarta EE or Java SE environments.

7.3. Obtaining an Entity Manager Factory

The `EntityManagerFactory` interface is used by the application to create an application-managed entity manager^[2].

Each entity manager factory provides entity manager instances that are all configured in the same manner (e.g., configured to connect to the same database, use the same initial settings as defined by the implementation, etc.)

More than one entity manager factory instance may be available simultaneously in the JVM.^[3]

Methods of the `EntityManagerFactory` interface are threadsafe.

7.3.1. Obtaining an Entity Manager Factory in a Jakarta EE Container

Within a Jakarta EE environment, an entity manager factory can be injected using the `PersistenceUnit` annotation or obtained through JNDI lookup. The `unitName` element may optionally be specified to designate the persistence unit whose entity manager factory is used. (See [Section 10.5.2](#)).

For example,

```
@PersistenceUnit
EntityManagerFactory emf;
```

7.3.2. Obtaining an Entity Manager Factory in a Java SE Environment

Outside a Jakarta EE container environment, the `jakarta.persistence.Persistence` class is the bootstrap class that provides access to an entity manager factory. The application creates an entity manager factory by calling the `createEntityManagerFactory` method of the `jakarta.persistence.Persistence` class, described in [Section 9.7](#).

For example,

```
EntityManagerFactory emf =
    jakarta.persistence.Persistence.createEntityManagerFactory("Order");
EntityManager em = emf.createEntityManager();
```

7.3.3. Obtaining an Entity Manager Factory for a programmatically-defined persistence unit

The class `jakarta.persistence.PersistenceConfiguration` described in [Section 9.8](#) may be used to programmatically define and configure a persistence unit (see [Section 8.1](#)), as an alternative to packaging a `persistence.xml` file, mapping files, and classes inside an archive as described in [Section 8.2](#).

An `EntityManagerFactory` may be obtained directly from the `PersistenceConfiguration`.

For example,

```
DataSource datasource = (DataSource)
    new InitialContext()
        .lookup("java:global/jdbc/MyOrderDB");
EntityManagerFactory emf =
    new PersistenceConfiguration()
        .name("OrderManagement")
        .jtaDataSource(datasource)
        .mappingFile("ormap.xml")
        .managedClass(Order.class)
        .managedClass(Customer.class)
        .createEntityManagerFactory();
```

7.4. EntityManagerFactory Interface

The `EntityManagerFactory` interface found in [Section B.3](#)

An `EntityManagerFactory` may be used by the application to obtain an application-managed entity manager. When the application has finished using the entity manager factory, and/or at application shutdown, the application should close the entity manager factory. Once an entity manager factory has been closed, all its entity managers are considered to be in the closed state.

An `EntityManagerFactory` also provides access to information and services that are global to the persistence unit. This includes access to the second level cache that is maintained by the persistence provider and to the `PersistenceUnitUtil` interface. The `Cache` interface is described in [Section 3.10.3](#); the `PersistenceUnitUtil` interface in [Section 7.11](#).

Any number of vendor-specific properties may be included in the map passed to the `createEntityManager` methods. Properties that are not recognized by a vendor must be ignored.

Note that the policies of the installation environment may restrict some information from being made available through the `EntityManagerFactory` `getProperties` method (for example, JDBC user, password, URL).

Vendors should use vendor namespaces for properties (e.g., `com.acme.persistence.logging`). Entries that make use of the namespace `jakarta.persistence` and its subnamespaces must not be used for vendor-specific information. The namespace `jakarta.persistence` is reserved for use by this specification.

7.5. Controlling Transactions

Depending on the transactional type of the entity manager, transactions involving `EntityManager` operations may be controlled either through JTA or through use of the resource-local `EntityTransaction` API, which is mapped to a resource transaction over the resource that underlies the entities managed by the entity manager.

An entity manager whose underlying transactions are controlled through JTA is termed a *JTA entity manager*.

An entity manager whose underlying transactions are controlled by the application through the `EntityTransaction` API is termed a *resource-local entity manager*.

A container-managed entity manager must be a JTA entity manager. JTA entity managers are only specified for use in Jakarta EE containers.

An application-managed entity manager may be either a JTA entity manager or a resource-local entity manager.

An entity manager is defined to be of a given transactional type—either JTA or resource-local—at the time its underlying entity manager factory is configured and created. See sections [Section 8.2.1.2](#) and [Section 9.1](#).

Both JTA entity managers and resource-local entity managers are required to be supported in Jakarta EE web containers and EJB containers. Within an EJB environment, a JTA entity manager is typically used. In general, in Java SE environments only resource-local entity managers are supported.

7.5.1. JTA EntityManagers

An entity manager whose transactions are controlled through JTA is a JTA entity manager. In general, a JTA entity manager participates in the current JTA transaction, which is begun and committed external to the entity manager and propagated to the underlying resource manager.

7.5.2. Resource-local EntityManagers

An entity manager whose transactions are controlled by the application through the `EntityTransaction` API is a resource-local entity manager. A resource-local entity manager transaction is mapped to a resource transaction over the resource by the persistence provider. Resource-local entity managers may use server or local resources to connect to the database and are unaware of the presence of JTA transactions that may or may not be active.

7.5.3. The EntityTransaction Interface

The `EntityTransaction` interface found in [Section B.2](#) is used to control resource transactions on resource-local entity managers. The `getTransaction()` method of `EntityManager` returns an instance of the `EntityTransaction` interface.

When a resource-local entity manager is used, and the persistence provider runtime throws an exception defined to cause transaction rollback, the persistence provider must mark the transaction for rollback.

If the `EntityTransaction.commit` operation fails, the persistence provider must roll back the transaction.

The following example illustrates the creation of an entity manager factory in a Java SE environment, and its use in creating and using a resource-local entity manager.

```
import jakarta.persistence.*;
```

```

public class PasswordChanger {
    public static void main (String[] args) {
        EntityManagerFactory emf =
            Persistence.createEntityManagerFactory("Order");
        EntityManager em = emf.createEntityManager();
        em.getTransaction().begin();

        User user = em.createQuery
            ("SELECT u FROM User u WHERE u.name=:name AND u.pass=:pass", User.class)
            .setParameter("name", args[0])
            .setParameter("pass", args[1])
            .getSingleResult();

        user.setPassword(args[2]);

        em.getTransaction().commit();
        em.close();
        emf.close();
    }
}

```

7.6. The `runInTransaction` and `callInTransaction` methods

The `runInTransaction` and `callInTransaction` methods of the `EntityManagerFactory` provide a shortcut for persistence context and transaction management with an application-managed `EntityManager`.

```

entityManagerFactory.runInTransaction(entityManager -> {
    User user = em.createQuery
        ("SELECT u FROM User u WHERE u.name=:name AND u.pass=:pass", User.class)
        .setParameter("name", args[0])
        .setParameter("pass", args[1])
        .getSingleResult();

    user.setPassword(args[2]);
})

```

The argument function passed to `runInTransaction` or `callInTransaction` must be called and passed a new instance of `EntityManager`. When the argument function returns or throws an exception, this `EntityManager` must be closed before `runInTransaction` or `callInTransaction` returns.

The argument function is executed in the context of a transaction associated with this new `EntityManager`.

- If the transaction type of the persistence unit is JTA, and there is a JTA transaction already associated with the caller, then the `EntityManager` is associated with this current transaction. If the argument function throws an exception, the JTA transaction must be marked for rollback, and the exception must be rethrown by `runInTransaction` or `callInTransaction`. Otherwise, `callInTransaction` must return the same value returned by the argument function.
- Otherwise, if the transaction type of the persistence unit is resource-local, or if there is no JTA transaction already associated with the caller, then the `EntityManager` is associated with a new transaction. If the argument function throws an exception, this transaction must be rolled back, and then the exception must be rethrown by `runInTransaction` or `callInTransaction`. If the argument function returns, then `runInTransaction` or `callInTransaction` must attempt to commit the transaction. If the attempt to commit the transaction fails, the exception must be rethrown. Otherwise, `callInTransaction` must return the same value returned by the argument function.

The application should not attempt to manage the lifecycle of the transaction or `EntityManager` directly. If the application calls an operation of `EntityManager` from within a call to `runInTransaction` or `callInTransaction`, the behavior is undefined.

7.7. Container-managed Persistence Contexts

When a container-managed entity manager is used, the lifecycle of the persistence context is always managed automatically, transparently to the application, and the persistence context is propagated with the JTA transaction.

A container-managed persistence context may be defined to have either a lifetime that is scoped to a single transaction or an extended lifetime that spans multiple transactions, depending on the `PersistenceContextType` that is specified when its entity manager is created. This specification refers to such persistence contexts as *transaction-scoped persistence contexts* and *extended persistence contexts* respectively.

The lifetime of the persistence context is declared using the `PersistenceContext` annotation or the `persistence-context-ref` deployment descriptor element. By default, a transaction-scoped persistence context is used.

Sections [Section 7.7.2](#) and [Section 7.7.3](#) describe transaction-scoped and extended persistence contexts in the absence of persistence context propagation. Persistence context propagation is described in [Section 7.7.4](#).

Persistence contexts are always associated with an entity manager factory. In the following sections, “the persistence context” should be understood to mean “the persistence context associated with a particular entity manager factory”.

7.7.1. Persistence Context Synchronization Type

By default, a container-managed persistence context is of type `SynchronizationType.SYNCHRONIZED`. Such a persistence context is automatically joined to the current JTA transaction, and updates made to the persistence context are propagated to the underlying resource manager.

A container-managed persistence context may be specified to be of type `SynchronizationType.UNSYNCHRONIZED`. A persistence context of type `SynchronizationType.UNSYNCHRONIZED` is not enlisted in any JTA transaction unless explicitly joined to that transaction by the application. A persistence context of type `SynchronizationType.UNSYNCHRONIZED` is enlisted in a JTA transaction and registered for subsequent transaction notifications against that transaction by the invocation of the `EntityManager.joinTransaction` method. The persistence context remains joined to the transaction until the transaction commits or rolls back. After the transaction commits or rolls back, the persistence context will not be joined to any subsequent transaction unless the `joinTransaction` method is invoked in the scope of that subsequent transaction.

A persistence context of type `SynchronizationType.UNSYNCHRONIZED` must not be flushed to the database unless it is joined to a transaction. The application’s use of queries with pessimistic locks, bulk update or delete queries, etc. result in the provider throwing the `TransactionRequiredException`. After the persistence context has been joined to the JTA transaction, these operations are again allowed.

The application is permitted to invoke the `persist`, `merge`, `remove`, and `refresh` entity lifecycle operations on an entity manager of type `SynchronizationType.UNSYNCHRONIZED` independent of whether the persistence context is joined to the current transaction. After the persistence context has been joined to a transaction, changes in a persistence context can be flushed to the database either explicitly by the application or by the provider. If the `flush` method is not explicitly invoked, the persistence provider may defer flushing until commit time depending on the operations invoked and the flush mode setting in effect.

If an extended persistence context of type `SynchronizationType.UNSYNCHRONIZED` has not been joined to the current JTA transaction, rollback of the JTA transaction will have no effect upon the persistence context. In general, it is recommended that a non-JTA datasource be specified for use by the persistence provider for a persistence context of type `SynchronizationType.UNSYNCHRONIZED` that has not been joined to a JTA transaction in order to alleviate the risk of integrating uncommitted changes into the persistence context in the event that the transaction is later rolled back.

If a persistence context of type `SynchronizationType.UNSYNCHRONIZED` has been joined to the JTA transaction, transaction rollback will cause the persistence context to be cleared and all pre-existing managed and removed instances to become detached. (See [Section 3.4.3](#).)

When a JTA transaction exists, a persistence context of type `SynchronizationType.UNSYNCHRONIZED` is propagated with that transaction according to the rules in [Section 7.7.4.1](#) regardless of whether the persistence context has been joined to that transaction.

7.7.2. Container-managed Transaction-scoped Persistence Context

The application can obtain a container-managed entity manager with transaction-scoped persistence context by injection or direct lookup in the JNDI namespace. The persistence context type for the entity manager is defaulted or defined as `PersistenceContextType.TRANSACTION`.

A new persistence context begins when the container-managed entity manager is invoked^[4] in the scope of an active JTA transaction, and there is no current persistence context already associated with the JTA transaction. The persistence context is created and then associated with the JTA transaction. This association of the persistence context with the JTA transaction is independent of the synchronization type of the persistence context and whether the persistence context has been joined to the transaction.

The persistence context ends when the associated JTA transaction commits or rolls back, and all entities that were managed by the `EntityManager` become detached.^[5]

If the entity manager is invoked outside the scope of a transaction, any entities loaded from the database will immediately become detached at the end of the method call.

7.7.3. Container-managed Extended Persistence Context

A container-managed extended persistence context can only be initiated within the scope of a stateful session bean. It exists from the point at which the stateful session bean that declares a dependency on an entity manager of type `PersistenceContextType.EXTENDED` is created, and is said to be bound to the stateful session bean. The dependency on the extended persistence context is declared by means of the `PersistenceContext` annotation or `persistence-context-ref` deployment descriptor element. The association of the extended persistence context with the JTA transaction is independent of the synchronization type of the persistence context and whether the persistence context has been joined to the transaction.

The persistence context is closed by the container when the `@Remove` method of the stateful session bean completes (or the stateful session bean instance is otherwise destroyed).

7.7.3.1. Inheritance of Extended Persistence Context

If a stateful session bean instantiates a stateful session bean (executing in the same EJB container instance) which also has such an extended persistence context with the same synchronization type, the extended persistence context of the first stateful session bean is inherited by the second stateful session bean and bound to it, and this rule recursively applies—independently of whether transactions are active or not at the point of the creation of the stateful session beans. If the stateful session beans differ in declared synchronization type, the `EJBException` is thrown by the container.

If the persistence context has been inherited by any stateful session beans, the container does not close the persistence context until all such stateful session beans have been removed or otherwise destroyed.

7.7.4. Persistence Context Propagation

As described in [Section 7.1](#), a single persistence context may correspond to one or more JTA entity manager instances (all associated with the same entity manager factory^[6]).

The persistence context is propagated across the entity manager instances as the JTA transaction is propagated. A persistence context of type `SynchronizationType.UNSYNCHRONIZED` is propagated with the JTA transaction regardless of whether it has been joined to the transaction.

Propagation of persistence contexts only applies within a local environment. Persistence contexts are not propagated to remote tiers.

7.7.4.1. Requirements for Persistence Context Propagation

Persistence contexts are propagated by the container across component invocations as follows.

If a component is called and there is no JTA transaction or the JTA transaction is not propagated, the persistence context is not propagated.

- If an entity manager is then invoked from within the component:
 - Invocation of an entity manager defined with `PersistenceContextType.TRANSACTION` will result in use of a new persistence context (as described in [Section 7.7.2](#)).
 - Invocation of an entity manager defined with `PersistenceContextType.EXTENDED` will result in the use of the existing extended persistence context bound to that component.
 - If the entity manager is invoked within a JTA transaction, the persistence context will be associated with the JTA transaction.

If a component is called and the JTA transaction is propagated into that component:

- If the component is a stateful session bean to which an extended persistence context has been bound and there is a different persistence context associated with the JTA transaction, an `EJBException` is thrown by the container.
- If there is a persistence context of type `SynchronizationType.UNSYNCHRONIZED` associated with the JTA transaction and the target component specifies a persistence context of type `SynchronizationType.SYNCHRONIZED`, the `IllegalStateException` is thrown by the container.
- Otherwise, if there is a persistence context associated with the JTA transaction, that persistence context is propagated and used.



Note that a component with a persistence context of type `SynchronizationType.UNSYNCHRONIZED` may be called by a component propagating either a persistence context of type `SynchronizationType.UNSYNCHRONIZED` or a persistence context of type `SynchronizationType.SYNCHRONIZED` into it.

The following example shows a container-managed, transaction-scoped persistence context:

```
@Stateless
public class ShoppingCartImpl implements ShoppingCart {
    @PersistenceContext
    EntityManager em;

    public Order getOrder(Long id) {
        Order order = em.find(Order.class, id);
        order.getLineItems();
        return order;
    }

    public Product getProduct(String name) {
        return (Product) em.createQuery("select p from Product p where p.name = : name")
            .setParameter("name", name)
            .getSingleResult();
    }
}
```

```

    public LineItem createLineItem(Order order, Product product, int quantity) {
        LineItem li = new LineItem(order, product, quantity);
        order.getLineItems().add(li);
        em.persist(li);
        return li;
    }
}

```

This example shows a container-managed extended persistence context:

```

/*
 * An extended transaction context is used. The entities remain
 * managed in the persistence context across multiple transactions.
 */
@Stateful
@Transaction(REQUIRES_NEW)
public class ShoppingCartImpl implements ShoppingCart {
    @PersistenceContext(type = EXTENDED)
    EntityManager em;

    private Order order;
    private Product product;

    public void initOrder(Long id) {
        order = em.find(Order.class, id);
    }

    public void initProduct(String name) {
        product = (Product) em.createQuery("select p from Product p where p.name = : name")
            .setParameter("name", name)
            .getSingleResult();
    }

    public LineItem createLineItem(int quantity) {
        LineItem li = new LineItem(order, product, quantity);
        order.getLineItems().add(li);
        em.persist(li);
        return li;
    }
}

```

7.8. Application-managed Persistence Contexts

When an application-managed entity manager is used, the application interacts directly with the persistence provider's entity manager factory to manage the entity manager lifecycle and to obtain and destroy persistence contexts.

All such application-managed persistence contexts are extended in scope, and can span multiple transactions.

The `EntityManagerFactory.createEntityManager` method and the `EntityManager.close` and `isOpen` methods are used to manage the lifecycle of an application-managed entity manager and its associated persistence context.

The extended persistence context exists from the point at which the entity manager has been created using `EntityManagerFactory.createEntityManager` until the entity manager is closed by means of `EntityManager.close`.

An extended persistence context obtained from the application-managed entity manager is a stand-alone persistence context—it is not propagated with the transaction.

When a JTA application-managed entity manager is used, an application-managed persistence context may be specified to be of type `SynchronizationType.UNSYNCHRONIZED`. A persistence context of type `SynchronizationType.UNSYNCHRONIZED` is not enlisted in any JTA transaction unless explicitly joined to that transaction by the application. A persistence context of type `SynchronizationType.UNSYNCHRONIZED` is enlisted in a JTA transaction and registered for subsequent transaction

notifications against that transaction by the invocation of the `EntityManager.joinTransaction` method. The persistence context remains joined to the transaction until the transaction commits or rolls back. After the transaction commits or rolls back, the persistence context will not be joined to any subsequent transaction unless the `joinTransaction` method is invoked in the scope of that subsequent transaction.

When a JTA application-managed entity manager is used, if the entity manager is created outside the scope of the current JTA transaction, it is the responsibility of the application to join the entity manager to the transaction (if desired) by calling `EntityManager.joinTransaction`. If the entity manager is created outside the scope of a JTA transaction, it is not joined to the transaction unless `EntityManager.joinTransaction` is called.

The `EntityManager.close` method closes an entity manager to release its persistence context and other resources. After calling `close`, the application must not invoke any further methods on the `EntityManager` instance except for `getTransaction` and `isOpen`, or the `IllegalStateException` will be thrown. If the `close` method is invoked when a transaction is active, the persistence context remains managed until the transaction completes.

The `EntityManager.isOpen` method indicates whether the entity manager is open. The `isOpen` method returns true until the entity manager has been closed.

This example shows an application-managed persistence context used in a stateless session bean:

```
/*
 * Container-managed transaction demarcation is used.
 * The session bean creates and closes an entity manager
 * in each business method.
 */
@Stateless
public class ShoppingCartImpl implements ShoppingCart {
    @PersistenceUnit
    private EntityManagerFactory emf;

    public Order getOrder(Long id) {
        EntityManager em = emf.createEntityManager();
        Order order = em.find(Order.class, id);
        order.getLineItems();
        em.close();
        return order;
    }

    public Product getProduct() {
        EntityManager em = emf.createEntityManager();
        Product product = (Product)
            em.createQuery("select p from Product p where p.name = :name")
                .setParameter("name", name)
                .getSingleResult();
        em.close();
        return product;
    }

    public LineItem createLineItem(Order order, Product product, int quantity) {
        EntityManager em = emf.createEntityManager();
        LineItem li = new LineItem(order, product, quantity);
        order.getLineItems().add(li);
        em.persist(li);
        em.close();
        return li; // remains managed until JTA transaction ends
    }
}
```

This examples shows an application-managed persistence context used in a stateless session bean:

```
/*
```

```

* Container-managed transaction demarcation is used.
* The session bean creates entity manager in PostConstruct
* method and clears persistence context at the end of each
* business method.
*/
@Stateless
public class ShoppingCartImpl implements ShoppingCart {
    @PersistenceUnit
    private EntityManagerFactory emf;

    private EntityManager em;

    @PostConstruct
    public void init() {
        em = emf.createEntityManager();
    }

    public Order getOrder(Long id) {
        Order order = em.find(Order.class, id);
        order.getLineItems();
        em.clear(); // entities are detached
        return order;
    }

    public Product getProduct() {
        Product product = (Product)
            em.createQuery("select p from Product p where p.name = :name")
                .setParameter("name", name)
                .getSingleResult();

        em.clear();
        return product;
    }

    public LineItem createLineItem(Order order, Product product, int quantity) {
        em.joinTransaction();
        LineItem li = new LineItem(order, product, quantity);
        order.getLineItems().add(li);
        em.persist(li);
        // persistence context is flushed to database;
        // all updates will be committed to database on tx commit
        em.flush();
        // entities in persistence context are detached
        em.clear();
        return li;
    }

    @PreDestroy
    public void destroy() {
        em.close();
    }
}

```

This example shows an application-managed persistence context used in a stateful session bean:

```

/*
* Container-managed transaction demarcation is used.
* Entities remain managed until the entity manager is closed.
*/
@Stateful
public class ShoppingCartImpl implements ShoppingCart {
    @PersistenceUnit
    private EntityManagerFactory emf;

    private EntityManager em;

    private Order order;

```



```

private Product product;

@PostConstruct
public void init() {
    em = emf.createEntityManager();
}

public void initOrder(Long id) {
    order = em.find(Order.class, id);
}

public void initProduct(String name) {
    product = (Product) em.createQuery("select p from Product p where p.name = : name")
        .setParameter("name", name)
        .getSingleResult();
}

public LineItem createLineItem(int quantity) {
    em.joinTransaction();
    LineItem li = new LineItem(order, product, quantity);
    order.getLineItems().add(li);
    em.persist(li);
    return li;
}

@Remove
public void destroy() {
    em.close();
}
}

```

Finally, this example shows an application-managed persistence context used with a resource transaction:

```

// Usage in an ordinary Java class
public class ShoppingImpl {
    private EntityManager em;
    private EntityManagerFactory emf;

    public ShoppingCart() {
        emf = Persistence.createEntityManagerFactory("orderMgt");
        em = emf.createEntityManager();
    }

    private Order order;
    private Product product;

    public void initOrder(Long id) {
        order = em.find(Order.class, id);
    }

    public void initProduct(String name) {
        product = (Product) em.createQuery("select p from Product p where p.name = : name")
            .setParameter("name", name)
            .getSingleResult();
    }

    public LineItem createLineItem(int quantity) {
        em.getTransaction().begin();
        LineItem li = new LineItem(order, product, quantity);
        order.getLineItems().add(li);
        em.persist(li);
        em.getTransaction().commit();
        return li;
    }
}

```

```
public void destroy() {  
    em.close();  
    emf.close();  
}  
}
```

7.9. Requirements on the Container

7.9.1. Application-managed Persistence Contexts

When application-managed persistence contexts are used, the container must instantiate the entity manager factory and expose it to the application via JNDI. The container might use internal APIs to create the entity manager factory, or it might use the `PersistenceProvider.createContainerEntityManagerFactory` method. However, the container is required to support third-party persistence providers, and in this case the container must use the `PersistenceProvider.createContainerEntityManagerFactory` method to create the entity manager factory and the `EntityManagerFactory.close` method to destroy the entity manager factory prior to shutdown (if it has not been previously closed by the application).

7.9.2. Container Managed Persistence Contexts

The container is responsible for managing the lifecycle of container-managed persistence contexts, for injecting `EntityManager` references into web components and session bean and message-driven bean components, and for making `EntityManager` references available to direct lookups in JNDI.

When operating with a third-party persistence provider, the container uses the contracts defined in [Section 7.10](#) to create and destroy container-managed persistence contexts. It is undefined whether a new entity manager instance is created for every persistence context, or whether entity manager instances are sometimes reused. Exactly how the container maintains the association between persistence context and JTA transaction is not defined.

If a persistence context is already associated with a JTA transaction, the container uses that persistence context for subsequent invocations within the scope of that transaction, according to the semantics for persistence context propagation defined in [Section 7.7.4](#).

7.10. Runtime Contracts between the Container and Persistence Provider

This section describes contracts between the container and the persistence provider for the pluggability of third-party persistence providers. Containers are required to support these pluggability contracts.^[7]

7.10.1. Container Responsibilities

For the management of a transaction-scoped persistence context, if there is no `EntityManager` already associated with the JTA transaction:

- The container creates a new entity manager by calling `EntityManagerFactory.createEntityManager` when the first invocation of an entity manager with `PersistenceContextType.TRANSACTION` occurs within the scope of a business method executing in the JTA transaction.
- After the JTA transaction has completed (either by transaction commit or rollback), the container closes the entity manager by calling `EntityManager.close`.^[8] Note that the JTA transaction may rollback in a background thread (e.g., as a result of transaction timeout), in which case the container should arrange for the entity manager to be closed but the `EntityManager.close` method should not be concurrently invoked while the application is in an `EntityManager` invocation.

The container must throw the `TransactionRequiredException` if a transaction-scoped persistence context is used and the `EntityManager.persist`, `remove`, `merge`, or `refresh` method is invoked when no transaction is active.

For stateful session beans with extended persistence contexts:

- The container creates an entity manager by calling `EntityManagerFactory.createEntityManager` when a stateful session bean is created that declares a dependency on an entity manager with `PersistenceContextType.EXTENDED`. (See [Section 7.7.3](#)).
- The container closes the entity manager by calling `EntityManager.close` after the stateful session bean and all other stateful session beans that have inherited the same persistence context as the entity manager have been removed.
- When a business method of the stateful session bean is invoked, if the stateful session bean uses container managed transaction demarcation, and the entity manager is not already associated with the current JTA transaction, the container associates the entity manager with the current JTA transaction and, if the persistence context is of type `SynchronizationType.SYNCHRONIZED`, the container calls `EntityManager.joinTransaction`. If there is a different persistence context already associated with the JTA transaction, the container throws the `EJBException`.
- When a business method of the stateful session bean is invoked, if the stateful session bean uses bean managed transaction demarcation and a `UserTransaction` is begun within the method, the container associates the persistence context with the JTA transaction and, if the persistence context is of type `SynchronizationType.SYNCHRONIZED`, the container calls `EntityManager.joinTransaction`.

The container must throw the `IllegalStateException` if the application calls `EntityManager.close` on a container-managed entity manager.

When the container creates an entity manager, it may pass a map of properties to the persistence provider by using the `EntityManagerFactory.createEntityManager(Map map)` method. If properties have been specified in the `PersistenceContext` annotation or the `persistence-context-ref` deployment descriptor element, this method must be used and the map must include the specified properties.

If the application invokes `EntityManager.unwrap(Class<T> cls)`, and the container cannot satisfy the request, the container must delegate the `unwrap` invocation to the provider's entity manager instance.

7.10.2. Provider Responsibilities

The Provider has no knowledge of the distinction between transaction-scoped and extended persistence contexts. It provides entity managers to the container when requested and registers for transaction synchronization notifications.

- When `EntityManagerFactory.createEntityManager` is invoked, the provider must create and return a new entity manager. If a JTA transaction is active and the persistence context is of type `SynchronizationType.SYNCHRONIZED`, the provider must register for synchronization notifications against the JTA transaction.
- When `EntityManager.joinTransaction` is invoked, the provider must register for synchronization notifications against the current JTA transaction if a previous `joinTransaction` invocation for the transaction has not already been processed.
- When the JTA transaction commits, if the persistence context is of type `SynchronizationType.SYNCHRONIZED` or has otherwise been joined to the transaction, the provider must flush all modified entity state to the database.
- When the JTA transaction rolls back, the provider must detach all managed entities if the persistence context is of type `SynchronizationType.SYNCHRONIZED` or has otherwise been joined to the transaction. Note that the JTA transaction may rollback in a background thread (e.g., as a result of transaction timeout), in which case the provider should arrange for the managed entities to be detached from the persistence context but not concurrently while the application is in an `EntityManager` invocation.
- When the provider throws an exception defined to cause transaction rollback, the provider must mark the transaction for rollback if the persistence context is of type `SynchronizationType.SYNCHRONIZED` or has otherwise been

joined to the transaction.

- When `EntityManager.close` is invoked, the provider should release all resources that it may have allocated after any outstanding transactions involving the entity manager have completed. If the entity manager was already in a closed state, the provider must throw the `IllegalStateException`.
- When `EntityManager.clear` is invoked, the provider must detach all managed entities.

7.11. PersistenceUnitUtil Interface

The `PersistenceUnitUtil` interface found in [Section B.20](#) declares utility methods that can be invoked on entities associated with the persistence unit. The behavior is undefined if these methods are invoked on an entity instance that is not associated with the persistence unit from whose entity manager factory this interface has been obtained.

7.12. SchemaManager Interface

The `SchemaManager` interface may be found in [Section B.16](#). An instance of `SchemaManager` may be obtained by calling the `getSchemaManager()` method of `EntityManagerFactory`.

The `SchemaManager` interface allows programmatic control over schema generation and cleanup at runtime. This differs from the functionality described in [Section 9.4](#) which allows schema generation before or during the application deployment and initialization process. Similarly, the `generateSchema` method described in [Section 9.2.1](#) is intended to be called before the `EntityManagerFactory` is available. By contrast, an instance of `SchemaManager` is only available after an `EntityManagerFactory` has already been created.

For example, `SchemaManager` is especially useful in tests.

The methods of `SchemaManager` correspond to values of the property `jakarta.persistence.schema-generation.scripts.action`. The methods `create()`, `drop()`, and `validate()` correspond to the actions `create`, `drop`, and `validate`. The method `truncate()` has no corresponding action.

Thus, the behavior of the `SchemaManager` may be controlled via the properties defined in [Section 9.4](#) and [Section 8.2.1.11](#).

[1] Note that the use of JTA is not required to be supported in application client containers.

[2] It may also be used internally by the Jakarta EE container. See [Section 7.10](#).

[3] This may be the case when using multiple databases, since in a typical configuration a single entity manager only communicates with a single database. There is only one entity manager factory per persistence unit, however.

[4] Specifically, when one of the methods of the `EntityManager` interface is invoked.

[5] Note that this applies to a transaction-scoped persistence context of type `SynchronizationType.UNSYNCHRONIZED` that has not been joined to the transaction as well.

[6] Entity manager instances obtained from different entity manager factories never share the same persistence context.

[7] It is not required that these contracts be used when a third-party persistence provider is not used: the container might use these same APIs or its might use its own internal APIs.

[8] The container may choose to pool `EntityManagers`: it instead of creating and closing in each case, it may acquire one from its pool and call `clear()` on it.

Chapter 8. Entity Packaging

This chapter describes the packaging of persistence units.

8.1. Persistence Unit

A persistence unit is a logical grouping that includes:

- an entity manager factory and its entity managers, together with their configuration information,
- the set of managed classes included in the persistence unit and managed by entity managers created by the entity manager factory, and
- mapping metadata (in the form of metadata annotations and/or XML metadata) specifying the mapping of these classes to the database.

8.2. Persistence Unit Packaging

Within Jakarta EE environments, any EJB-JAR, WAR, EAR, or application client JAR can define a persistence unit. Any number of persistence units may be defined within these scopes.

A persistence unit may be packaged:

- within one or more jar files contained within a WAR or EAR,
- as a set of classes within an EJB-JAR file or in the WAR `classes` directory, or
- as a combination of these, as defined below.

A persistence unit is defined by a `persistence.xml` file. The jar file or directory whose `META-INF` directory contains the `persistence.xml` file is termed the `root` of the persistence unit. In Jakarta EE environments, the root of a persistence unit must be either:

- an EJB-JAR file,
- the `WEB-INF/classes` directory of a WAR file^[1],
- a jar file in the `WEB-INF/lib` directory of a WAR file,
- a jar file in the library directory or an EAR, or
- an application client JAR file.

It is not required that an EJB-JAR or WAR file containing a persistence unit be packaged in an EAR unless the persistence unit contains extra persistence classes in addition to those contained within the EJB-JAR or WAR. See [Section 8.2.1.8](#).



Java Persistence 1.0 supported the use of a jar file in the root of the EAR as the root of a persistence unit. This use is no longer supported. Portable applications should use the EAR library directory for this case instead. See [\[6\]](#).

A persistence unit must have a name. The name of the persistence unit must be unique within a given EJB-JAR file, within a given WAR file, within a given application client JAR, or within an EAR. See [Section 8.2.2](#).

The `persistence.xml` file may be used to define more than one persistence unit within the same scope.

All persistence classes defined at the level of the Jakarta EE EAR must be accessible to other Jakarta EE components in the application—that is, to all components loaded by the application classloader—such that if the same entity class is referenced by two different Jakarta EE components (which may be using different persistence units), the referenced class is the same identical class.

In Java SE environments, the metadata mapping files, jar files, and classes described in the following sections can be used. To insure the portability of a Java SE application, it is necessary to explicitly list the managed persistence classes included in the persistence unit using the `class` element of the `persistence.xml` file. See [Section 8.2.1.8](#).

8.2.1. persistence.xml file

A `persistence.xml` file defines a persistence unit. The `persistence.xml` file is located in the `META-INF` directory of the root of the persistence unit. It may be used to specify:

- managed persistence classes included in the persistence unit,
- object/relational mapping information for those classes,
- scripts for use in schema generation and bulk loading of data, and
- other configuration information for the persistence unit and for the entity managers and entity manager factory of the persistence unit.

This information may be defined by containment or by reference, as described below.

The object/relational mapping information can take the form of:

- annotations on the managed persistence classes included in the persistence unit,
- an `orm.xml` file contained in the `META-INF` directory of the root of the persistence unit,
- one or more XML files accessible on the classpath and referenced from the `persistence.xml` file, or
- any combination of the previous options.

The managed persistence classes may be:

- contained within the root of the persistence unit,
- specified by reference—that is, by naming the classes, class archives, or XML mapping files (which in turn reference classes) that are accessible on the application classpath, or
- specified by any combination of these means.

See [Section 8.2.1.8](#).

The root element of the `persistence.xml` file is the `persistence` element. The `persistence` element consists of one or more `persistence-unit` elements.

The `persistence-unit` element consists of the `name` and `transaction-type` attributes and the following sub-elements: `description`, `provider`, `jta-data-source`, `non-jta-data-source`, `mapping-file`, `jar-file`, `class`, `exclude-unlisted-classes`, `shared-cache-mode`, `validation-mode`, and `properties`.

The `name` attribute is required; the other attributes and elements are optional. Their semantics are described in the following subsections.

Examples:

```
<persistence>
  <persistence-unit name="OrderManagement">
    <description>
      This unit manages orders and customers.
      It does not rely on any vendor-specific features and can
      therefore be deployed to any persistence provider.
    </description>
    <jta-data-source>jdbc/MyOrderDB</jta-data-source>
    <mapping-file>ormap.xml</mapping-file>
    <jar-file>MyOrderApp.jar</jar-file>
    <class>com.widgets.Order</class>
    <class>com.widgets.Customer</class>
  </persistence-unit>
</persistence>
```

```

    </persistence-unit>
</persistence>

<persistence>
  <persistence-unit name="OrderManagement2">
    <description>
      This unit manages inventory for auto parts.
      It depends on features provided by the
      com.acme.persistence implementation.
    </description>
    <provider>com.acme.AcmePersistence</provider>
    <jta-data-source>jdbc/MyPartDB</jta-data-source>
    <mapping-file>ormap2.xml</mapping-file>
    <jar-file>MyPartsApp.jar</jar-file>
    <properties>
      <property name="com.acme.persistence.sql-logging" value="on"/>
    </properties>
  </persistence-unit>
</persistence>

```

8.2.1.1. name

The `name` attribute defines the name of the persistence unit. This name is used to identify the persistence unit referred to by a `PersistenceContext` or `PersistenceUnit` annotation and in the programmatic API for creating an entity manager factory.

8.2.1.2. transaction-type

The `transaction-type` attribute specifies whether entity managers created by the entity manager factory for the persistence unit are JTA entity managers or resource-local entity managers. The value of this element must be `JTA` or `RESOURCE_LOCAL`:

- JTA means that a JTA data source is provided—either as specified by the `jta-data-source` element, or by the container.
- In a Jakarta EE environment, `RESOURCE_LOCAL` usually means that a non-JTA datasource is provided.

Configuration of datasources is described below in [Section 8.2.1.7](#).

If the `transaction-type` is not explicitly specified, its value is defaulted:

- in a Jakarta EE environment, the default is `JTA`, but
- in a Java SE environment, the default is `RESOURCE_LOCAL`.

8.2.1.3. description

The `description` element provides optional descriptive information about the persistence unit.

8.2.1.4. provider

The `provider` element specifies the name of a provider-specific implementation of `jakarta.persistence.spi.PersistenceProvider`. The `provider` element is optional, but should be explicitly specified if the application depends on the use of a particular persistence provider.

8.2.1.5. qualifier

The `qualifier` element specifies the fully-qualified class name of an annotation annotated `jakarta.inject.Qualifier`. This qualifier annotation may be used to disambiguate the persistence unit for the purposes of dependency injection.

8.2.1.6. scope

The `scope` element specifies the fully-qualified class name of an annotation annotated `jakarta.inject.Scope` or `jakarta.enterprise.context.NormalScope`. This `scope` annotation may be used to determine the scope of a persistence context for the purposes of dependency injection.

8.2.1.7. jta-data-source, non-jta-data-source

In Jakarta EE environments:

- the `jta-data-source` element specifies the JNDI name of a JTA data source, and/or
- the `non-jta-data-source` element specifies the JNDI name of a non-JTA data source.

The specified data source is used by the persistence provider to obtain database connections. If neither element is specified, the deployer must specify a data source at deployment, or a default data source must be provided by the container.

In Java SE environments, these elements may be used, or the data source information may be specified by other means, depending upon the requirements of the provider.

8.2.1.8. mapping-file, jar-file, class, exclude-unlisted-classes

The following classes must be implicitly or explicitly denoted as managed persistence classes to be included within a persistence unit:

- entity classes;
- embeddable classes;
- mapped superclasses;
- converter classes.

The set of managed persistence classes managed by a persistence unit is specified using one or more of the following.^[2]

- annotated managed persistence classes contained in the root of the persistence unit (unless the `exclude-unlisted-classes` element is specified);
- one or more object/relational mapping XML files;
- one or more JAR files to be searched for classes;
- an explicit list of classes.

The set of entities managed by the persistence unit is the union of these sources, with the mapping metadata annotations (or annotation defaults) for any given class being overridden by the XML mapping information file if there are both annotations and XML mappings for that class. The minimum portable level of overriding is at the level of the persistent field or property.

The classes and/or jars that named as part of a persistence unit must be on the classpath; referencing them from the `persistence.xml` file does not cause them to be placed on the classpath.

All classes must be on the classpath to ensure that entity managers from different persistence units that map the same class will be accessing the same identical class.

Annotated Classes in the Root of the Persistence Unit

By default, in the Java EE environment, the root of the persistence unit is searched for annotated managed persistence

classes—classes with an `Entity`, `Embeddable`, `MappedSuperclass`, or `Converter` annotation—and mapping metadata annotations found on these classes are processed. Where mapping annotations are missing, the classes are mapped using mapping annotation defaults.

This behavior is disabled if the `exclude-unlisted-classes` of the `persistence.xml` file is specified as `true`. In this case, an annotated persistence class located in the root of the persistence unit is not included in the persistence unit unless it is explicitly listed in a `class` element of the `persistence.xml` file or in a mapping file.

In the Java SE environment, this behavior is not required. Portable Java SE applications should explicitly list each persistence class in a `class` element of the `persistence.xml` file or in a mapping file. The `exclude-unlisted-classes` element is not intended for use in Java SE environments.

Object/relational Mapping Files

An object/relational mapping XML file contains mapping information for the classes it lists.

- An object/relational mapping XML file named `orm.xml` may be located in the `META-INF` directory in the root of the persistence unit or in the `META-INF` directory of any jar file referenced by the `persistence.xml`.
- Alternatively, or in addition, one or more mapping files may be referenced by the `mapping-file` elements of the `persistence-unit` element. These mapping files may be present anywhere on the class path.

An `orm.xml` mapping file or other mapping file is loaded as a resource by the persistence provider. If a mapping file is specified, the classes and mapping information listed in the mapping file are used as described in [Chapter 12](#).

If multiple mapping files are specified (possibly including one or more `orm.xml` files), the resulting mappings are obtained by combining the mappings from all the files. If multiple mapping files referenced within a single persistence unit (including any `orm.xml` file) contain overlapping mapping information for a given class, the result is undefined. That is, the object/relational mapping information contained in any given mapping file referenced within the persistence unit must be disjoint at the class level from object/relational mapping information contained in other mapping files referenced within the persistence unit.

Jar Files

One or more JAR files may be specified using `jar-file` elements instead of, or in addition to, the mapping files listed by the `mapping-file` elements. These JAR files are searched for managed persistence classes and any mapping metadata annotations found on them are processed. Where mapping annotations are missing, the classes are mapped using the mapping annotation defaults defined by this specification. Such JAR files are specified relative to the directory or jar file that contains the root of the persistence unit.^[3]

The following examples illustrate the use of the `jar-file` element to reference additional persistence classes. These examples make use of the convention that a jar file with a name terminating in “PUnit” contains the `persistence.xml` file and that a jar file with a name terminating in “Entities” contains additional persistence classes.

Example 1:

```
app.ear
  lib/earEntities.jar
  earRootPUnit.jar (with META-INF/persistence.xml)
```

`persistence.xml` contains:

```
<jar-file>lib/earEntities.jar</jar-file>
```

Example 2:

```
app.ear
  lib/earEntities.jar
  lib/earLibPUnit.jar (with META-INF/persistence.xml)
```

persistence.xml contains:

```
<jar-file>earEntities.jar</jar-file>
```

Example 3:

```
app.ear
  lib/earEntities.jar
  ejbjar.jar (with META-INF/persistence.xml)
```

persistence.xml contains:

```
<jar-file>lib/earEntities.jar</jar-file>
```

Example 4:

```
app.ear
  war1.war
    WEB-INF/lib/warEntities.jar
    WEB-INF/lib/warPUnit.jar (with META-INF/persistence.xml)
```

persistence.xml contains:

```
<jar-file>warEntities.jar</jar-file>
```

Example 5:

```
app.ear
  war2.war
    WEB-INF/lib/warEntities.jar
    WEB-INF/classes/META-INF/persistence.xml
```

persistence.xml contains:

```
<jar-file>lib/warEntities.jar</jar-file>
```

Example 6:

```
app.ear
  lib/earEntities.jar
  war2.war
    WEB-INF/classes/META-INF/persistence.xml
```

persistence.xml contains:

```
<jar-file>../../lib/earEntities.jar</jar-file>
```

Example 7:

```
app.ear
  lib/earEntities.jar
  war1.war
    WEB-INF/lib/warPUnit.jar (with META-INF/persistence.xml)
```

persistence.xml contains:

```
<jar-file>../../../../lib/earEntities.jar</jar-file>
```

List of Managed Classes

A list of named managed persistence classes—entity classes, embeddable classes, mapped superclasses, and converter classes—may be specified instead of, or in addition to, the listed JAR files and mapping files. Any mapping metadata annotations found on these classes are processed. Where mapping annotations are missing, the classes are mapped using the mapping annotation defaults. The `class` element is used to list a managed persistence class.

In Java SE environments, an explicit list of all managed persistence class names must be specified to insure portability. Portable Java SE applications should not rely on the other mechanisms described here to determine the managed persistence classes of a persistence unit. In Java SE environments, a persistence provider may require that the set of entity classes and other classes to be managed is fully enumerated in each `persistence.xml` file.

8.2.1.9. shared-cache-mode

The `shared-cache-mode` element determines whether second-level caching is in effect for the persistence unit. See [Section 3.10.1](#).

8.2.1.10. validation-mode

The `validation-mode` element determines whether automatic lifecycle event time validation is in effect. See [Section 3.7.1.1](#).

8.2.1.11. properties

The `properties` element is used to specify both standard and vendor-specific properties and hints that apply to the persistence unit and its entity manager factory configuration.

The following properties and hints defined by this specification are intended for use in both Jakarta EE and Java SE environments:

`jakarta.persistence.lock.timeout`

The pessimistic lock timeout in milliseconds. This is a hint only.

`jakarta.persistence.query.timeout`

The query timeout in milliseconds. This is a hint only.

`jakarta.persistence.validation.group.pre-persist`

Bean Validation groups that are targeted for validation upon the pre-persist event (overrides the default behavior).

`jakarta.persistence.validation.group.pre-update`

Bean Validation groups that are targeted for validation upon the pre-update event (overrides the default behavior).

`jakarta.persistence.validation.group.pre-remove`

Bean Validation groups that are targeted for validation upon the pre-remove event (overrides the default behavior).

The following properties defined by this specification are intended for use in Java SE environments.

`jakarta.persistence.jdbc.driver`

Fully qualified name of the JDBC driver class.

`jakarta.persistence.jdbc.url`

Driver-specific connection URL.

`jakarta.persistence.jdbc.user`

Username for database connection authentication.

`jakarta.persistence.jdbc.password`

Password for database connection authentication

Scripts for use in schema generation may be specified using the `jakarta.persistence.schema-generation.create-script-source` and `jakarta.persistence.schema-generation.drop-script-source` properties. A script to specify SQL for the bulk loading of data may be specified by the `jakarta.persistence.sql-load-script-source` property. These properties are intended for use in both Jakarta EE and Java SE environments:

`jakarta.persistence.schema-generation.create-script-source`

Name of a script packaged as part of the persistence application or a string identifying a file URL that designates a script.

`jakarta.persistence.schema-generation.drop-script-source`

Name of a script packaged as part of the persistence application or a string identifying a file URL that designates a script.

`jakarta.persistence.sql-load-script-source`

Name of a script packaged as part of the persistence unit or a string identifying a file URL that designates a script.

When scripts are packaged as part of the persistence application, these properties must specify locations relative to the root of the persistence unit. When scripts are provided externally (or when schema generation is configured to write script files, as described below), strings identifying file URLs must be specified. In Jakarta EE environments, such file URLs must be absolute paths. In Jakarta EE environments, all source and target file locations must be accessible to the application server deploying the persistence unit.

In general, it is expected that schema generation will be initiated by means of the APIs described in [Section 9.4](#). However, schema generation actions may also be specified by means of the following properties used in the `persistence.xml` file.

`jakarta.persistence.schema-generation.database.action`

The `jakarta.persistence.schema-generation.database.action` property specifies the action to be taken by the persistence provider with regard to the database artifacts. The values for this property are `none`, `create`, `drop-and-create`, `drop`, `validate`. If this property is not specified, it is assumed that schema generation is not needed or will be initiated by other means, and, by default, no schema generation actions will be taken on the database. (See [Section 9.4](#).)

`jakarta.persistence.schema-generation.scripts.action`

The `jakarta.persistence.schema-generation.scripts.action` property specifies which scripts are to be generated by the persistence provider. The values for this property are `none`, `create`, `drop-and-create`, `drop`. A script will only be generated if the script target is specified. If this property is not specified, it is assumed that script generation is

not needed or will be initiated by other means, and, by default, no scripts will be generated. (See [Section 9.4](#).)

`jakarta.persistence.schema-generation.create-source`

The `jakarta.persistence.schema-generation.create-source` property specifies whether the creation of database artifacts is to occur on the basis of the object/relational mapping metadata, DDL script, or a combination of the two. The values for this property are `metadata`, `script`, `metadata-then-script`, `script-then-metadata`. If this property is not specified, and a script is specified by the `jakarta.persistence.schema-generation.create-script-source` property, the script (only) will be used for schema generation; otherwise if this property is not specified, schema generation will occur on the basis of the object/relational mapping metadata (only). The `metadata-then-script` and `script-then-metadata` values specify that a combination of metadata and script is to be used and the order in which this use is to occur. If either of these values is specified and the resulting database actions are not disjoint, the results are undefined and schema generation may fail.

`jakarta.persistence.schema-generation.drop-source`

The `jakarta.persistence.schema-generation.drop-source` property specifies whether the dropping of database artifacts is to occur on the basis of the object/relational mapping metadata, DDL script, or a combination of the two. The values for this property are `metadata`, `script`, `metadata-then-script`, `script-then-metadata`. If this property is not specified, and a script is specified by the `jakarta.persistence.schema-generation.drop-script-source` property, the script (only) will be used for the dropping of database artifacts; otherwise if this property is not specified, the dropping of database artifacts will occur on the basis of the object/relational mapping metadata (only). The `metadata-then-script` and `script-then-metadata` values specify that a combination of metadata and script is to be used and the order in which this use is to occur. If either of these values is specified and the resulting database actions are not disjoint, the results are undefined and the dropping of database artifacts may fail.

`jakarta.persistence.schema-generation.scripts.create-target`,

`jakarta.persistence.schema-generation.scripts.drop-target`

If scripts are to be generated, the target locations for the writing of these scripts must be specified. These targets are specified as strings corresponding to file URLs.

If a persistence provider does not recognize a property (other than a property defined by this specification), the provider must ignore it.

Vendors should define properties in vendor-specific namespaces, (e.g `com.acme.persistence.logging`). The namespace `jakarta.persistence` is reserved for use by this specification, and must not be used to define vendor-specific properties.

The following are sample contents of a `persistence.xml` file.

Example 1:

```
<persistence-unit name="OrderManagement"/>
```

A persistence unit named `OrderManagement` is created.

Any annotated managed persistence classes found in the root of the persistence unit are added to the list of managed persistence classes. If a `META-INF/orm.xml` file exists, any classes referenced by it and mapping information contained in it are used as specified above. Because no provider is specified, the persistence unit is assumed to be portable across providers. Because the transaction type is not specified, JTA is assumed for Jakarta EE environments. The container must provide the data source (it may be specified at application deployment, for example). In Java SE environments, the data source may be specified by other means and a transaction type of `RESOURCE_LOCAL` is assumed.

Example 2:

```
<persistence-unit name="OrderManagement2">
```

```
<mapping-file>mappings.xml</mapping-file>
</persistence-unit>
```

A persistence unit named `OrderManagement2` is created. Any annotated managed persistence classes found in the root of the persistence unit are added to the list of managed persistence classes. The `mappings.xml` resource exists on the classpath and any classes and mapping information contained in it are used as specified above. If a `META-INF/orm.xml` file exists, any classes and mapping information contained in it are used as well. The transaction type, data source, and provider are as described above.

Example 3:

```
<persistence-unit name="OrderManagement3">
  <jar-file>order.jar</jar-file>
  <jar-file>order-supplemental.jar</jar-file>
</persistence-unit>
```

A persistence unit named `OrderManagement3` is created. Any annotated managed persistence classes found in the root of the persistence unit are added to the list of managed persistence classes. If a `META-INF/orm.xml` file exists, any classes and mapping information contained in it are used as specified above. The `order.jar` and `order-supplemental.jar` files are searched for managed persistence classes and any annotated managed persistence classes found in them and/or any classes specified in the `orm.xml` files of these jar files are added. The transaction-type, data source and provider are as described above.

Example 4:

```
<persistence-unit name="OrderManagement4" transaction-type=RESOURCE_LOCAL>
  <non-jta-data-source>java:app/jdbc/MyDB</non-jta-data-source>
  <mapping-file>order-mappings.xml</mapping-file>
  <class>com.acme.Order</class>
  <class>com.acme.Customer</class>
  <class>com.acme.Item</class>
  <exclude-unlisted-classes/>
</persistence-unit>
```

A persistence unit named `OrderManagement4` is created. The file `order-mappings.xml` is read as a resource and any classes referenced by it and mapping information contained in it are used^[4]. The annotated `Order`, `Customer` and `Item` classes are loaded and are added. No (other) classes contained in the root of the persistence unit are added to the list of managed persistence classes. The persistence unit assumed to be portable across providers. A entity manager factory supplying resource-local entity managers will be created. The data source `java:app/jdbc/MyDB` must be used.

Example 5:

```
<persistence-unit name="OrderManagement5">
  <provider>com.acme.AcmePersistence</provider>
  <mapping-file>order1.xml</mapping-file>
  <mapping-file>order2.xml</mapping-file>
  <jar-file>order.jar</jar-file>
  <jar-file>order-supplemental.jar</jar-file>
</persistence-unit>
```

A persistence unit named `OrderManagement5` is created. Any annotated managed persistence classes found in the root of the persistence unit are added to the list of managed classes. The `order1.xml` and `order2.xml` files are read as resources and any classes referenced by them and mapping information contained in them are also used as specified above. The `order.jar` is a jar file on the classpath containing another persistence unit, while `order-supplemental.jar` is just a library of classes. Both of these jar files are searched for annotated managed persistence classes and any annotated managed persistence classes found in them and any classes specified in the `orm.xml` files (if any) of these jar files are added. The

provider `com.acme.AcmePersistence` must be used.



Note that the `persistence.xml` file contained in `order.jar` is not used to augment the persistence unit `OrderManagement5` with the classes of the persistence unit whose root is `order.jar`.

8.2.2. Persistence Unit Scope

An EJB-JAR, WAR, application client JAR, or EAR can define a persistence unit. When referencing a persistence unit using the `unitName` annotation element or `persistence-unit-name` deployment descriptor element, the visibility scope of the persistence unit is determined by its point of definition:

- A persistence unit defined at the level of an EJB-JAR, WAR, or application client JAR is scoped to that EJB-JAR, WAR, or application JAR respectively and is visible to the components defined in that jar or WAR.
- A persistence unit defined at the level of an EAR is generally visible to all components in the application. However, if a persistence unit of the same name is defined by an EJB-JAR, WAR, or application JAR file within the EAR, the persistence unit of that name defined at EAR level will not be visible to the components defined by that EJB-JAR, WAR, or application JAR file, unless the persistence unit reference uses the persistence unit name `#` syntax to specify a path name to disambiguate the reference.

The `#` syntax may be used with both the `unitName` annotation element or `persistence-unit-name` deployment descriptor element to reference a persistence unit defined at EAR level.

When the `#` syntax is used, the path name is interpreted relative to the referencing application component jar file. For example, the syntax `../lib/persistenceUnitRoot.jar#myPersistenceUnit` refers to a persistence unit with:

- name `myPersistenceUnit`, as specified in the `name` element of the `persistence.xml` file, and
- root given by the relative path name `../lib/persistenceUnitRoot.jar`.

8.3. persistence.xml Schema

This section provides the XML schema for the `persistence.xml` file.

```
<?xml version="1.0" encoding="UTF-8"?>

<!-- persistence.xml schema -->
<xsd:schema targetNamespace="https://jakarta.ee/xml/ns/persistence"
  xmlns:xsd="http://www.w3.org/2001/XMLSchema"
  xmlns:persistence="https://jakarta.ee/xml/ns/persistence"
  elementFormDefault="qualified"
  attributeFormDefault="unqualified"
  version="3.2">
```

```
<xsd:annotation>
  <xsd:documentation><![CDATA[
```

This is the XML Schema for the persistence configuration file.
The file must be named "META-INF/persistence.xml" in the persistence archive.

Persistence configuration files must indicate the persistence schema by using the persistence namespace:

```
https://jakarta.ee/xml/ns/persistence
```

and indicate the version of the schema by using the version element as shown below:

```
<persistence xmlns="https://jakarta.ee/xml/ns/persistence"
```

```

xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="https://jakarta.ee/xml/ns/persistence
https://jakarta.ee/xml/ns/persistence/persistence_3_2.xsd"
version="3.2">
    ...
</persistence>

]]></xsd:documentation>
</xsd:annotation>

<xsd:simpleType name="versionType">
  <xsd:restriction base="xsd:token">
    <xsd:pattern value="[0-9]+(\.[0-9]+)*"/>
  </xsd:restriction>
</xsd:simpleType>

<!-- ***** -->

<xsd:element name="persistence">
  <xsd:complexType>
    <xsd:sequence>

      <!-- ***** -->

      <xsd:element name="persistence-unit"
        minOccurs="1" maxOccurs="unbounded">
        <xsd:complexType>
          <xsd:annotation>
            <xsd:documentation>

              Configuration of a persistence unit.

            </xsd:documentation>
          </xsd:annotation>
        </xsd:complexType>
      </xsd:element>

      <!-- ***** -->

      <xsd:element name="description" type="xsd:string"
        minOccurs="0">
        <xsd:annotation>
          <xsd:documentation>

            Description of this persistence unit.

          </xsd:documentation>
        </xsd:annotation>
      </xsd:element>

      <!-- ***** -->

      <xsd:element name="provider" type="xsd:string"
        minOccurs="0">
        <xsd:annotation>
          <xsd:documentation>

            Provider class that supplies EntityManager for this
            persistence unit.

          </xsd:documentation>
        </xsd:annotation>
      </xsd:element>

      <!-- ***** -->

      <xsd:element name="qualifier" type="xsd:string"
        minOccurs="0" maxOccurs="unbounded">

```



```

<xsd:annotation>
  <xsd:documentation>

    Qualifier annotation class used for dependency injection.

  </xsd:documentation>
</xsd:annotation>
</xsd:element>

<!-- ***** -->

<xsd:element name="scope" type="xsd:string"
  minOccurs="0">
  <xsd:annotation>
    <xsd:documentation>

      Scope annotation class used for dependency injection.

    </xsd:documentation>
  </xsd:annotation>
</xsd:element>

<!-- ***** -->

<xsd:element name="jta-data-source" type="xsd:string"
  minOccurs="0">
  <xsd:annotation>
    <xsd:documentation>

      The container-specific name of the JTA datasource to use.

    </xsd:documentation>
  </xsd:annotation>
</xsd:element>

<!-- ***** -->

<xsd:element name="non-jta-data-source" type="xsd:string"
  minOccurs="0">
  <xsd:annotation>
    <xsd:documentation>

      The container-specific name of a non-JTA datasource to use.

    </xsd:documentation>
  </xsd:annotation>
</xsd:element>

<!-- ***** -->

<xsd:element name="mapping-file" type="xsd:string"
  minOccurs="0" maxOccurs="unbounded">
  <xsd:annotation>
    <xsd:documentation>

      File containing mapping information. Loaded as a resource
      by the persistence provider.

    </xsd:documentation>
  </xsd:annotation>
</xsd:element>

<!-- ***** -->

<xsd:element name="jar-file" type="xsd:string"
  minOccurs="0" maxOccurs="unbounded">
  <xsd:annotation>

```

```

<xsd:documentation>

    Jar file that is to be scanned for managed classes.

</xsd:documentation>
</xsd:annotation>
</xsd:element>

<!-- ***** -->

<xsd:element name="class" type="xsd:string"
             minOccurs="0" maxOccurs="unbounded">
  <xsd:annotation>
    <xsd:documentation>

        Managed class to be included in the persistence unit and
        to scan for annotations. It should be annotated
        with either @Entity, @Embeddable or @MappedSuperclass.

    </xsd:documentation>
  </xsd:annotation>
</xsd:element>

<!-- ***** -->

<xsd:element name="exclude-unlisted-classes" type="xsd:boolean"
             default="true" minOccurs="0">
  <xsd:annotation>
    <xsd:documentation>

        When set to true then only listed classes and jars will
        be scanned for persistent classes, otherwise the
        enclosing jar or directory will also be scanned.
        Not applicable to Java SE persistence units.

    </xsd:documentation>
  </xsd:annotation>
</xsd:element>

<!-- ***** -->

<xsd:element name="shared-cache-mode"
             type="persistence:persistence-unit-caching-type"
             minOccurs="0">
  <xsd:annotation>
    <xsd:documentation>

        Defines whether caching is enabled for the
        persistence unit if caching is supported by the
        persistence provider. When set to ALL, all entities
        will be cached. When set to NONE, no entities will
        be cached. When set to ENABLE_SELECTIVE, only entities
        specified as cacheable will be cached. When set to
        DISABLE_SELECTIVE, entities specified as not cacheable
        will not be cached. When not specified or when set to
        UNSPECIFIED, provider defaults may apply.

    </xsd:documentation>
  </xsd:annotation>
</xsd:element>

<!-- ***** -->

<xsd:element name="validation-mode"
             type="persistence:persistence-unit-validation-mode-type"
             minOccurs="0">
  <xsd:annotation>

```

```

<xsd:documentation>

    The validation mode to be used for the persistence unit.

</xsd:documentation>
</xsd:annotation>
</xsd:element>

<!-- ***** -->

<xsd:element name="properties" minOccurs="0">
  <xsd:annotation>
    <xsd:documentation>

      A list of standard and vendor-specific properties
      and hints.

    </xsd:documentation>
  </xsd:annotation>
  <xsd:complexType>
    <xsd:sequence>
      <xsd:element name="property"
        minOccurs="0" maxOccurs="unbounded">
        <xsd:annotation>
          <xsd:documentation>
            A name-value pair.
          </xsd:documentation>
        </xsd:annotation>
        <xsd:complexType>
          <xsd:attribute name="name" type="xsd:string"
            use="required"/>
          <xsd:attribute name="value" type="xsd:string"
            use="required"/>
        </xsd:complexType>
      </xsd:element>
    </xsd:sequence>
  </xsd:complexType>
</xsd:element>

<xsd:any namespace="##other" processContents="lax"
  minOccurs="0" maxOccurs="unbounded">
  <xsd:annotation>
    <xsd:documentation>
      An extension point for integration related configuration, e.g. cdi:
      <!--
      <persistence-unit name="my-unit" xmlns:cdi="https://jakarta.ee/xml/ns/persistence-cdi">
        ...
        <cdi:scope>com.example.jpa.ACustomScope</cdi:scope>
        <cdi:qualifier>com.example.jpa.CustomQualifier</cdi:qualifier>
      </persistence-unit>
      -->
    </xsd:documentation>
  </xsd:annotation>
</xsd:any>
</xsd:sequence>

<!-- ***** -->

<xsd:attribute name="name" type="xsd:string" use="required">
  <xsd:annotation>
    <xsd:documentation>

      Name used in code to reference this persistence unit.

    </xsd:documentation>
  </xsd:annotation>

```

```

</xsd:attribute>

<!-- ***** -->

<xsd:attribute name="transaction-type"
              type="persistence:persistence-unit-transaction-type">
  <xsd:annotation>
    <xsd:documentation>

      Type of transactions used by EntityManagers from this
      persistence unit.

    </xsd:documentation>
  </xsd:annotation>
</xsd:attribute>

</xsd:complexType>
</xsd:element>
</xsd:sequence>
<xsd:attribute name="version" type="persistence:versionType"
              fixed="3.2" use="required"/>
</xsd:complexType>
</xsd:element>

<!-- ***** -->

<xsd:simpleType name="persistence-unit-transaction-type">
  <xsd:annotation>
    <xsd:documentation>

      public enum PersistenceUnitTransactionType {JTA, RESOURCE_LOCAL};

    </xsd:documentation>
  </xsd:annotation>
  <xsd:restriction base="xsd:token">
    <xsd:enumeration value="JTA"/>
    <xsd:enumeration value="RESOURCE_LOCAL"/>
  </xsd:restriction>
</xsd:simpleType>

<!-- ***** -->

<xsd:simpleType name="persistence-unit-caching-type">
  <xsd:annotation>
    <xsd:documentation>

      public enum SharedCacheMode { ALL, NONE, ENABLE_SELECTIVE, DISABLE_SELECTIVE, UNSPECIFIED};

    </xsd:documentation>
  </xsd:annotation>
  <xsd:restriction base="xsd:token">
    <xsd:enumeration value="ALL"/>
    <xsd:enumeration value="NONE"/>
    <xsd:enumeration value="ENABLE_SELECTIVE"/>
    <xsd:enumeration value="DISABLE_SELECTIVE"/>
    <xsd:enumeration value="UNSPECIFIED"/>
  </xsd:restriction>
</xsd:simpleType>

<!-- ***** -->

<xsd:simpleType name="persistence-unit-validation-mode-type">
  <xsd:annotation>
    <xsd:documentation>

      public enum ValidationMode { AUTO, CALLBACK, NONE};


```

```
    </xsd:documentation>
  </xsd:annotation>
  <xsd:restriction base="xsd:token">
    <xsd:enumeration value="AUTO"/>
    <xsd:enumeration value="CALLBACK"/>
    <xsd:enumeration value="NONE"/>
  </xsd:restriction>
</xsd:simpleType>

</xsd:schema>
```

[1] The root of the persistence unit is the WEB-INF/classes directory; the persistence.xml file is therefore contained in the WEB-INF/classes/META-INF directory.

[2] Note that an given class may be used in more than one persistence unit.

[3] Persistence providers are encouraged to support this syntax for use in Java SE environments.

[4] Note that in this example a META-INF/orm.xml file is assumed not to exist.

Chapter 9. Container and Provider Contracts for Deployment and Bootstrapping

This chapter defines requirements on the Jakarta EE container and on the persistence provider for deployment and bootstrapping.

9.1. Jakarta EE Deployment

Each persistence unit deployed into a Jakarta EE container consists of a single `persistence.xml` file, any number of mapping files, and any number of class files.

At deployment time the container is responsible for scanning the locations specified in [Section 8.2](#) and discovering the `persistence.xml` files and processing them.

When the container finds a `persistence.xml` file, it must process the persistence unit definitions that it contains. The container must validate the `persistence.xml` file against the `persistence_3_2.xsd`, `persistence_3_0.xsd` or `persistence_2_2.xsd` schema in accordance with the version specified by the `persistence.xml` file and report any validation errors. Provider or data source information not specified in the `persistence.xml` file must be provided at deployment time or defaulted by the container. The container may optionally add any container-specific properties to be passed to the provider when creating the entity manager factory for the persistence unit.

Once the container has read the persistence metadata, it determines the `jakarta.persistence.spi.PersistenceProvider` implementation class for each deployed named persistence unit. The container then creates an instance of the `PersistenceProvider` implementation class for each deployed named persistence unit and invokes the `createContainerEntityManagerFactory` method on that instance.

- The container must implement the `PersistenceUnitInfo` interface described in [Section 9.6](#) and pass the metadata—in the form of a `PersistenceUnitInfo` instance—to the persistence provider as part of this call.
- If a Bean Validation provider exists in the container environment and the `validation-mode NONE` is not specified, a `ValidatorFactory` instance must be made available by the container. The container is responsible for passing this `ValidatorFactory` instance via the map that is passed as an argument to the `createContainerEntityManagerFactory` call. The map key used must be the standard property name `jakarta.persistence.validation.factory`.
- If CDI is enabled, a `BeanManager` instance must be made available by the container. The container is responsible for passing this `BeanManager` instance via the map that is passed as an argument to the `createContainerEntityManagerFactory` call. The map key used must be the standard property name `jakarta.persistence.bean.manager`.

The `EntityManagerFactory` instance obtained as a result will be used by the container to create container-managed entity managers. Only one `EntityManagerFactory` is permitted to be created for each deployed persistence unit configuration. Any number of `EntityManager` instances may be created from a given factory.

In a Jakarta EE environment, the classes of the persistence unit should not be loaded by the application class loader or any of its parent class loaders until after the entity manager factory for the persistence unit has been created.

When a persistence unit is redeployed, the container should call the `close` method on the previous `EntityManagerFactory` instance and call the `createContainerEntityManagerFactory` method again, with the required `PersistenceUnitInfo` metadata, to achieve the redeployment.

9.2. Bootstrapping in Java SE Environments

In Java SE environments, the `Persistence.createEntityManagerFactory` method is used by the application to create an entity manager factory^[1].

A persistence provider implementation running in a Java SE environment should also act as a service provider by supplying a service provider configuration file as defined by the Java SE platform.

The provider configuration file serves to export the provider implementation class to the `Persistence` bootstrap class, positioning the provider as a candidate for backing named persistence units. The provider supplies the provider configuration file by creating a text file named `jakarta.persistence.spi.PersistenceProvider` and placing it in the `META-INF/services` directory of one of its JAR files. The contents of the file should be the name of the provider implementation class of the `jakarta.persistence.spi.PersistenceProvider` interface.

Example:

A persistence vendor called ACME persistence products ships a JAR called `acme.jar` that contains its persistence provider implementation. The JAR includes the provider configuration file.

```
acme.jar
META-INF/services/jakarta.persistence.spi.PersistenceProvider
com.acme.PersistenceProvider
...
```

The contents of the `META-INF/services/jakarta.persistence.spi.PersistenceProvider` file is nothing more than the name of the implementation class: `com.acme.PersistenceProvider`.

Persistence provider jars may be installed or made available in the same ways as other service providers, e.g. as extensions or added to the application classpath.

The `Persistence` bootstrap class must locate all of the persistence providers using the `PersistenceProviderResolver` mechanism described in [Section 9.3](#) and call `createEntityManagerFactory` on them in turn until an appropriate backing provider returns an `EntityManagerFactory` instance. A provider may deem itself as appropriate for the persistence unit if any of the following are true:

- Its implementation class has been specified in the provider element for that persistence unit in the `persistence.xml` file and has not been overridden by a different `jakarta.persistence.provider` property value included in the Map passed to the `createEntityManagerFactory` method.
- The `jakarta.persistence.provider` property was included in the Map passed to `createEntityManagerFactory` and the value of the property is the provider's implementation class.
- No provider was specified for the persistence unit in either the `persistence.xml` or the property map.

If a provider does not qualify as the provider for the named persistence unit, it must return `null` when `createEntityManagerFactory` is invoked on it.

9.2.1. Schema Generation

In Java SE environments, the `Persistence.generateSchema` method may be used by the application to cause schema generation to occur as a separate phase from entity manager factory creation.

In this case, the `Persistence` bootstrap class must locate all of the persistence providers using the `PersistenceProviderResolver` mechanism described in [Section 9.3](#) and call `generateSchema` on them in turn until an appropriate backing provider returns `true`. A provider may deem itself as appropriate for the persistence unit if any of the following are true:

- Its implementation class has been specified in the provider element for that persistence unit in the `persistence.xml` file and has not been overridden by a different `jakarta.persistence.provider` property value included in the Map passed to the `generateSchema` method.
- The `jakarta.persistence.provider` property was included in the Map passed to `generateSchema` and the value of the property is the provider's implementation class.
- No provider was specified for the persistence unit in either the `persistence.xml` or the property map.

If a provider does not qualify as the provider for the named persistence unit, it must return false when `generateSchema` is invoked on it.

9.3. Determining the Available Persistence Providers

The `PersistenceProviderResolver` and `PersistenceProviderResolverHolder` mechanism supports the dynamic discovery of persistence providers.^[2]

- The `PersistenceProviderResolver` instance is responsible for returning the list of providers available in the environment.
- The `PersistenceProviderResolverHolder` class holds the `PersistenceProviderResolver` instance that is in use.

These interfaces may be found in [Appendix E](#).

The implementation of `PersistenceProviderResolverHolder` must be threadsafe, but no guarantee is made against multiple threads setting the resolver.

The container is allowed to implement and set a specific `PersistenceProviderResolver` provided that it respects the `PersistenceProviderResolver` contract. The `PersistenceProviderResolver` instance to be used is set by the container using the `PersistenceProviderResolverHolder.setPersistenceProviderResolver` method.^[3]

If no `PersistenceProviderResolver` is set, the `PersistenceProviderResolverHolder` must return a `PersistenceProviderResolver` that returns the providers whose persistence provider jars have been installed or made available as service providers or extensions. This default `PersistenceProviderResolver` instance does not guarantee the order in which persistence providers are returned.

A `PersistenceProviderResolver` must be threadsafe.

The `PersistenceProviderResolver.getPersistenceProviders()` method must be used to determine the list of available persistence providers.

The results of calling the `PersistenceProviderResolverHolder.getPersistenceProviderResolver` and the `PersistenceProviderResolver.getPersistenceProviders` methods must not be cached. In particular, the following methods must use the `PersistenceProviderResolver` instance returned by the `PersistenceProviderResolverHolder.getPersistenceProviderResolver` method to determine the list of available providers:

- `Persistence.createEntityManagerFactory(String)`
- `Persistence.createEntityManagerFactory(String, Map)`
- `PersistenceUtil.isLoaded(Object)`
- `PersistenceUtil.isLoaded(Object, String)`

These methods must not cache the list of providers and must not cache the `PersistenceProviderResolver` instance.



Note that the `PersistenceProviderResolver.getPersistenceProviders()` method can potentially be called many times. It is therefore recommended that the implementation of this method make use of caching.

Note that only a single `PersistenceProviderResolver` instance can be defined in a given classloader hierarchy at a given time.

9.4. Schema Generation

In cases where a preconfigured database (or a “legacy” database) is not used or is not available, the Jakarta Persistence schema generation facility may be used to generate the tables and other database artifacts required by the persistence

application. Whether schema generation entails the creation of schemas proper in the database is determined by the environment and the configuration of the schema generation process, as described below.

Schema generation may happen either prior to application deployment or when the entity manager factory is created as part of the application deployment and initialization process.

- In Jakarta EE environments, the container may call the `PersistenceProvider generateSchema` method separately from and/or prior to the creation of the entity manager factory for the persistence unit, or the container may pass additional information to the `createContainerEntityManagerFactory` call to cause schema generation to happen as part of the entity manager factory creation and application initialization process. The information passed to these methods controls whether the generation occurs directly in the target database, whether DDL scripts for schema generation are created, or both.
- In Java SE environments, the application may call the `Persistence generateSchema` method separately from and/or prior to the creation of the entity manager factory or may pass information to the `createEntityManagerFactory` method to cause schema generation to occur as part of the entity manager factory creation.

The application may provide DDL scripts to be used for schema generation as described in [Section 8.2.1.11](#). The application developer may package these scripts as part of the persistence unit or may specify strings corresponding to file URLs for the location of such scripts. In Jakarta EE environments, such scripts may be executed by the container, or the container may direct the persistence provider to execute the scripts. In Java SE environments, the execution of the scripts is the responsibility of the persistence provider. In the absence of the specification of scripts, schema generation, if requested, will be determined by the object/relational metadata of the persistence unit.

The following standard properties are defined for configuring the schema generation process. In Jakarta EE environments these properties are passed by the container in the `Map` argument to either the `PersistenceProvider generateSchema` method or the `createContainerEntityManagerFactory` method. In Java SE environments, they are passed in the `Map` argument to either the `Persistence generateSchema` method or `createEntityManagerFactory` method.

In Jakarta EE environments, any strings corresponding to file URLs for script sources or targets must specify absolute paths (not relative). In Jakarta EE environments, all source and target file locations must be accessible to the application server deploying the persistence unit

`jakarta.persistence.schema-generation.database.action`

The `jakarta.persistence.schema-generation.database.action` property specifies the action to be taken by the persistence provider with regard to the database artifacts. The values for this property are *"none"*, *"create"*, *"drop-and-create"*, *"drop"*, *"validate"*. If the `jakarta.persistence.schema-generation.database.action` property is not specified, no schema generation actions must be taken on the database.

`jakarta.persistence.schema-generation.scripts.action`

The `jakarta.persistence.schema-generation.scripts.action` property specifies which scripts are to be generated by the persistence provider. The values for this property are *"none"*, *"create"*, *"drop-and-create"*, *"drop"*. A script will only be generated if the script target is specified. If this property is not specified, no scripts will be generated.

`jakarta.persistence.schema-generation.create-source`

The `jakarta.persistence.schema-generation.create-source` property specifies whether the creation of database artifacts is to occur on the basis of the object/relational mapping metadata, DDL script, or a combination of the two. The values for this property are *"metadata"*, *"script"*, *"metadata-then-script"*, *"script-then-metadata"*. If this property is not specified, and a script is specified by the `jakarta.persistence.schema-generation.create-script-source` property, the script (only) will be used for schema generation; otherwise if this property is not specified, schema generation will occur on the basis of the object/relational mapping metadata (only). The *"metadata-then-script"* and *"script-then-metadata"* values specify that a combination of metadata and script is to be used and the

order in which this use is to occur. If either of these values is specified and the resulting database actions are not disjoint, the results are undefined and schema generation may fail.

`jakarta.persistence.schema-generation.drop-source`

The `jakarta.persistence.schema-generation.drop-source` property specifies whether the dropping of database artifacts is to occur on the basis of the object/relational mapping metadata, DDL script, or a combination of the two. The values for this property are `"metadata"`, `"script"`, `"metadata-then-script"`, `"script-then-metadata"`. If this property is not specified, and a script is specified by the `jakarta.persistence.schema-generation.drop-script-source` property, the script (only) will be used for the dropping of database artifacts; otherwise if this property is not specified, the dropping of database artifacts will occur on the basis of the object/relational mapping metadata (only). The `"metadata-then-script"` and `"script-then-metadata"` values specify that a combination of metadata and script is to be used and the order in which this use is to occur. If either of these values is specified and the resulting database actions are not disjoint, the results are undefined and the dropping of database artifacts may fail.

`jakarta.persistence.schema-generation.create-database-schemas`

In Jakarta EE environments, it is anticipated that the Jakarta EE platform provider may wish to control the creation of database schemas rather than delegate this task to the persistence provider. The `jakarta.persistence.schema-generation.create-database-schemas` property specifies whether the persistence provider is to create the database schema(s) in addition to creating database objects such as tables, sequences, constraints, etc. The value of this boolean property should be set to true if the persistence provider is to create schemas in the database or to generate DDL that contains "CREATE SCHEMA" commands. If this property is not supplied, the provider should not attempt to create database schemas. This property may also be specified in Java SE environments. `jakarta.persistence.schema-generation.scripts.create-target`,

`jakarta.persistence.schema-generation.scripts.drop-target`

If scripts are to be generated, the target locations for the writing of these scripts must be specified.

The `jakarta.persistence.schema-generation.scripts.create-target` property specifies a `java.io.Writer` configured for use by the persistence provider for output of the DDL script or a string specifying the file URL for the DDL script. This property should only be specified if scripts are to be generated.

The `jakarta.persistence.schema-generation.scripts.drop-target` property specifies a `java.io.Writer` configured for use by the persistence provider for output of the DDL script or a string specifying the file URL for the DDL script. This property should only be specified if scripts are to be generated.

`jakarta.persistence.database-product-name`,

`jakarta.persistence.database-major-version`,

`jakarta.persistence.database-minor-version`

If scripts are to be generated by the persistence provider and a connection to the target database is not supplied, the `jakarta.persistence.database-product-name` property must be specified. The value of this property should be the value returned for the target database by the JDBC `DatabaseMetaData` method `getDatabaseProductName`. If sufficient database version information is not included in the result of this method, the `jakarta.persistence.database-major-version` and `jakarta.persistence.database-minor-version` properties should be specified as needed. These should contain the values returned by the JDBC `getDatabaseMajorVersion` and `getDatabaseMinorVersion` methods respectively. `jakarta.persistence.schema-generation.create-script-source`,

`jakarta.persistence.schema-generation.drop-script-source`

The `jakarta.persistence.schema-generation.create-script-source` and `jakarta.persistence.schema-generation.drop-script-source` properties are used for script execution. In Jakarta EE container environments, it is generally expected that the container will be responsible for executing DDL scripts, although the container is permitted to delegate this task to the persistence provider. If DDL scripts are to be used in Java SE environments or if the

Jakarta EE container delegates the execution of scripts to the persistence provider, these properties must be specified.

The `jakarta.persistence.schema-generation.create-script-source` property specifies a `java.io.Reader` configured for reading of the DDL script or a string designating a file URL for the DDL script.

The `jakarta.persistence.schema-generation.drop-script-source` property specifies a `java.io.Reader` configured for reading of the DDL script or a string designating a file URL for the DDL script.

`jakarta.persistence.schema-generation.connection`

The `jakarta.persistence.schema-generation.connection` property specifies the JDBC connection to be used for schema generation. This is intended for use in Jakarta EE environments, where the platform provider may want to control the database privileges that are available to the persistence provider. This connection is provided by the container, and should be closed by the container when the schema generation request or entity manager factory creation completes. The connection provided must have credentials sufficient for the persistence provider to carry out the requested actions. If this property is not specified, the persistence provider should use the `DataSource` that has otherwise been provided.

9.4.1. Data Loading

Data loading, by means of the use of SQL scripts, may occur as part of the schema generation process after the creation of the database artifacts or independently of schema generation. The specification of the `jakarta.persistence.sql-load-script-source` controls whether data loading will occur.

`jakarta.persistence.sql-load-script-source`

In Jakarta EE container environments, it is generally expected that the container will be responsible for executing data load scripts, although the container is permitted to delegate this task to the persistence provider. If a load script is to be used in Java SE environments or if the Jakarta EE container delegates the execution of the load script to the persistence provider, this property must be specified. + The `jakarta.persistence.sql-load-script-source` property specifies a `java.io.Reader` configured for reading of the SQL load script for database initialization or a string designating a file URL for the script.

9.5. Responsibilities of the Persistence Provider

The persistence provider must implement the `PersistenceProvider` SPI.

In Jakarta EE environments, the persistence provider must process the metadata that is passed to it at the time `createContainerEntityManagerFactory` method is called and create an instance of `EntityManagerFactory` using the `PersistenceUnitInfo` metadata for the factory. The factory is then returned to the container.

In Java SE environments, the persistence provider must validate the `persistence.xml` file against the persistence schema that corresponds to the version specified by the `persistence.xml` file and report any validation errors.

The persistence provider processes the metadata annotations on the managed classes of the persistence unit.

When the entity manager factory for a persistence unit is created, it is the responsibility of the persistence provider to initialize the state of the metamodel classes of the persistence unit.

When the persistence provider obtains an object/relational mapping file, it processes the definitions that it contains. The persistence provider must validate any object/relational mapping files against the object/relational mapping schema version specified by the object/relational mapping file and report any validation errors. The object relational mapping file must specify the object/relational mapping schema that it is written against by indicating the `version` element.

In Java SE environments, the application can pass the `ValidatorFactory` instance via the map that is passed as an argument to the `Persistence.createEntityManagerFactory` call. The map key used must be the standard property name `jakarta.persistence.validation.factory`. If no `ValidatorFactory` instance is provided by the application, and if a Bean Validation provider is present in the classpath, the persistence provider must instantiate the `ValidatorFactory` using the default bootstrapping approach as defined by the Bean Validation specification [5], namely `Validation.buildDefaultValidatorFactory()`.

9.5.1. `jakarta.persistence.spi.PersistenceProvider`

The `PersistenceProvider` interface found in [Section E.3](#) must be implemented by the persistence provider.

The `PersistenceProvider` implementation class must have a public constructor with no parameters.

An instance of `PersistenceProvider` is responsible for creating provider-specific implementations of `EntityManagerFactory`. It is invoked by the container in Jakarta EE environments and by the `jakarta.persistence.Persistence` class in Java SE environments. The `jakarta.persistence.spi.PersistenceProvider` implementation is not intended to be used by the application.

The properties passed to the `createEntityManagerFactory()` method in Java SE environments are described further in [Section 9.7](#) below.

9.5.2. `jakarta.persistence.spi.ProviderUtil`

The `ProviderUtil` interface found in [Section E.7](#) is called by the `PersistenceUtil` implementation to determine the load status of an entity or entity attribute. It is not intended to be invoked by the application.

9.6. `jakarta.persistence.spi.PersistenceUnitInfo` Interface

The `PersistenceUnitInfo` interface may be found in [Section E.6](#).

The enum `jakarta.persistence.spi.PersistenceUnitTransactionType` defines whether the entity managers created by the factory will be JTA or resource-local entity managers. This enum is deprecated.

```
/**
 * Specifies whether entity managers created by the
 * {@link jakarta.persistence.EntityManagerFactory}
 * are JTA or resource-local entity managers.
 *
 * @since 1.0
 *
 * @deprecated replaced by
 *   {@link jakarta.persistence.PersistenceUnitTransactionType}
 */
@Deprecated(since = "3.2", forRemoval = true)
public enum PersistenceUnitTransactionType {

    /** JTA entity managers are created. */
    JTA,

    /** Resource-local entity managers are created. */
    RESOURCE_LOCAL
}
```

The enum `jakarta.persistence.SharedCacheMode` defines the use of caching. The `persistence.xml` `shared-cache-mode` element has no default value. The `getSharedCacheMode` method must return `UNSPECIFIED` if the `shared-cache-mode` element has not been specified for the persistence unit.

```

import jakarta.persistence.spi.PersistenceUnitInfo;

/**
 * Specifies how the provider must use a second-level cache for the
 * persistence unit. Corresponds to the value of the {code persistence.xml}
 * {code shared-cache-mode} element, and returned as the result of
 * {@link PersistenceUnitInfo#getSharedCacheMode()}.
 *
 * @since 2.0
 */
public enum SharedCacheMode {

    /**
     * All entities and entity-related state and data are cached.
     */
    ALL,

    /**
     * Caching is disabled for the persistence unit.
     */
    NONE,

    /**
     * Caching is enabled for all entities for which
     * {@link Cacheable Cacheable(true)} is specified. All other
     * entities are not cached.
     */
    ENABLE_SELECTIVE,

    /**
     * Caching is enabled for all entities except those for which
     * {@link Cacheable Cacheable(false)} is specified. Entities
     * for which {code Cacheable(false)} is specified are not cached.
     */
    DISABLE_SELECTIVE,

    /**
     * Caching behavior is undefined: provider-specific defaults may apply.
     */
    UNSPECIFIED
}

```

The enum `jakarta.persistence.ValidationMode` defines the validation mode.

```

/**
 * The validation mode to be used by the provider for the persistence
 * unit.
 *
 * @since 2.0
 */
public enum ValidationMode {

    /**
     * If a Bean Validation provider is present in the environment,
     * the persistence provider must perform the automatic validation
     * of entities. If no Bean Validation provider is present in the
     * environment, no lifecycle event validation takes place.
     * This is the default behavior.
     */
    AUTO,

    /**
     * The persistence provider must perform the lifecycle event
     * validation. It is an error if there is no Bean Validation
     * provider present in the environment.
     */
}

```

```

    */
    CALLBACK,

    /**
     * The persistence provider must not perform lifecycle event
     * validation.
     */
    NONE
}

```

9.6.1. jakarta.persistence.spi.ClassTransformer Interface

The `ClassTransformer` interface found in [Section E.1](#) may be implemented by a persistence provider to transform entities and managed classes at class load time or at class redefinition time. A persistence provider is not required to implement this interface.

9.7. jakarta.persistence.Persistence Class

The `Persistence` class may be found in [Section B.17](#).

The `Persistence` class is used to obtain an `EntityManagerFactory` instance in Java SE environments. It may also be used for schema generation—i.e., to create database schemas and/or tables and/or to create DDL scripts.

The `Persistence` class is also available in a Jakarta EE container environment; however, support for the Java SE bootstrapping APIs is not required in container environments.

The `Persistence` class is used to obtain a `PersistenceUtil` instance in both Jakarta EE and Java SE environments.

The `properties` argument passed to the `createEntityManagerFactory` method is used to specify both standard and vendor-specific properties and hints intended for use in creating the entity manager factory and controlling its behavior.

The following properties correspond to the elements and attributes in the `persistence.xml` file. When any of these properties are specified in the `Map` parameter passed to the `createEntityManagerFactory` method, their values override the values of the corresponding elements and attributes in the `persistence.xml` file for the named persistence unit. They also override any defaults that the persistence provider might have applied.

| Property | Type | Corresponding element in <code>persistence.xml</code> | Notes |
|---|----------|---|---------------------------------------|
| <code>jakarta.persistence.provider</code> | String | <code>provider</code> | See Section 8.2.1.4 . |
| <code>jakarta.persistence.qualifiers</code> | String[] | <code>qualifier</code> | See Section 8.2.1.5 . |
| <code>jakarta.persistence.scope</code> | String | <code>scope</code> | See Section 8.2.1.5 . |
| <code>jakarta.persistence.transactionType</code> | String | <code>transaction-type</code> | See Section 8.2.1.2 . |
| <code>jakarta.persistence.jtaDataSource</code> | String | <code>jta-data-source</code> | See Section 8.2.1.7 . |
| <code>jakarta.persistence.nonJtaDataSource</code> | String | <code>non-jta-data-source</code> | See Section 8.2.1.7 . |
| <code>jakarta.persistence.sharedCache.mode</code> | String | <code>shared-cache-mode</code> | See Section 8.2.1.9 . |

| Property | Type | Corresponding element in persistence.xml | Notes |
|-------------------------------------|--------|--|--|
| jakarta.persistence.validation.mode | String | validation-mode | Legal values are " auto ", " callback ", or " none ". See Section 8.2.1.10 and Section 3.7.1.1 . |

The following properties correspond to the properties in the persistence.xml file. When any of these properties are specified in the Map parameter passed to the createEntityManagerFactory method, their values override the values of the corresponding properties in the persistence.xml file for the named persistence unit. They also override any defaults that the persistence provider might have applied.

| Property | Type | Corresponding property in persistence.xml | Notes |
|--|-------------------|--|--|
| jakarta.persistence.lock.timeout | Integer or String | jakarta.persistence.lock.timeout | Hint only. Value in milliseconds for pessimistic lock timeout. See Section 3.5.4.3 . |
| jakarta.persistence.query.timeout | Integer or String | jakarta.persistence.query.timeout | Hint only. Value in milliseconds for query timeout. See Section 3.11.4 . |
| jakarta.persistence.validation.group.pre-persist | String | jakarta.persistence.validation.group.pre-persist | See Section 8.2.1.11 and Section 3.7.1.2 . |
| jakarta.persistence.validation.group.pre-update | String | jakarta.persistence.validation.group.pre-update | See Section 8.2.1.11 and Section 3.7.1.2 . |
| jakarta.persistence.validation.group.pre-remove | String | jakarta.persistence.validation.group.pre-remove | See Section 8.2.1.11 and Section 3.7.1.2 . |
| jakarta.persistence.schema-generation.create-script-source | String | jakarta.persistence.schema-generation.create-script-source | See Section 8.2.1.11 . |
| jakarta.persistence.schema-generation.drop-script-source | String | jakarta.persistence.schema-generation.drop-script-source | See Section 8.2.1.11 . |
| jakarta.persistence.sql-load-script-source | String | jakarta.persistence.sql-load-script-source | See Section 8.2.1.11 . |
| jakarta.persistence.schema-generation.database.action | String | jakarta.persistence.schema-generation.database.action | See Section 8.2.1.11 . |
| jakarta.persistence.schema-generation.scripts.action | String | jakarta.persistence.schema-generation.scripts.action | See Section 8.2.1.11 . |
| jakarta.persistence.schema-generation.create-source | String | jakarta.persistence.schema-generation.create-source | See Section 8.2.1.11 . |
| jakarta.persistence.schema-generation.drop-source | String | jakarta.persistence.schema-generation.drop-source | See Section 8.2.1.11 . |

| Property | Type | Corresponding property in persistence.xml | Notes |
|---|--------|---|--|
| jakarta.persistence.schema-generation.scripts.create-target | String | jakarta.persistence.schema-generation.scripts.create-target | See Section 8.2.1.11 . |
| jakarta.persistence.schema-generation.scripts.drop-target | String | jakarta.persistence.schema-generation.scripts.drop-target | See Section 8.2.1.11 . |

The following additional standard properties are defined by this specification for the configuration of the entity manager factory:

| Property | Value |
|--|--|
| jakarta.persistence.jdbc.driver | Fully qualified name of the driver class. |
| jakarta.persistence.jdbc.url | Driver-specific JDBC URL as a string. |
| jakarta.persistence.jdbc.user | Username for database connection. |
| jakarta.persistence.jdbc.password | Password for database connection authentication. |
| jakarta.persistence.dataSource | Instance of <code>javax.sql.DataSource</code> to be used for the specified persistence unit. |
| jakarta.persistence.validation.factory | Instance of <code>jakarta.validation.ValidatorFactory</code> . |

Any number of vendor-specific properties may also be included in the map. If a persistence provider does not recognize a property (other than a property defined by this specification), the provider must ignore it.

Vendors should use vendor namespaces for properties (e.g., `com.acme.persistence.logging`). Entries that make use of the namespace `jakarta.persistence` and its subnamespaces must not be used for vendor-specific information. The namespace `jakarta.persistence` is reserved for use by this specification.

9.8. `jakarta.persistence.PersistenceConfiguration` Class

The `PersistenceConfiguration` class found in [Section B.18](#) is used to programmatically define and configure a persistence unit and create an `EntityManagerFactory` instance directly. Thus, `PersistenceConfiguration` is an alternative to XML-based configuration using `persistence.xml`, and so the configuration options available via this API reflect the similarly-named elements of `persistence.xml`. See [Section 8.2.1](#).

A programmatically-configured persistence unit is considered a Java SE persistence unit, even when this API is used within the Jakarta EE environment.^[4]

A persistence provider may define a subclass of `PersistenceConfiguration` with vendor-specific configuration options. A provider must support configuration via any instance of `PersistenceConfiguration` or of any subclass of `PersistenceConfiguration`. If a subclass defines configuration options the provider does not recognize, it should ignore those options.

9.9. `PersistenceUtil` Interface

The `PersistenceUtil` interface found in [Section B.19](#) is used to determine the load state of entity instances. The semantics of the methods of this interface are defined in [Section 9.9.1](#) below.

9.9.1. Contracts for Determining the Load State of an Entity or Entity Attribute

The implementation of the `PersistenceUtil.isLoaded(Object)` method must determine the list of persistence providers available in the runtime environment^[5] and call the `ProviderUtil.isLoaded(Object)` method on each of them until either:

- one provider returns `LoadState.LOADED`. In this case `PersistenceUtil.isLoaded` returns `true`.
- one provider returns `LoadState.NOT_LOADED`. In this case `PersistenceUtil.isLoaded` returns `false`.
- all providers return `LoadState.UNKNOWN`. In this case `PersistenceUtil.isLoaded` returns `true`.

If the `PersistenceUtil` implementation determines that only a single provider is available in the environment, it is permitted to use provider-specific methods to determine the result of `isLoaded(Object)` as long as the semantics defined in [Section 3.3.9](#) are observed.

The implementation of the `PersistenceUtil.isLoaded(Object, String)` method must determine the list of persistence providers available in the environment and call the `ProviderUtil.isLoadedWithoutReference` method on each of them until either:

- one provider returns `LoadState.LOADED`. In this case `PersistenceUtil.isLoaded` returns `true`.
- one provider returns `LoadState.NOT_LOADED`. In this case `PersistenceUtil.isLoaded` returns `false`.
- all providers return `LoadState.UNKNOWN`. In this case, the `PersistenceUtil.isLoaded` method then calls `ProviderUtil.isLoadedWithReference` on each of the providers until:
 - one provider returns `LoadState.LOADED`. In this case `PersistenceUtil.isLoaded` return `true`.
 - one provider returns `LoadState.NOT_LOADED`. In this case, `PersistenceUtil.isLoaded` returns `false`.
 - all providers return `LoadState.UNKNOWN`. In this case, `PersistenceUtil.isLoaded` returns `true`.

If the `PersistenceUtil` implementation determines that only a single provider is available in the environment, it is permitted to use provider specific methods to determine the result of `isLoaded(Object, String)` as long as the semantics defined in [Section 3.3.9](#) are observed.



The rationale for splitting the determination of load state between the methods `isLoadedWithoutReference` and `isLoadedWithReference` is the following.

- *It is assumed that the provider that loaded the entity is present in the environment.*
- *Providers that use bytecode enhancement don't need to access an attribute reference to determine its load state, and can determine if the entity has been provided by them.*
- *By first querying all providers using bytecode enhancement, it is insured that no attribute will be loaded by side effect.*
- *Proxy-based providers do need to access an attribute reference to determine load state, but will not trigger attribute loading as a side effect.*
- *If no provider recognizes an entity as provided by it, it is assumed to be an object that is not instrumented and is considered loaded.*

[1] Use of these Java SE bootstrapping APIs may be supported in Jakarta EE containers; however, support for such use is not required.

[2] In dynamic environments (e.g., OSGi-based environments, containers based on dynamic kernels, etc.), the list of persistence providers may change.

[3] If a custom `PersistenceProviderResolver` is needed in a JavaSE environment, it must be set before `Persistence.createEntityManagerFactory` is called. Note, however, that the `setPersistenceProviderResolver` method is not intended for general use, but rather is aimed at containers maintaining a dynamic environment.

[4] Persistence units defined programmatically using the `PersistenceConfiguration` class do not support JNDI lookup or injection via the `PersistenceContext` or `PersistenceUnit` annotations.

[5] The determining of the persistence providers that are available is discussed in [Section 9.3](#).

Chapter 10. Metadata Annotations

This chapter and chapter [Chapter 11](#) define the metadata annotations introduced by this specification.

The XML schema defined in chapter [Chapter 12](#) provides an alternative to the use of metadata annotations.

These annotations and types are in the package `jakarta.persistence`.

10.1. Entity

The `Entity` annotation specifies that the class is an entity. This annotation is applied to the entity class.

The `name` annotation element specifies the entity name. If the `name` element is not specified, the entity name defaults to the unqualified name of the entity class. This name is used to refer to the entity in queries.

```
@Documented
@Target(TYPE)
@Retention(RUNTIME)
public @interface Entity {
    String name() default "";
}
```

10.2. Callback Annotations

The `EntityListeners` annotation specifies the callback listener classes to be used for an entity or mapped superclass. The `EntityListeners` annotation may be applied to an entity class or mapped superclass.

```
@Target({TYPE})
@Retention(RUNTIME)
public @interface EntityListeners {
    Class[] value();
}
```

The `ExcludeSuperclassListeners` annotation specifies that the invocation of superclass listeners is to be excluded for the entity class (or mapped superclass) and its subclasses.

```
@Target({TYPE})
@Retention(RUNTIME)
public @interface ExcludeSuperclassListeners {
}
```

The `ExcludeDefaultListeners` annotation specifies that the invocation of default listeners is to be excluded for the entity class (or mapped superclass) and its subclasses.

```
@Target({TYPE})
@Retention(RUNTIME)
public @interface ExcludeDefaultListeners {
}
```

The following annotations are used to specify callback methods for the corresponding lifecycle events. These annotations may be applied to methods of an entity class, of a mapped superclass, or of an entity listener class.

```
@Target({METHOD})
@Retention(RUNTIME)
public @interface PrePersist {}

@Target({METHOD})
```

```

@Retention(RUNTIME)
public @interface PostPersist {}

@Target({METHOD})
@Retention(RUNTIME)
public @interface PreRemove {}

@Target({METHOD})
@Retention(RUNTIME)
public @interface PostRemove {}

@Target({METHOD})
@Retention(RUNTIME)
public @interface PreUpdate {}

@Target({METHOD})
@Retention(RUNTIME)
public @interface PostUpdate {}

@Target({METHOD})
@Retention(RUNTIME)
public @interface PostLoad {}

```

10.3. EntityGraph Annotations

10.3.1. NamedEntityGraph and NamedEntityGraphs Annotations

The `NamedEntityGraph` annotation defines a named entity graph. The annotation must be applied to the root entity of the graph, and specifies the limits of the graph of associated attributes and entities fetched when an operation which retrieves an instance or instances of the root entity is executed.

The `name` element assigns a name to the entity graph, and is used to identify the entity graph in calls to `EntityManager.getEntityGraph()`. If no name is explicitly specified, the name defaults to the entity name of the annotated root entity. Entity graph names must be unique within the persistence unit.

The `attributeNodes` element lists attributes of the annotated entity class that are to be included in the entity graph.

The `includeAllAttributes` element specifies that all attributes of the annotated entity class are to be included in the entity graph. An `attributeNode` element may still be used in conjunction with this element to specify a subgraph for the attribute.

The `subgraphs` element specifies a list of subgraphs, further specifying attributes that are managed types. These subgraphs are referenced by name from `NamedAttributeNode` definitions.

The `subclassSubgraphs` element specifies a list of subgraphs that add additional attributes for subclasses of the root entity to which the annotation is applied.

The `NamedEntityGraphs` annotation can be used to specify multiple named entity graphs for the entity to which it is applied.

```

@Target({TYPE})
@Retention(RUNTIME)
@Repeatable(NamedEntityGraphs.class)
public @interface NamedEntityGraph {
    String name() default "";
    NamedAttributeNode[] attributeNodes() default {};
    boolean includeAllAttributes() default false;
    NamedSubgraph[] subgraphs() default {};
    NamedSubgraph[] subclassSubgraphs() default {};
}

```

```

@Target({TYPE})
@Retention(RUNTIME)
public @interface NamedEntityGraphs {
    NamedEntityGraph[] value();
}

```

10.3.2. NamedAttributeNode Annotation

The `NamedAttributeNode` annotation is used to specify an attribute node of within an entity graph or subgraph.

The `value` element specifies the name of the corresponding attribute.

The `subgraph` element is used to refer to a `NamedSubgraph` specification that further characterizes an attribute node corresponding to a managed type (entity or embeddable). The value of the `subgraph` element must correspond to the name used for the subgraph in the `NamedSubgraph` element. If the referenced attribute is an entity which has entity subclasses, there may be more than one `NamedSubgraph` element with this name, and the `subgraph` element is considered to refer to all of these.

The `keySubgraph` element is used to refer to a `NamedSubgraph` specification that further characterizes an attribute node corresponding to the key of a Map-valued attribute. The value of the `keySubgraph` element must correspond to the name used for the subgraph in the `NamedSubgraph` element. If the referenced attribute is an entity which has entity subclasses, there may be more than one `NamedSubgraph` element with this name, and the `keySubgraph` element is considered to refer to all of these.

```

@Target({})
@Retention(RUNTIME)
public @interface NamedAttributeNode {
    String value();
    String subgraph() default "";
    String keySubgraph() default "";
}

```

10.3.3. NamedSubgraph Annotation

The `NamedSubgraph` annotation is used to further define an attribute node. It is referenced by its name from the `subgraph` or `keySubgraph` element of a `NamedAttributeNode` element.

The `name` element is the name used to reference the subgraph from a `NamedAttributeNode` definition. In the case of entity inheritance, multiple subgraph elements have the same name.

The `type` element must be specified when the subgraph corresponds to a subclass of the entity type corresponding to the referencing attribute node.

The `attributeNodes` element lists attributes of the class that must be included. If the subgraph corresponds to a subclass of the class referenced by the corresponding attribute node, only subclass-specific attributes are listed.

```

@Target({})
@Retention(RUNTIME)
public @interface NamedSubgraph {
    String name();
    Class type() default void.class;
    NamedAttributeNode[] attributeNodes();
}

```

10.4. Annotations for Queries

The following annotations are used to declare named queries.

10.4.1. NamedQuery Annotation

The `NamedQuery` annotation declares a named query written in the Jakarta Persistence query language.

The `name` element assigns a name to the query, which is used to identify the query in calls to `EntityManager.createNamedQuery()`.

The `query` element must specify a query string itself, written in the Jakarta Persistence query language.

The `resultClass` element specifies the Java class of each query result. The query result class may be overridden by explicitly passing a `Class` object to `EntityManager.createNamedQuery(String, Class)`. If the `resultClass` element of a `NamedQuery` annotation is not specified, the persistence implementation is entitled to default the result class to `Object` or `Object[]`.

The `lockMode` element specifies a lock mode for the entity instances in results returned by the query. If a lock mode other than `NONE` is specified, the query may only be executed within a persistence context with an associated active transaction.

The `hints` elements may be used to specify query properties and hints. Properties defined by this specification must be observed by the provider; hints defined by this specification should be observed by the provider when possible. Vendor-specific hints that are not recognized by a provider must be ignored.

The `NamedQuery` and `NamedQueries` annotations can be applied to an entity or mapped superclass.

```
@Target({TYPE})
@Retention(RUNTIME)
@Repeatable(NamedQueries.class)
public @interface NamedQuery {
    String name();
    String query();
    Class<?> resultClass() default void.class;
    LockModeType lockMode() default NONE;
    QueryHint[] hints() default {};
}

@Target({})
@Retention(RUNTIME)
public @interface QueryHint {
    String name();
    String value();
}

@Target({TYPE})
@Retention(RUNTIME)
public @interface NamedQueries {
    NamedQuery[] value ();
}
```

10.4.2. NamedNativeQuery Annotation

The `NamedNativeQuery` annotation defines a named native SQL query.

The `name` element assigns a name to the query, which is used to identify the query in calls to `EntityManager.createNamedQuery()`.

The `query` element must specify the query string itself, written in the native SQL dialect of the database.

The `resultClass` element specifies the class of each query result. If a result set mapping is specified, the specified result class must agree with the type inferred from the result set mapping. If a `resultClass` is not explicitly specified, then it is inferred from the result set mapping, if any, or defaults to `Object` or `Object[]`. The query result class may be overridden by explicitly passing a `Class` object to `EntityManager.createNamedQuery(String, Class)`.

The `resultSetMapping` element specifies the name of a `SqlResultSetMapping` specification defined elsewhere in metadata. The named `SqlResultSetMapping` is used to interpret the result set of the native SQL query. Alternatively, the elements `entities`, `classes`, and `columns` may be used to specify a result set mapping. These elements may not be used in conjunction with `resultSetMapping`.

The `hints` element may be used to specify query properties and hints. Hints defined by this specification should be observed by the provider when possible. Vendor-specific hints which are not recognized by the provider must be ignored.

The `NamedNativeQuery` and `NamedNativeQueries` annotations can be applied to an entity or mapped superclass.

```
@Target({TYPE})
@Retention(RUNTIME)
@Repeatable(NamedNativeQueries.class)
public @interface NamedNativeQuery {
    String name();
    String query();
    QueryHint[] hints() default {};
    Class resultClass() default void.class;
    String resultSetMapping() default "";
    EntityResult[] entities() default {};
    ConstructorResult[] classes() default {};
    ColumnResult[] columns() default {};
}

@Target({TYPE})
@Retention(RUNTIME)
public @interface NamedNativeQueries {
    NamedNativeQuery[] value ();
}
```

10.4.3. NamedStoredProcedureQuery Annotation

The `NamedStoredProcedureQuery` annotation is used to specify a stored procedure, its parameters, and its result type.

The `name` element is the name that is passed as an argument to the `createNamedStoredProcedureQuery` method to create an executable `StoredProcedureQuery` object.

The `procedureName` element is the name of the stored procedure in the database.

The parameters of the stored procedure are specified by the `parameters` element. All parameters must be specified in the order in which they occur in the parameter list of the stored procedure.

The `resultClasses` element refers to the class (or classes) that are used to map the results. The `resultSetMappings` element names one or more result set mappings, as defined by the `SqlResultSetMapping` annotation.

If there are multiple result sets, it is assumed that they will be mapped using the same mechanism—e.g., either all via a set of result class mappings or all via a set of result set mappings. The order of the specification of these mappings must be the same as the order in which the result sets will be returned by the stored procedure invocation. If the stored procedure returns one or more result sets and no `resultClasses` or `resultSetMappings` element is specified, any result set will be returned as a list of type `Object[]`. The combining of different strategies for the mapping of stored procedure

result sets is undefined.

The `hints` element may be used to specify query properties and hints. Properties defined by this specification must be observed by the provider. Vendor-specific hints that are not recognized by a provider must be ignored.

The `NamedStoredProcedureQuery` and `NamedStoredProcedureQueries` annotations can be applied to an entity or mapped superclass.

```
@Target(TYPE)
@Retention(RUNTIME)
@Repeatable(NamedStoredProcedureQueries.class)
public @interface NamedStoredProcedureQuery {
    String name();
    String procedureName();
    StoredProcedureParameter[] parameters() default {};
    Class[] resultClasses() default {};
    String[] resultSetMappings() default {};
    QueryHint[] hints() default {};
}

@Target(TYPE)
@Retention(RUNTIME)
public @interface NamedStoredProcedureQueries {
    NamedStoredProcedureQuery [] value;
}
```

All parameters of a named stored procedure query must be specified using the `StoredProcedureParameter` annotation. The `name` element refers to the name of the parameter as defined by the stored procedure in the database. If a parameter name is not specified, it is assumed that the stored procedure uses positional parameters. The `mode` element specifies whether the parameter is an IN, INOUT, OUT, or REF_CURSOR parameter. REF_CURSOR parameters are used by some databases to return result sets from stored procedures. The `type` element refers to the JDBC type for the parameter.

```
@Target({})
@Retention(RUNTIME)
public @interface StoredProcedureParameter {
    String name() default "";
    ParameterMode mode() default ParameterMode.IN;
    Class type();
}

public enum ParameterMode {
    IN,
    INOUT,
    OUT,
    REF_CURSOR
}
```

10.4.4. Annotations for SQL Result Set Mappings

The `SqlResultSetMapping` annotation is used to specify the mapping of the result set of a native SQL query or stored procedure.

```
@Target({TYPE})
@Retention(RUNTIME)
@Repeatable(SqlResultSetMappings.class)
public @interface SqlResultSetMapping {
    String name();
    EntityResult[] entities() default {};
    ConstructorResult[] classes() default {};
    ColumnResult[] columns() default {};
}
```



```

@Target({TYPE})
@Retention(RUNTIME)
public @interface SqlResultSetMappings {
    SqlResultSetMapping[] value();
}

```

The `name` element is the name given to the result set mapping, and is used to identify it when calling methods of the `EntityManager` which create instances of `Query` and `StoredProcedureQuery`. The `entities`, `classes`, and `columns` elements are used to specify the mapping of result set columns to entities, to constructors, and to scalar values, respectively.

```

@Target({})
@Retention(RUNTIME)
public @interface EntityResult {
    Class entityClass();
    LockModeType lockMode() default LockModeType.OPTIMISTIC;
    FieldResult[] fields() default {};
    String discriminatorColumn() default "";
}

```

The `entityClass` element specifies the class of the result.

The `lockMode` element specifies the `LockModeType` obtained when the native SQL query is executed.

The `fields` element is used to map the columns specified in the `SELECT` list of the query to the properties or fields of the entity class.

The `discriminatorColumn` element is used to specify the column name (or alias) of the column in the `SELECT` list that is used to determine the type of the entity instance.

```

@Target({})
@Retention(RUNTIME)
public @interface FieldResult {
    String name();
    String column();
}

```

The `name` element is the name of the persistent field or property of the class.

The `column` element specifies the name of the corresponding column in the `SELECT` list—i.e., column alias, if applicable.

```

@Target(value={})
@Retention(RUNTIME)
public @interface ConstructorResult {
    Class targetClass();
    ColumnResult[] columns();
}

```

The `targetClass` element specifies the class whose constructor is to be invoked.

The `columns` element specifies the mapping of columns in the `SELECT` list to the arguments of the intended constructor.

```

@Target({})
@Retention(RUNTIME)
public @interface ColumnResult {
    String name();
    Class type() default void.class;
}

```

The `name` element specifies the name of the column in the `SELECT` list.

The `type` element specifies the Java type to which the column type is to be mapped. If the `type` element is not specified, the default JDBC type mapping for the column will be used.

10.5. References to `EntityManager` and `EntityManagerFactory`

These annotations are used to express dependencies on entity managers and entity manager factories.

10.5.1. `PersistenceContext` Annotation

The `PersistenceContext` annotation is used to express a dependency on a container-managed entity manager and its associated persistence context.

The `name` element refers to the name by which the entity manager is to be accessed in the environment referencing context, and is not needed when dependency injection is used.

The optional `unitName` element refers to the name of the persistence unit. If the `unitName` element is specified, the persistence unit for the entity manager that is accessible in JNDI must have the same name.

The `type` element specifies whether a transaction-scoped or extended persistence context is to be used. If the `type` element is not specified, a transaction-scoped persistence context is used.

The `synchronizationType` element specifies whether the persistence context is always automatically synchronized with the current transaction or whether the persistence context must be explicitly joined to the current transaction by means of the `joinTransaction` method of `EntityManager`.

The optional `properties` element may be used to specify properties for the container or persistence provider. Properties defined by this specification must be observed by the provider. Vendor specific properties may be included in the set of properties, and are passed to the persistence provider by the container when the entity manager is created. Properties that are not recognized by a vendor must be ignored.

```
@Target({TYPE, METHOD, FIELD})
@Retention(RUNTIME)
@Repeatable(PersistenceContexts.class)
public @interface PersistenceContext {
    String name() default "";
    String unitName() default "";
    PersistenceContextType type() default TRANSACTION;
    SynchronizationType synchronization() default SYNCHRONIZED;
    PersistenceProperty[] properties() default {};
}

public enum PersistenceContextType {
    TRANSACTION,
    EXTENDED
}

public enum SynchronizationType {
    SYNCHRONIZED,
    UNSYNCHRONIZED
}

@Target({})
@Retention(RUNTIME)
public @interface PersistenceProperty {
    String name();
    String value();
}
```

The `PersistenceContexts` annotation declares one or more `PersistenceContext` annotations. It is used to express a

dependency on multiple persistence contexts^[1].

```
@Target({TYPE})
@Retention(RUNTIME)
public @interface PersistenceContexts {
    PersistenceContext[] value();
}
```

10.5.2. PersistenceUnit Annotation

The `PersistenceUnit` annotation is used to express a dependency on an entity manager factory and its associated persistence unit.

The `name` element refers to the name by which the entity manager factory is to be accessed in the environment referencing context, and is not needed when dependency injection is used.

The optional `unitName` element refers to the name of the persistence unit as defined in the `persistence.xml` file. If the `unitName` element is specified, the persistence unit for the entity manager factory that is accessible in JNDI must have the same name.

```
@Target({TYPE, METHOD, FIELD})
@Retention(RUNTIME)
@Repeatable(PersistenceUnits.class)
public @interface PersistenceUnit {
    String name() default "";
    String unitName() default "";
}
```

The `PersistenceUnits` annotation declares one or more `PersistenceUnit` annotations. It is used to express a dependency on multiple persistence units^[2].

```
@Target(TYPE)
@Retention(RUNTIME)
public @interface PersistenceUnits {
    PersistenceUnit[] value();
}
```

10.6. Annotations for Attribute Converter Classes

The `Converter` annotation declares that the annotated class is a converter and specifies whether the converter is applied automatically. Every converter class must implement `AttributeConverter` and must be annotated with the `Converter` annotation or declared as a converter in the XML descriptor. The target type for a converter is determined by the actual type argument of the first type parameter of `AttributeConverter`.

```
@Target({TYPE})
@Retention(RUNTIME)
public @interface Converter {
    boolean autoApply() default false;
}
```

If the `autoApply` element is specified as `true`, the persistence provider must automatically apply the converter to every mapped attribute of the specified target type belonging to any entity in the persistence unit, except for attributes for which conversion is overridden by means of the `Convert` annotation (or XML equivalent). The `Convert` annotation is described in [Section 11.1.10](#). The `Convert` annotation may be used to override or disable auto-apply conversion on a per-attribute basis.

In determining whether a converter applies to an attribute, the provider must treat primitive types and wrapper types as equivalent.

A converter never applies to id attributes, version attributes, relationship attributes, or to attributes explicitly annotated as `Enumerated` or `Temporal` (or designated as such via XML).

A converter never applies to any attribute annotated `@Convert(disableConversion=true)` or to an attribute for which the `Convert` annotation explicitly specifies a different converter.

If `autoApply` is `false`, the converter applies only to attributes of the target type for which conversion is explicitly enabled via the `Convert` annotation (or corresponding XML element).

If there is more than one converter defined for the same target type, the `Convert` annotation must be used to explicitly specify which converter applies.

[1] A dependency on multiple persistence contexts may be needed, for example, when multiple persistence units are used.

[2] Multiple persistence units may be needed, for example, when mapping to multiple databases.

Chapter 11. Metadata for Object/Relational Mapping

The object/relational mapping metadata is part of the application domain model contract. It expresses requirements and expectations on the part of the application as to the mapping of the entities and relationships of the application domain to a database. Queries (and, in particular, SQL queries) written against the database schema that corresponds to the application domain model are dependent upon the mappings expressed by means of the object/relational mapping metadata. The implementation of this specification must assume this application dependency upon the object/relational mapping metadata and insure that the semantics and requirements expressed by that mapping are observed.

The use of object/relational mapping metadata to control schema generation is specified in [Section 11.2](#).

11.1. Annotations for Object/Relational Mapping

These annotations and types are in the package `jakarta.persistence`.

XML metadata may be used as an alternative to these annotations, or to override or augment annotations, as described in [Chapter 12](#).

11.1.1. Access Annotation

The `Access` annotation is used to specify an access type to be applied to an entity class, mapped superclass, or embeddable class, or to a specific attribute of such a class.

```
@Target({TYPE, METHOD, FIELD})
@Retention(RUNTIME)
public @interface Access {
    AccessType value();
}
```

[Table 4](#) lists the annotation elements that may be specified for the `Access` annotation.

Table 4. Access Annotation Elements

| Type | Name | Description | Default |
|-------------------------|--------------------|---|---------|
| <code>AccessType</code> | <code>value</code> | (Required) The access type to be applied to the class or attribute. | |

11.1.2. AssociationOverride Annotation

The `AssociationOverride` annotation is used to override a mapping for an entity relationship.

The `AssociationOverride` annotation may be applied to an entity that extends a mapped superclass to override a relationship mapping defined by the mapped superclass. If the `AssociationOverride` annotation is not specified, the association is mapped the same as in the original mapping. When used to override a mapping defined by a mapped superclass, the `AssociationOverride` annotation is applied to the entity class.

The `AssociationOverride` annotation may be used to override a relationship mapping from an embeddable within an entity to another entity when the embeddable is on the owning side of the relationship. When used to override a relationship mapping defined by an embeddable class (including an embeddable class embedded within another embeddable class), the `AssociationOverride` annotation is applied to the field or property containing the embeddable.

When the `AssociationOverride` annotation is used to override a relationship mapping from an embeddable class, the `name` element specifies the referencing relationship field or property within the embeddable class. To override mappings at multiple levels of embedding, a dot (".") notation syntax must be used in the `name` element to indicate an attribute within an embedded attribute. The value of each identifier used with the dot notation is the name of the respective embedded field or property. When the `AssociationOverride` annotation is applied to override the mappings of an embeddable class used as a map value, "value." must be used to prefix the name of the attribute within the embeddable class that is being overridden in order to specify it as part of the map value.^[1]

If the relationship mapping is a foreign key mapping, the `joinColumns` element of the `AssociationOverride` annotation is used. If the relationship mapping uses a join table, the `joinTable` element of the `AssociationOverride` element must be specified to override the mapping of the join table and/or its join columns.^[2]

The `joinColumns` element refers to the table for the class that contains the annotation.

The `foreignKey` element is used to specify or control the generation of a foreign key constraint for the columns corresponding to the `joinColumns` element when table generation is in effect. If both this element and the `foreignKey` element of any of the `joinColumns` elements are specified, the behavior is undefined.

```

@Target({TYPE, METHOD, FIELD})
@Retention(RUNTIME)
@Repeatable(AssociationOverrides.class)
public @interface AssociationOverride {
    String name();

    JoinColumn[] joinColumns() default {};

    ForeignKey foreignKey() default

    @ForeignKey(PROVIDER_DEFAULT);
    JoinTable joinTable() default @JoinTable;
}

```

Table 5 lists the annotation elements that may be specified for the `AssociationOverride` annotation.

Table 5. AssociationOverride Annotation Elements

| Type | Name | Description | Default |
|--------|------|---|---------|
| String | name | (Required) The name of the relationship property whose mapping is being overridden if property-based access is being used, or the name of the relationship field if field-based access is used. | |

| Type | Name | Description | Default |
|--------------|-------------|---|--------------------|
| JoinColumn[] | joinColumns | The join column(s) being mapped to the persistent attribute(s). The joinColumns element must be specified if a foreign key mapping is used in the overriding of the mapping of the relationship. The joinColumns element must not be specified if a join table is used in the overriding of the mapping of the relationship | |
| ForeignKey | foreignKey | (Optional) The foreign key constraint specification for the join columns. This is used only if table generation is in effect. | Provider's default |
| JoinTable | joinTable | The join table that maps the relationship. The joinTable element must be specified if a join table is used in the overriding of the mapping of the relationship. The joinTable element must not be specified if a foreign key mapping is used in the overriding of the mapping of the relationship. | |

Example 1:

```

@MappedSuperclass
public class Employee {
    @Id
    protected Integer id;

    @Version
    protected Integer version;

    @ManyToOne
    protected Address address;

    public Integer getId() { ... }

    public void setId(Integer id) { ... }

    public Address getAddress() { ... }

    public void setAddress(Address address) { ... }
}

@Entity

```

```

@AssociationOverride(name="address", joinColumns=@JoinColumn(name="ADDR_ID"))
public class PartTimeEmployee extends Employee {
    // address field mapping overridden to ADDR_ID foreign key
    @Column(name="WAGE")
    protected Float hourlyWage;

    public Float getHourlyWage() { ... }

    public void setHourlyWage(Float wage) { ... }
}

```

Example 2: Overriding of the mapping for the phoneNumbers relationship defined in the ContactInfo embeddable class.

```

@Entity
public class Employee {
    @Id
    int id;

    @AssociationOverride(
        name="phoneNumbers",
        joinTable=@JoinTable(
            name="EMPPHONES",
            joinColumns=@JoinColumn(name="EMP"),
            inverseJoinColumns=@JoinColumn(name="PHONE")
        )
    )
    @Embedded
    ContactInfo contactInfo;

    // ...
}

@Embeddable
public class ContactInfo {
    @ManyToOne Address address; // Unidirectional
    @ManyToMany(targetEntity=PhoneNumber.class)
    List phoneNumbers;
}

@Entity
public class PhoneNumber {
    @Id
    int number;

    @ManyToMany(mappedBy="contactInfo.phoneNumbers")
    Collection<Employee> employees;
}

```

11.1.3. AssociationOverrides Annotation

The mappings of multiple relationship properties or fields may be overridden. The AssociationOverrides annotation can be used for this purpose.

```

@Target({TYPE, METHOD, FIELD})
@Retention(RUNTIME)
public @interface AssociationOverrides {
    AssociationOverride[] value();
}

```

Table 6 lists the annotation elements that may be specified for the AssociationOverrides annotation.

Table 6. AssociationOverrides Annotation Elements

| Type | Name | Description | Default |
|-----------------------|-------|--|---------|
| AssociationOverride[] | value | (Required) The association override mappings that are to be applied to the relationship field or property. | |

Example:

```

@MappedSuperclass
public class Employee {
    @Id
    protected Integer id;

    @Version
    protected Integer version;

    @ManyToOne
    protected Address address;

    @OneToOne
    protected Locker locker;

    public Integer getId() { ... }

    public void setId(Integer id) { ... }

    public Address getAddress() { ... }

    public void setAddress(Address address) { ... }

    public Locker getLocker() { ... }

    public void setLocker(Locker locker) { ... }
}

@Entity
@AssociationOverrides({
    @AssociationOverride(name="address", joinColumns=@JoinColumn("ADDR_ID")),
    @AssociationOverride(name="locker", joinColumns=@JoinColumn("LCKR_ID"))})
public PartTimeEmployee { ... }

```

Alternatively:

```

@Entity
@AssociationOverride(name="address", joinColumns=@JoinColumn("ADDR_ID"))
@AssociationOverride(name="locker", joinColumns=@JoinColumn("LCKR_ID"))
public PartTimeEmployee { ... }

```

11.1.4. AttributeOverride Annotation

The `AttributeOverride` annotation is used to override the mapping of a `Basic` (whether explicit or default) property or field or `Id` property or field.

The `AttributeOverride` annotation may be applied to an entity that extends a mapped superclass or to an embedded field or property to override a `Basic` mapping or `Id` mapping defined by the mapped superclass or embeddable class (or embeddable class of one of its attributes).

The `AttributeOverride` annotation may be applied to an element collection containing instances of an embeddable class

or to a map collection whose key and/or value is an embeddable class. When the `AttributeOverride` annotation is applied to a map, " key. " or " value. " must be used to prefix the name of the attribute that is being overridden in order to specify it as part of the map key or map value.

To override mappings at multiple levels of embedding, a dot (".") notation form must be used in the `name` element to indicate an attribute within an embedded attribute. The value of each identifier used with the dot notation is the name of the respective embedded field or property.

If the `AttributeOverride` annotation is not specified, the column is mapped the same as in the original mapping.

[Table 7](#) lists the annotation elements that may be specified for the `AttributeOverride` annotation.

The `column` element refers to the table for the class that contains the annotation.

```
@Target({TYPE, METHOD, FIELD})
@Retention(RUNTIME)
@Repeatable(AttributeOverrides.class)
public @interface AttributeOverride {
    String name();
    Column column();
}
```

Table 7. AttributeOverride Annotation Elements

| Type | Name | Description | Default |
|--------|--------|---|---------|
| String | name | (Required) The name of the property whose mapping is being overridden if property-based access is being used, or the name of the field if field-based access is used. | |
| Column | column | (Required) The column that is being mapped to the persistent attribute. The mapping type will remain the same as is defined in the embeddable class or mapped superclass. | |

Example 1:

```
@MappedSuperclass
public class Employee {
    @Id
    protected Integer id;

    @Version
    protected Integer version;

    protected String address;

    public Integer getId() { ... }

    public void setId(Integer id) { ... }
```

```

    public String getAddress() { ... }

    public void setAddress(String address) { ... }
}

@Entity
@AttributeOverride(name="address", column=@Column(name="ADDR"))
public class PartTimeEmployee extends Employee {
    // address field mapping overridden to ADDR
    protected Float wage();

    public Float getHourlyWage() { ... }

    public void setHourlyWage(Float wage) { ... }
}

```

Example 2:

```

@Embeddable public class Address {
    protected String street;

    protected String city;

    protected String state;

    @Embedded
    protected Zipcode zipcode;
}

@Embeddable
public class Zipcode {
    protected String zip;
    protected String plusFour;
}

@Entity
public class Customer {
    @Id
    protected Integer id;

    protected String name;

    @AttributeOverride(name="state", column=@Column(name="ADDR_STATE"))
    @AttributeOverride(name="zipcode.zip", column=@Column(name="ADDR_ZIP"))
    @Embedded
    protected Address address;

    // ...
}

```

Example 3:

```

@Entity
public class PropertyRecord {
    @EmbeddedId
    PropertyOwner owner;

    @AttributeOverrides(name="key.street", column=@Column(name="STREET_NAME"))
    @AttributeOverride(name="value.size", column=@Column(name="SQUARE_FEET"))
    @AttributeOverride(name="value.tax", column=@Column(name="ASSESSMENT"))
    @ElementCollection
    Map<Address, PropertyInfo> parcels;
}

@Embeddable

```

```
public class PropertyInfo {
    Integer parcelNumber;
    Integer size;
    BigDecimal tax;
}
```

11.1.5. AttributeOverrides Annotation

The mappings of multiple properties or fields may be overridden. The `AttributeOverrides` annotation can be used for this purpose.

```
@Target({TYPE, METHOD, FIELD})
@Retention(RUNTIME)
public @interface AttributeOverrides {
    AttributeOverride[] value();
}
```

Table 8 lists the annotation elements that may be specified for the `AttributeOverrides` annotation.

Table 8. *AttributeOverrides* Annotation Elements

| Type | Name | Description | Default |
|---------------------|-------|--|---------|
| AttributeOverride[] | value | (Required) The AttributeOverride mappings that are to be applied to the field or property. | |

Example:

```
@Embedded
@AttributeOverrides({
    @AttributeOverride(name="startDate", column=@Column(name="EMP_START")),
    @AttributeOverride(name="endDate", column=@Column(name="EMP_END"))
})
public EmploymentPeriod getEmploymentPeriod() { ... }
```

11.1.6. Basic Annotation

The `Basic` annotation is the simplest type of mapping to a database column. The `Basic` annotation may be applied to any persistent property or instance variable whose type is one of the basic types listed in Section 2.6.

For the types listed above, the persistence provider must support mappings to the column types listed in tables B-2 and B-4 of Appendix B of the JDBC 4.3 specification. See [3]. In addition, the provider must support mapping:

- `java.time.Instant` to the JDBC `TIMESTAMP` or `TIMESTAMP_WITH_TIMEZONE` type,
- `java.time.Year` to the JDBC `INTEGER` and `SMALLINT` types,
- `java.math.BigInteger` and `java.math.BigDecimal` to the JDBC `NUMERIC` and `DECIMAL` types,
- `java.util.UUID` to the JDBC `CHAR` and `VARCHAR` types, and
- `char[]` to the JDBC `CHAR`, `NCHAR`, `VARCHAR`, `NVARCHAR`, `LONGVARCHAR`, and `LONGNVARCHAR` types.

As described in Section 2.10, the use of the `Basic` annotation is optional for persistent fields and properties of the types listed above. If the `Basic` annotation is not specified for such a field or property, the default values of the `Basic` annotation will apply.

```
@Target({METHOD, FIELD})
```

```

@Retention(RUNTIME)
public @interface Basic {
    FetchType fetch() default EAGER;
    boolean optional() default true;
}

```

Table 9 lists the annotation elements that may be specified for the `Basic` annotation and their default values.

The `FetchType` enum defines strategies for fetching data from the database:

```

public enum FetchType { LAZY, EAGER };

```

The `EAGER` strategy is a requirement on the persistence provider runtime that data must be eagerly fetched. The `LAZY` strategy is a *hint* to the persistence provider runtime that data should be fetched lazily when it is first accessed. The implementation is permitted to eagerly fetch data for which the `LAZY` strategy hint has been specified. In particular, lazy fetching might only be available for `Basic` mappings for which property-based access is used.

The `optional` element is a hint as to whether the value of the field or property may be null. It is disregarded for primitive types.

Table 9. Basic Annotation Elements

| Type | Name | Description | Default |
|-----------|----------|--|---------|
| FetchType | fetch | (Optional) Whether the value of the field or property should be lazily loaded or must be eagerly fetched. The <code>EAGER</code> strategy is a requirement on the persistence provider runtime that the value must be eagerly fetched. The <code>LAZY</code> strategy is a hint to the persistence provider runtime. | EAGER |
| boolean | optional | (Optional) Whether the value of the field or property may be null. This is a hint and is disregarded for primitive types; it may be used in schema generation. | true |

Example 1:

```

@Basic
protected String name;

```

Example 2:

```

@Basic(fetch=LAZY)
protected String getName() { return name; }

```

If the persistence provider stores a value of type `java.util.UUID` in a column of type `VARCHAR` or equivalent, the value

must be stored in its canonical representation, unless the application explicitly indicates that some other representation is preferred.

11.1.7. Cacheable Annotation

The `Cacheable` annotation specifies whether an entity should be cached if caching is enabled when the value of the `persistence.xml` `shared-cache-mode` element is `ENABLE_SELECTIVE` or `DISABLE_SELECTIVE`. The value of the `Cacheable` annotation is inherited by subclasses; it can be overridden by specifying `Cacheable` on a subclass.

```
@Target({TYPE})
@Retention(RUNTIME)
public @interface Cacheable {
    boolean value() default true;
}
```

`Cacheable(false)` means that the entity and its state must not be cached by the provider.

If the `shared-cache-mode` element is not specified in the `persistence.xml` file and the `jakarta.persistence.sharedCache.mode` property is not specified when the entity manager factory for the persistence unit is created, the semantics of the `Cacheable` annotation are undefined.

Table 10. *Cacheable Annotation Elements*

| Type | Name | Description | Default |
|---------|-------|--|---------|
| boolean | value | (Optional) Whether or not the entity should be cached. | true |

11.1.8. CollectionTable Annotation

The `CollectionTable` annotation is used in the mapping of collections of basic or embeddable types. The `CollectionTable` annotation specifies the table that is used for the mapping of the collection and is specified on the collection-valued field or property.

```
@Target({METHOD, FIELD})
@Retention(RUNTIME)
public @interface CollectionTable {
    String name() default "";
    String catalog() default "";
    String schema() default "";
    JoinColumn[] joinColumns() default {};
    ForeignKey foreignKey() default @ForeignKey(PROVIDER_DEFAULT);
    UniqueConstraint[] uniqueConstraints() default {};
    Index[] indexes() default {};
    String options() default "";
}
```

By default, the columns of the collection table that correspond to the embeddable class or basic type are derived from the attributes of the embeddable class or from the basic type according to the default values of the `Column` annotation, as described in [Section 11.1.9](#). In the case of a basic type, the column name is derived from the name of the collection-valued field or property. In the case of an embeddable class, the column names are derived from the field or property names of the embeddable class.

To override the default properties of the column used for a basic type, the `Column` annotation is used on the collection-valued attribute in addition to the `ElementCollection` annotation. The value of the `table` element of the `Column` annotation defaults to the name of the collection table.

To override these defaults for an embeddable class, the `AttributeOverride` and/or `AttributeOverrides` annotations must be used in addition to the `ElementCollection` annotation. The value of the `table` element of the `Column` annotation used in the `AttributeOverride` annotation defaults to the name of the collection table. If the embeddable class contains references to other entities, the default values for the columns corresponding to those references may be overridden by means of the `AssociationOverride` and/or `AssociationOverrides` annotations.

The `foreignKey` element is used to specify or control the generation of a foreign key constraint for the columns corresponding to the `joinColumns` element when table generation is in effect. If both this element and the `foreignKey` element of any of the `joinColumns` elements are specified, the behavior is undefined. If no `foreignKey` annotation element is specified in either location, the persistence provider's default foreign key strategy will apply.

If the `CollectionTable` annotation is missing, the default values of the `CollectionTable` annotation elements apply.

This annotation may not be applied to a persistent field or property not annotated `@ElementCollection`.

[Table 11](#) lists the annotation elements that may be specified for the `CollectionTable` annotation and their default values.

Table 11. CollectionTable Annotation Elements

| Type | Name | Description | Default |
|--------------|-------------|---|---|
| String | name | (Optional) The name of the collection table. | The concatenation of the name of the containing entity and the name of the collection attribute, separated by an underscore. |
| String | catalog | (Optional) The catalog of the table. | Default catalog. |
| String | schema | (Optional) The schema of the table. | Default schema for user. |
| JoinColumn[] | joinColumns | (Optional) The foreign key columns of the collection table which reference the primary table of the entity. | (Default only applies if a single join column is used.) The same defaults as for <code>JoinColumn</code> (i.e., the concatenation of the following: the name of the entity; “_”; the name of the referenced primary key column.) However, if there is more than one join column, a <code>JoinColumn</code> annotation must be specified for each join column using the <code>JoinColumns</code> annotation. Both the name and the <code>referencedColumnName</code> elements must be specified in each such <code>JoinColumn</code> annotation. |

| Type | Name | Description | Default |
|--------------------|-------------------|---|---------------------------|
| ForeignKey | foreignKey | (Optional) The foreign key constraint specification for the join columns. This is used only if table generation is in effect. | Provider's default |
| UniqueConstraint[] | uniqueConstraints | (Optional) Unique constraints that are to be placed on the table. These are only used if table generation is in effect. | No additional constraints |
| Index[] | indexes | (Optional) Indexes for the table. These are only used if table generation is in effect. | No additional indexes |
| String | options | (Optional) A SQL fragment appended to the generated DDL. | Nothing appended. |

Example:

```

@Embeddable
public class Address {
    protected String street;
    protected String city;
    protected String state;

    // ...
}

@Entity public class Person {
    @Id
    protected String ssn;

    protected String name;

    protected Address home;

    // ...

    @ElementCollection // use default table (PERSON_NICKNAMES)
    @Column(name="name", length=50)
    protected Set<String> nickNames = new HashSet();

    // ...
}

@Entity
public class WealthyPerson extends Person {
    @ElementCollection
    @CollectionTable(name="HOMES") // use default join column name
    @AttributeOverrides({
        @AttributeOverride(name="street", column=@Column(name="HOME_STREET")),
        @AttributeOverride(name="city", column=@Column(name="HOME_CITY")),
        @AttributeOverride(name="state", column=@Column(name="HOME_STATE"))
    })
    protected Set<Address> vacationHomes = new HashSet();
}

```



```

    // ...
}

```

11.1.9. Column Annotation

The Column annotation is used to specify a mapped column for a persistent property or field.

Table 12 lists the annotation elements that may be specified for the Column annotation and their default values.

If no Column annotation is specified, the default values in Table 12 apply.

```

@Target({METHOD, FIELD})
@Retention(RUNTIME)
public @interface Column {
    String name() default "";
    boolean unique() default false;
    boolean nullable() default true;
    boolean insertable() default true;
    boolean updatable() default true;
    String columnDefinition() default "";
    String options() default "";
    String table() default "";
    int length() default 255;
    int precision() default 0; // decimal precision
    int scale() default 0; // decimal scale
    int secondPrecision() default -1; //fractional second precision
    CheckConstraint[] check() default {}
    String comment() default "";
}

```

Table 12. Column Annotation Elements

| Type | Name | Description | Default |
|---------|----------|---|-----------------------------|
| String | name | (Optional) The name of the column. | The property or field name. |
| boolean | unique | (Optional) Whether the column is a unique key. This is a shortcut for the UniqueConstraint annotation at the table level and is useful for when the unique key constraint corresponds to only a single column. This constraint applies in addition to any constraint entailed by primary key mapping and to constraints specified at the table level. | false |
| boolean | nullable | (Optional) Whether the database column is nullable. | true |

| Type | Name | Description | Default |
|---------|------------------|---|--|
| boolean | insertable | (Optional) Whether the column is included in SQL INSERT statements generated by the persistence provider. | true |
| boolean | updatable | (Optional) Whether the column is included in SQL UPDATE statements generated by the persistence provider. | true |
| String | columnDefinition | (Optional) The SQL fragment that is used when generating the DDL for the column. The specified DDL must be written in the native SQL dialect of the target database, and is not portable across databases. | Generated SQL to create a column of the inferred type. |
| String | options | (Optional) A SQL fragment appended to the generated DDL. The specified DDL must be written in the native SQL dialect of the target database, and is not portable across databases. | Nothing appended. |
| String | table | (Optional) The name of the table that contains the column. If absent the column is assumed to be in the primary table for the mapped object. | Column is in primary table. |
| int | length | (Optional) The column length Applies only to columns whose type is parameterized by length, for example, varchar or varbinary types. | 255 |

| Type | Name | Description | Default |
|-------------------|-----------------|--|---------------------|
| int | precision | <p>(Optional) The precision of a column of SQL type <code>decimal</code> or <code>numeric</code>, or of similar database-native type.</p> <p>Applies only to columns of exact numeric type.</p> <p>The default value <code>0</code> indicates that a provider-determined precision should be inferred.</p> | 0 |
| int | scale | <p>(Optional) The scale of a column of SQL type <code>decimal</code> or <code>numeric</code>, or of similar database-native type.</p> <p>Applies only to columns of exact numeric type.</p> <p>The default value <code>0</code> indicates that a provider-determined scale should be inferred.</p> | 0 |
| int | secondPrecision | <p>(Optional) The number of decimal digits to use for storing fractional seconds in a SQL time or timestamp column.</p> <p>Applies only to columns of time or timestamp type.</p> <p>The default value <code>-1</code> indicates that fractional seconds should not be stored in a time column, or that the maximum number of digits supported by the database and JDBC driver should be stored in a timestamp column.</p> | -1 |
| CheckConstraint[] | check | <p>(Optional) Check constraints for the column. These are only used if table generation is in effect.</p> | No check constraint |

| Type | Name | Description | Default |
|--------|---------|--|------------|
| String | comment | (Optional) Comment for the column. This is only used if table generation is in effect. | No comment |

Portable applications which make use of schema generation should explicitly specify the precision and scale of columns of type numeric or decimal.

Example 1:

```
@Column(name="DESC", nullable=false, length=512)
public String getDescription() {
    return description;
}
```

Example 2:

```
@Column(name="DESC", columnDefinition="CLOB NOT NULL", table="EMP_DETAIL")
@Lob
public String getDescription() {
    return description;
}
```

Example 3:

```
@Column(name="ORDER_COST", updatable=false, precision=12, scale=2)
public BigDecimal getCost() {
    return cost;
}
```

11.1.10. Convert Annotation

The Convert annotation specifies how the values of a field or property are converted to a basic type, enabling a converter which was defined `autoApply=false`, overriding the use of a converter which was defined `autoApply=true` (see [Section 10.6](#)), or overriding the use of a converter specified by a field or property of an embedded type or inherited mapped superclass.

When persistent properties are used, the Convert annotation is applied to the getter method.

It is not necessary to use the Basic annotation or corresponding XML element to specify the converted basic type. Nor is it usually necessary to explicitly specify the converter class, except to disambiguate cases where multiple converters would otherwise apply.

The Convert annotation may be applied to an entity that extends a mapped superclass to specify or override the conversion mapping for an inherited basic attribute.

```
@Target({METHOD, FIELD, TYPE})
@Retention(RUNTIME)
@Repeatable(Converts.class)
public @interface Convert {
    Class converter() default void.class;
    String attributeName() default "";
    boolean disableConversion() default false;
}
```

[Table 13](#) lists the annotation elements that may be specified for the Convert annotation.

Table 13. Convert Annotation Elements

| Type | Name | Description | Default |
|---------|-------------------|--|--|
| Class | converter | (Optional) The converter to be applied. | No converter |
| String | attributeName | (Optional) The name of the attribute to convert. Must be specified unless the <code>Convert</code> annotation is applied to an attribute of basic type or to an element collection of basic type. Must not be specified otherwise. | The basic attribute or basic element collection attribute to which the annotation is applied |
| boolean | disableConversion | (Optional) Whether conversion of the attribute is to be disabled. | false |

The `converter` element specifies the converter that is applied. Even if an automatically-applied converter would otherwise be applicable to the annotated field or property, the converter specified by the `converter` element must be applied instead.

The `disableConversion` element specifies that any automatically-applied converter that would otherwise be applicable to the given field or property must not be applied.

If neither the `converter` element nor the `disableConversion` element is specified, and there is exactly one converter for the type of the annotated field or property, that converter is applied, even if it is not an automatically-applied converter.

If multiple converters are applicable to the annotated field or property, and the `converter` element is not specified, the behavior is undefined.

The `Convert` annotation should not be used to specify conversion of id attributes, (including the attributes of embedded ids and derived identities), of version attributes, of relationship attributes, or of attributes explicitly annotated (or designated via XML) as `Enumerated` or `Temporal`. Applications that depend on such conversions are not portable.

The `Convert` annotation may be applied to:

- a basic attribute, or
- a collection attribute (that is, an `ElementCollection`) of any type other than `Map`, in which case the converter is applied to the elements of the collection.

In these cases, the `attributeName` element must not be specified.

Alternatively, the `Convert` annotation may be applied to:

- an embedded attribute,
- a collection attribute (that is, an `ElementCollection`) whose element type is an embeddable type, in which case the converter is applied to the specified attribute of the embeddable instances contained in the collection,
- a map collection attribute (that is, an `ElementCollection` of type `Map`), in which case the converter is applied to the keys or values of the map, or to the specified attribute of the embeddable instances contained in the map, or
- an entity class which extends a mapped superclass, to enable or override conversion of an inherited basic or embedded attribute.

In these cases, the `attributeName` element must be specified.

To override conversion mappings at multiple levels of embedding, a dot (“.”) notation form must be used in the `attributeName` element to indicate an attribute within an embedded attribute. The value of each identifier used with the dot notation is the name of the respective embedded field or property.

The dot notation may also be used with map entries:

- When the `Convert` annotation is applied to a map to specify conversion of a map key or value of basic type, "key" or "value", respectively, must be used as the value of the `attributeName` element to specify that it is the map key or value that is converted.
- When the `Convert` annotation is applied to a map whose key or value type is an embeddable type, the `attributeName` element must be specified, and "key." or "value." (respectively) must be used to prefix the name of the attribute of the key or value type that is converted.

Example 1: Convert a basic attribute

```
@Converter
public class BooleanToIntegerConverter implements AttributeConverter<Boolean, Integer> { ... }

@Entity
public class Employee {
    @Id
    long id;

    @Convert(converter=BooleanToIntegerConverter.class)
    boolean fullTime;

    // ...
}
```

Example 2: Auto-apply conversion of a basic attribute

```
@Converter(autoApply=true)
public class EmployeeDateConverter implements
    AttributeConverter<com.acme.EmployeeDate, java.sql.Date> { ... }

@Entity
public class Employee {
    @Id
    long id;

    // ...

    // EmployeeDateConverter is applied automatically
    EmployeeDate startDate;
}
```

Example 3: Disable conversion in the presence of an auto-apply converter

```
@Convert(disableConversion=true)
EmployeeDate lastReview;
```

Example 4: Apply a converter to an element collection of basic type

```
@ElementCollection
// applies to each element in the collection
@Convert(converter=NameConverter.class)
List<String> names;
```

Example 5: Apply a converter to an element collection that is a map of basic values. The converter is applied to the map value.

```
@ElementCollection
@Convert(converter=EmployeeNameConverter.class)
Map<String, String> responsibilities;
```

Example 6: Apply a converter to a map key of basic type

```
@OneToMany
@Convert(converter=ResponsibilityCodeConverter.class, attributeName="key")
Map<String, Employee> responsibilities;
```

Example 7: Apply a converter to an embeddable attribute

```
@Embedded
@Convert(converter=CountryConverter.class, attributeName="country")
Address address;
```

Example 8: Apply a converter to a nested embeddable attribute

```
@Embedded
@Convert(converter=CityConverter.class, attributeName="region.city")
Address address;
```

Example 9: Apply a converter to a nested attribute of an embeddable that is a map key of an element collection

```
@Entity
public class PropertyRecord {
    // ...

    @Convert(converter=CityConverter.class, attributeName="key.region.city")
    @ElementCollection
    Map<Address, PropertyInfo> parcels;
}
```

Example 10: Apply a converter to an embeddable that is a map key for a relationship

```
@OneToMany
@Convert(converter=ResponsibilityCodeConverter.class, attributeName="key.jobType")
Map<Responsibility, Employee> responsibilities;
```

Example 11: Override conversion mappings for attributes inherited from a mapped superclass

```
@Entity
@Convert(converter=DateConverter.class, attributeName="startDate")
@Convert(converter=DateConverter.class, attributeName="endDate")
public class FullTimeEmployee extends GenericEmployee { ... }
```

11.1.11. Converts Annotation

The Converts annotation can be used to group Convert annotations. Multiple converters must not be applied to the same basic attribute.

```
@Target({METHOD, FIELD, TYPE})
@Retention(RUNTIME)
public @interface Converts {
    Convert[] value();
}
```

```
}
```

Table 14 lists the annotation elements that may be specified for the `Converts` annotation.

Table 14. `Converts` Annotation Elements

| Type | Name | Description | Default |
|------------------------|-------|---|---------|
| <code>Convert[]</code> | value | (Required) The <code>Convert</code> mappings that are to be applied to the entity or the field or property. | |

Example: Multiple converters applied to an embedded attribute

```
@Embedded
@Converts({
    @Convert(converter=CountryConverter.class, attributeName="country"),
    @Convert(converter=CityConverter.class, attributeName="region.city")
})
Address address;
```

11.1.12. DiscriminatorColumn Annotation

For the `SINGLE_TABLE` mapping strategy, and typically also for the `JOINED` strategy, the persistence provider will use a type discriminator column. The `DiscriminatorColumn` annotation is used to define the discriminator column for the `SINGLE_TABLE` and `JOINED` inheritance mapping strategies.

The strategy and the discriminator column are only specified in the root of an entity class hierarchy or subhierarchy in which a different inheritance strategy is applied.^[3]

The `DiscriminatorColumn` annotation can be specified on an entity class (including on an abstract entity class).

If the `DiscriminatorColumn` annotation is missing, and a discriminator column is required, the name of the discriminator column defaults to "DTYPE" and the discriminator type to `STRING`.

Table 15 lists the annotation elements that may be specified for the `DiscriminatorColumn` annotation and their default values.

The supported discriminator types are defined by the `DiscriminatorType` enum:

```
public enum DiscriminatorType { STRING, CHAR, INTEGER };
```

The type of the discriminator column, if specified in the optional `columnDefinition` element, must be consistent with the discriminator type.

```
@Target({TYPE})
@Retention(RUNTIME)
public @interface DiscriminatorColumn {
    String name() default "DTYPE";
    DiscriminatorType discriminatorType() default STRING;
    String columnDefinition() default "";
    String options() default "";
    int length() default 31;
}
```

Table 15. `DiscriminatorColumn` Annotation Elements

| Type | Name | Description | Default |
|-------------------|-------------------|---|--|
| String | name | (Optional) The name of column to be used for the discriminator. | "DTYPE" |
| DiscriminatorType | discriminatorType | (Optional) The type of object/column to use as a class discriminator. | DiscriminatorType.STRING |
| String | columnDefinition | (Optional) The SQL fragment that is used when generating the DDL for the discriminator column. | Provider-generated SQL to create a column of the specified discriminator type. |
| String | options | (Optional) A SQL fragment appended to the generated DDL. | Nothing appended. |
| int | length | (Optional) The column length for String-based discriminator types. Ignored for other discriminator types. | 31 |

Example:

```

@Entity
@Table(name="CUST")
@DiscriminatorColumn(name="DISC", discriminatorType=STRING, length=20)
public class Customer { ... }

@Entity
public class ValuedCustomer extends Customer { ... }

```

11.1.13. DiscriminatorValue Annotation

The `DiscriminatorValue` annotation is used to specify the value of the discriminator column for entities of the given type. The `DiscriminatorValue` annotation can only be specified on a concrete entity class. If the `DiscriminatorValue` annotation is not specified and a discriminator column is used, a provider-specific function will be used to generate a value representing the entity type.

The inheritance strategy and the discriminator column are only specified in the root of an entity class hierarchy or subhierarchy in which a different inheritance strategy is applied. The discriminator value, if not defaulted, should be specified for each entity class in the hierarchy.

[Table 16](#) lists the annotation elements that may be specified for the `DiscriminatorValue` annotation and their default values.

The discriminator value must be consistent in type with the discriminator type of the specified or defaulted discriminator column. If the discriminator type is an integer, the value specified must be able to be converted to an integer value (e.g., "1").

```

@Target({TYPE})
@Retention(RUNTIME)

```

```
public @interface DiscriminatorValue {
    String value();
}
```

Table 16. DiscriminatorValue Annotation Elements

| Type | Name | Description | Default |
|--------|-------|---|---|
| String | value | (Optional) The value that indicates that the row is an entity of the annotated entity type. | If the DiscriminatorValue annotation is not specified, a provider-specific function to generate a value representing the entity type is used for the value of the discriminator column. If the DiscriminatorType is STRING, the discriminator value default is the entity name. |

Example:

```
@Entity
@Table(name="CUST")
@Inheritance(strategy=SINGLE_TABLE)
@DiscriminatorColumn(name="DISC", discriminatorType=STRING,length=20)
@DiscriminatorValue("CUSTOMER")
public class Customer { ... }

@Entity
@DiscriminatorValue("VCUSTOMER")
public class ValuedCustomer extends Customer { ... }
```

11.1.14. ElementCollection Annotation

The ElementCollection annotation defines a collection of instances of a basic type or embeddable class. The ElementCollection annotation (or equivalent XML element) must be specified if the collection is to be mapped by means of a collection table.^[4]

```
@Target({METHOD, FIELD})
@Retention(RUNTIME)
public @interface ElementCollection {
    Class targetClass() default void.class;
    FetchType fetch() default LAZY;
}
```

Table 17 lists the annotation elements that may be specified for the ElementCollection annotation and their default values.

Table 17. ElementCollection Annotation Elements

| Type | Name | Description | Default |
|-----------|-------------|--|---|
| Class | targetClass | (Optional) The basic or embeddable class that is the element type of the collection. Optional only if the collection field or property is defined using Java generics. Must be specified otherwise. | The parameterized type of the collection when defined using generics. |
| FetchType | fetch | (Optional) Whether the collection should be lazily loaded or must be eagerly fetched. The EAGER strategy is a requirement on the persistence provider runtime that the collection elements must be eagerly fetched. The LAZY strategy is a hint to the persistence provider runtime. | LAZY |

Example:

```

@Entity public class Person {
    @Id
    protected String ssn;

    protected String name;

    @ElementCollection
    protected Set<String> nickNames = new HashSet();

    // ...
}

```

11.1.15. Embeddable Annotation

The Embeddable annotation is used to specify a class whose instances are stored as an intrinsic part of an owning entity and share the identity of the entity.

```

@Documented
@Target({TYPE})
@Retention(RUNTIME)
public @interface Embeddable {

}

```

Example 1:

```

@Embeddable
public class EmploymentPeriod {
    @Temporal(DATE)
    java.util.Date startDate;
}

```

```

    @Temporal(DATE)
    java.util.Date endDate;

    // ...
}

```

Example 2:

```

@Embeddable
public class PhoneNumber {
    protected String areaCode;
    protected String localNumber;

    @ManyToOne
    PhoneServiceProvider provider;

    // ...
}

@Entity
public class PhoneServiceProvider {
    @Id
    protected String name;

    // ...
}

```

Example 3:

```

@Embeddable
public class Address {
    protected String street;
    protected String city;
    protected String state;

    @Embedded
    protected Zipcode zipcode;
}

@Embeddable
public class Zipcode {
    protected String zip;
    protected String plusFour;
}

```

11.1.16. Embedded Annotation

The `Embedded` annotation is used to specify a persistent field or property of an entity or embeddable class whose value is an instance of an embeddable class.^[5] Each of the persistent properties or fields of the embedded object is mapped to the database table for the entity or embeddable class. The embeddable class must be annotated as `Embeddable`.^[6]

The `AttributeOverride`, `AttributeOverrides`, `AssociationOverride`, and `AssociationOverrides` annotations may be used to override mappings declared or defaulted by the embeddable class.

Implementations are not required to support embedded objects that are mapped across more than one table (e.g., split across primary and secondary tables or multiple secondary tables).

```

@Target({METHOD, FIELD})
@Retention(RUNTIME)
public @interface Embedded {}

```

Example:

```
@Embedded
@AttributeOverrides({
    @AttributeOverride(name="startDate", column=@Column(name="EMP_START")),
    @AttributeOverride(name="endDate", column=@Column(name="EMP_END"))
})
public EmploymentPeriod getEmploymentPeriod() { ... }
```

11.1.17. EmbeddedId Annotation

The `EmbeddedId` annotation is applied to a persistent field or property of an entity class or mapped superclass to denote a composite primary key that is an embeddable class. The embeddable class must be annotated as `Embeddable`.^[7]

Relationship mappings defined within an embedded id class are not supported.

There must be only one `EmbeddedId` annotation and no `Id` annotation when the `EmbeddedId` annotation is used.

The `AttributeOverride` annotation may be used to override the column mappings declared within the embeddable class.

The `MapsId` annotation may be used in conjunction with the `EmbeddedId` annotation to specify a derived primary key. See [Section 2.4.2](#) and [Section 11.1.38](#).

If the entity has a derived primary key, the `AttributeOverride` annotation may only be used to override those attributes of the embedded id that do not correspond to the relationship to the parent entity.

```
@Target({METHOD, FIELD})
@Retention(RUNTIME)
public @interface EmbeddedId {}
```

Example 1:

```
@Entity public class Employee {
    @EmbeddedId
    protected EmployeePK empPK;

    String name;

    @ManyToOne
    Set<Department> dept;

    // ...
}
```

Example 2:

```
@Embeddable
public class DependentId {
    String name;
    EmployeeId empPK; // corresponds to PK type of Employee
}

@Entity
public class Dependent {
    // default column name for "name" attribute is overridden
    @AttributeOverride(name="name", @Column(name="dep_name"))
    @EmbeddedId
    DependentId id;

    // ...

    @MapsId("empPK")
```

```

    @ManyToOne
    Employee emp;
}

```

11.1.18. Enumerated Annotation

An Enumerated annotation specifies that a persistent property or field should be persisted as an enumerated type. The Enumerated annotation is optional if the type of a persistent field or property is a Java enum type.

The Enumerated annotation may be used in conjunction with the Basic annotation. The Enumerated annotation may be used in conjunction with the ElementCollection annotation^[8] when the element type of the collection is an enum type.

An enum can be mapped as either a string or an integer^[9]. The EnumType enum defines the available options for mapping enumerated types.

```

public enum EnumType {
    ORDINAL,
    STRING
}

```

The value member of the Enumerated annotation specifies the EnumType:

```

@Target({METHOD, FIELD})
@Retention(RUNTIME)
public @interface Enumerated {
    EnumType value() default ORDINAL;
}

```

Table 18 lists the annotation elements that may be specified for the Enumerated annotation and their default values.

Table 18. Enumerated Annotation Elements

| Type | Name | Description | Default |
|----------|-------|---|---------|
| EnumType | value | (Optional) The type used in mapping an enum type. | ORDINAL |

If a persistent field or property of enum type has no explicit Enumerated annotation, and if no converter is applied to the field or property:

- if the enum type has a final field of type `java.lang.String` annotated `EnumeratedValue`, the enumerated type is inferred to be `STRING`;
- otherwise, the enumerated type is taken to be `ORDINAL`.

The enum type may have a final field annotated `EnumeratedValue`. This field, if it exists, controls the mapping of enum values to database column values:

- if the enum type does have a field annotated `EnumeratedValue`, each enum value is mapped to the value of the annotated field, or, otherwise,
- if the enumerated type is `ORDINAL`, each enum value is mapped to the value of the `ordinal` field, but
- if the enumerated type is `STRING`, each enum value is mapped to the value of the `name` field.

Example:

```

public enum EmployeeStatus {FULL_TIME, PART_TIME, CONTRACT}
public enum SalaryRate {JUNIOR, SENIOR, MANAGER, EXECUTIVE}

```

```

@Entity
public class Employee {
    // ...

    public EmployeeStatus getStatus() {...}

    @Enumerated(STRING)
    public SalaryRate getPayScale() {...}

    // ...
}

```

If the status property is mapped to a column of integer type, and the payscale property to a column of varchar type, an instance that has a status of PART_TIME and a pay rate of JUNIOR will be stored with STATUS set to 1 and PAYSCALE set to "JUNIOR".

11.1.19. EnumeratedValue Annotation

The EnumeratedValue annotation specifies that an annotated field of a Java enum type is the source of database column values when the enum occurs as the declared type of an Enumerated property or field. The annotated field must be declared final, and must be of type:

- byte, short, or int for an ORDINAL enumerated type, or
- java.lang.String for a STRING enumerated type.

The field must not be set to null, and must hold a distinct value for each value of the enum type.

If the type of the field annotated EnumeratedValue disagrees with the enumerated type mapping specified by the Enumerated annotation, the behavior is undefined. Portable applications should ensure that the type of the field annotated EnumeratedValue agrees with the type mapping wherever the enum type is used in a field or property explicitly annotated Enumerated.

If a converter is applied to an Enumerated field or property, the EnumeratedValue annotation is ignored for that field or property.

Example:

```

enum Status {
    OPEN(0), CLOSED(1), CANCELLED(-1);

    @EnumeratedValue
    final int intValue;

    Status(int intValue) {
        this.intValue = intValue;
    }
}

```

11.1.20. ForeignKey Annotation

The ForeignKey annotation is used to specify the handling of foreign key constraints when schema generation is in effect. If this annotation is not specified, the persistence provider's default foreign key strategy will be used.

```

@Target({})
@Retention(RUNTIME)
public @interface ForeignKey {
    String name() default "";
    ConstraintMode value() default CONSTRAINT;
    String foreignKeyDefinition() default "";
}

```

```

    String options() default "";
}

```

The `name` element specifies a name for the foreign key constraint.

The `ConstraintMode` enum is used to control the application of constraints.

```

public enum ConstraintMode {CONSTRAINT, NO_CONSTRAINT, PROVIDER_DEFAULT}

```

The enum values have the following semantics: A value of `CONSTRAINT` will cause the persistence provider to generate a foreign key constraint. A value of `NO_CONSTRAINT` will result in no constraint being generated. A value of `PROVIDER_DEFAULT` will result in the provider's default behavior (which may or may not result in the generation of a constraint for any given join column or set of join columns).

The syntax used in the `foreignKeyDefinition` element should follow the SQL syntax used by the target database for foreign key constraints. For example, this may be similar to the following:

```

FOREIGN KEY (<COLUMN expression> {, <COLUMN expression>}... )
REFERENCES <TABLE identifier> [ (<COLUMN expression> {, <COLUMN expression>}... ) ]
[ ON UPDATE <referential action> ]
[ ON DELETE <referential action> ]

```

If the `ForeignKey` annotation is specified with a `ConstraintMode` value of `CONSTRAINT`, but the `foreignKeyDefinition` element is not specified, the provider will generate a foreign key constraint whose update and delete actions it determines most appropriate for the join column(s) to which the foreign key constraint is applied

Table 19 lists the annotation elements that may be specified for the `ForeignKey` annotation.

Table 19. *ForeignKey* Annotation Elements

| Type | Name | Description | Default |
|-----------------------------|-----------------------------------|--|--|
| String | <code>name</code> | (Optional) The name of the foreign key constraint. | A provider-generated name. |
| <code>ConstraintMode</code> | <code>value</code> | (Optional) Whether to generate a constraint. | <code>CONSTRAINT</code> |
| String | <code>foreignKeyDefinition</code> | (Optional) The foreign key constraint definition. | Provider-default. If the value of the <code>ConstraintMode</code> element is <code>NO_CONSTRAINT</code> , the provider must not generate a foreign key constraint. |
| String | <code>options</code> | (Optional) A SQL fragment appended to the generated DDL. | Nothing appended. |

11.1.21. GeneratedValue Annotation

The `GeneratedValue` annotation specifies a generation strategy for the values of primary keys. The `GeneratedValue` annotation may be applied to a primary key property or field of an entity or mapped superclass in conjunction with the `Id` annotation.^[10] The persistence provider is only required to support the use of the `GeneratedValue` annotation for simple primary keys. Use of the `GeneratedValue` annotation for derived primary keys is not supported.

Table 20 lists the annotation elements that may be specified for the `GeneratedValue` annotation and their default values.

The types of primary key generation are defined by the `GenerationType` enum:

```
public enum GenerationType { TABLE, SEQUENCE, IDENTITY, UUID, AUTO };
```

The `TABLE` generator type value indicates that the persistence provider must assign primary keys for the entity using an underlying database table to ensure uniqueness.

The `SEQUENCE` and `IDENTITY` values specify the use of a database sequence or identity column, respectively.^[11]

The further specification of table generators and sequence generators is described in [Section 11.1.49](#) and [Section 11.1.52](#).

A `TABLE`, `SEQUENCE`, or `IDENTITY` generator may be used to generate values for a primary key property or field of type `java.lang.Long`, `java.lang.Integer`, `long`, or `int`.

The `UUID` value indicates that the persistence provider should assign an RFC 4122 Universally Unique Identifier.

A `UUID` generator may be used to generate values for a primary key property or field of type `java.util.UUID` or `java.lang.String`.

The `AUTO` value indicates that the persistence provider should pick an appropriate strategy given the type of the primary key property or field, and the capabilities of the particular database. In the case of a field or property of type `java.util.UUID` or `java.lang.String`, the `AUTO` strategy is equivalent to `UUID`. In the case of a field or property of type `java.lang.Long`, `java.lang.Integer`, `long`, or `int`, the `AUTO` strategy may select between `TABLE`, `SEQUENCE`, or `IDENTITY`.

The `AUTO` generation strategy may expect a database resource to exist, or it may attempt to create one. A vendor may provide documentation on how to create such resources in the event that it does not support schema generation or cannot create the schema resource at runtime.

This specification does not define the exact behavior of these strategies.

However, if the persistence provider stores a value generated according to the `UUID` strategy in a column of type `VARCHAR` or equivalent, the value must be stored in its canonical representation, unless the application explicitly indicates that some other representation is preferred.

The `name` member specifies the name of a generator to use, and defaults to the entity name of the entity in which the `GeneratedValue` annotation occurs. If the `name` is not specified, and if there is no generator with the defaulted name, then the persistence provider supplies a default id generator, of a type compatible with the value of the `strategy` member.

```
@Target({METHOD, FIELD})
@Retention(RUNTIME)
public @interface GeneratedValue {
    GenerationType strategy() default AUTO;
    String generator() default "";
}
```

Table 20. *GeneratedValue* Annotation Elements

| Type | Name | Description | Default |
|----------------|-----------|--|---|
| GenerationType | strategy | (Optional) The primary key generation strategy that the persistence provider must use to generate the annotated entity primary key. | GenerationType.AUTO |
| String | generator | (Optional) The name of the primary key generator to use as specified in the <code>SequenceGenerator</code> or <code>TableGenerator</code> annotation which declares the generator. | The entity name of the entity in which the annotation occurs. |

Example 1:

```
@Id
@GeneratedValue(strategy=SEQUENCE, generator="CUST_SEQ")
@Column(name="CUST_ID")
public Long getId() { return id; }
```

Example 2:

```
@Id
@GeneratedValue(strategy=TABLE, generator="CUST_GEN")
@Column(name="CUST_ID")
Long id;
```

11.1.22. Id Annotation

The `Id` annotation declares a primary key property or field of an entity. The `Id` annotation may be applied to a property or field of:

- an entity class that is the root of an entity hierarchy, or
- a mapped superclass that is a superclass of all entity classes in an entity hierarchy.

The field or property to which the `Id` annotation is applied should have one of the legal simple primary key types listed in [Section 2.4](#).^{[12][13]}

The mapped column for the primary key of the entity is assumed to be the primary key of the primary table. If no `Column` annotation is specified, the primary key column name is assumed to be the name of the primary key property or field.

```
@Target({METHOD, FIELD})
@Retention(RUNTIME)
public @interface Id {}
```

Example:

```
@Id
public Long getId() { return id; }
```

11.1.23. IdClass Annotation

The `IdClass` annotation is applied to an entity class or a mapped superclass to specify a composite primary key class that is mapped to multiple fields or properties of the entity.

The names of the fields or properties in the primary key class and the primary key fields or properties of the entity must correspond and their types must match according to the rules specified in [Section 2.4](#) and [Section 2.4.2](#).

The `Id` annotation must also be applied to the corresponding fields or properties of the entity.

```
@Target({TYPE})
@Retention(RUNTIME)
public @interface IdClass {
    Class value();
}
```

[Table 21](#) lists the annotation elements that may be specified for the `IdClass` annotation.

Table 21. *IdClass* Annotation Elements

| Type | Name | Description | Default |
|-------|-------|---|---------|
| Class | value | (Required) The composite primary key class. | |

Example:

```
@IdClass(com.acme.EmployeePK.class)
@Entity
public class Employee {
    @Id
    String empName;

    @Id
    Date birthDay;

    // ...
}
```

11.1.24. Index Annotation

The `Index` annotation is used in schema generation. Note that it is not necessary to specify an index for a primary key, as the primary key index will be created automatically, however, the `Index` annotation may be used to specify the ordering of the columns in the index for the primary key.

```
@Target({})
@Retention(RUNTIME)
public @interface Index {
    String name() default "";
    String columnList();
    boolean unique() default false;
    String options() default "";
}
```

The syntax of the `columnList` element is a `column_list`, as follows:

```
column_list ::= index_column [, index_column]*
index_column ::= column_name [ASC | DESC]
```

The persistence provider must observe the specified ordering of the columns.

If ASC or DESC is not specified, ASC (ascending order) is assumed.

Table 22 lists the annotation elements that may be specified for the `Index` annotation.

Table 22. Index Annotation Elements

| Type | Name | Description | Default |
|---------|------------|--|----------------------------|
| String | name | (Optional) The name of the index. | A provider-generated name. |
| String | columnList | (Required) The names of the columns to be included in the index. | |
| boolean | unique | (Optional) Whether the index is unique. | false |
| String | options | (Optional) A SQL fragment appended to the generated DDL. | Nothing appended. |

11.1.25. Inheritance Annotation

The `Inheritance` annotation defines the inheritance strategy to be used for an entity class hierarchy. It is specified on the entity class that is the root of the entity class hierarchy.

If the `Inheritance` annotation is not specified or if no inheritance type is specified for an entity class hierarchy, the `SINGLE_TABLE` mapping strategy is used.

Support for the combination of inheritance strategies is not required by this specification. Portable applications should only use a single inheritance strategy within an entity hierarchy.

The three inheritance mapping strategies are the single table per class hierarchy, joined subclass, and table per concrete class strategies. See Section 2.14 for a more detailed discussion of inheritance strategies.

The inheritance strategy options are defined by the `InheritanceType` enum:

```
public enum InheritanceType { SINGLE_TABLE, JOINED, TABLE_PER_CLASS };
```

Support for the `TABLE_PER_CLASS` mapping strategy is optional in this release.

Table 23 lists the annotation elements that may be specified for the `Inheritance` annotation and their default values.

```
@Target({TYPE})  
@Retention(RUNTIME)  
public @interface Inheritance {  
    InheritanceType strategy() default SINGLE_TABLE;  
}
```

Table 23. Inheritance Annotation Elements

| Type | Name | Description | Default |
|-----------------|----------|--|------------------------------|
| InheritanceType | strategy | (Optional) The inheritance strategy to use for the entity inheritance hierarchy. | InheritanceType.SINGLE_TABLE |

Example:

```

@Entity
@Inheritance(strategy=JOINED)
public class Customer { ... }

@Entity
public class ValuedCustomer extends Customer { ... }

```

11.1.26. JoinColumn Annotation

The `JoinColumn` annotation is used to specify a column for joining an entity association or element collection.

[Table 24](#) lists the annotation elements that may be specified for the `JoinColumn` annotation and their default values.

If the `JoinColumn` annotation itself is defaulted, a single join column is assumed and the default values described in [Table 24](#) apply.

The `name` annotation element defines the name of the foreign key column. The remaining annotation elements (other than `referencedColumnName`) refer to this column and have the same semantics as for the `Column` annotation.

If the `referencedColumnName` element is missing, the foreign key is assumed to refer to the primary key of the referenced table.

Support for referenced columns that are not primary key columns of the referenced table is optional. Applications that use such mappings will not be portable.

The `foreignKey` annotation element is used to specify or control the generation of a foreign key constraint when schema generation is in effect. If this element is not specified, the persistence provider's default foreign key strategy will apply.

If more than one `JoinColumn` annotation is applied to a field or property, both the `name` and the `referencedColumnName` elements must be specified in each such `JoinColumn` annotation.

```

@Target({METHOD, FIELD})
@Retention(RUNTIME)
@Repeatable(JoinColumns.class)
public @interface JoinColumn {
    String name() default "";
    String referencedColumnName() default "";
    boolean unique() default false;
    boolean nullable() default true;
    boolean insertable() default true;
    boolean updatable() default true;
    String columnDefinition() default "";
    String options() default "";
    String table() default "";
    ForeignKey foreignKey() default @ForeignKey(PROVIDER_DEFAULT);
    CheckConstraint[] check() default {};
    String comment() default "";
}

```

Table 24. JoinColumn Annotation Elements

| Type | Name | Description | Default |
|--------|------|---|---|
| String | name | <p>(Optional) The name of the foreign key column. The table in which it is found depends upon the context. If the join is for a OneToOne or ManyToOne mapping using a foreign key mapping strategy, the foreign key column is in the table of the source entity or embeddable. If the join is for a unidirectional OneToMany mapping using a foreign key mapping strategy, the foreign key is in the table of the target entity. If the join is for a ManyToMany mapping or for a OneToOne or bidirectional ManyToOne/OneToMany mapping using a join table, the foreign key is in a join table. If the join is for an element collection, the foreign key is in a collection table.</p> | <p>(Default only applies if a single join column is used.) The concatenation of the following: the name of the referencing relationship property or field of the referencing entity or embeddable class; “_”; the name of the referenced primary key column. If there is no such referencing relationship property or field in the entity, or if the join is for an element collection, the join column name is formed as the concatenation of the following: the name of the entity; “_”; the name of the referenced primary key column.</p> |

| Type | Name | Description | Default |
|---------|----------------------|---|--|
| String | referencedColumnName | (Optional) The name of the column referenced by this foreign key column. When used with entity relationship mappings other than the cases described below, the referenced column is in the table of the target entity. When used with a unidirectional OneToMany foreign key mapping, the referenced column is in the table of the source entity. When used inside a JoinTable annotation, the referenced key column is in the entity table of the owning entity, or inverse entity if the join is part of the inverse join definition. When used in a collection table mapping, the referenced column is in the table of the entity containing the collection. | (Default only applies if single join column is being used.) The same name as the primary key column of the referenced table. |
| boolean | unique | (Optional) Whether the property is a unique key. This is a shortcut for the UniqueConstraint annotation at the table level and is useful for when the unique key constraint is only a single field. It is not necessary to explicitly specify this for a join column that corresponds to a primary key that is part of a foreign key. | false |
| boolean | nullable | (Optional) Whether the foreign key column is nullable. | true |
| boolean | insertable | (Optional) Whether the column is included in SQL INSERT statements generated by the persistence provider. | true |

| Type | Name | Description | Default |
|-------------------|------------------|--|---|
| boolean | updatable | (Optional) Whether the column is included in SQL UPDATE statements generated by the persistence provider. | true |
| String | columnDefinition | (Optional) The SQL fragment that is used when generating the DDL for the column. | Generated SQL for the column. |
| String | table | (Optional) The name of the table that contains the column. | If the join is for a OneToOne or ManyToOne mapping using a foreign key mapping strategy, the name of the table of the source entity or embeddable. If the join is for a unidirectional OneToMany mapping using a foreign key mapping strategy, the name of the table of the target entity. If the join is for a ManyToMany mapping or for a OneToOne or bidirectional ManyToOne/OneToMany mapping using a join table, the name of the join table. If the join is for an element collection, the name of the collection table. |
| ForeignKey | foreignKey | (Optional) The foreign key constraint for the join column. This is used only if table generation is in effect. | Provider's default |
| CheckConstraint[] | check | (Optional) Check constraints for the column. These are only used if table generation is in effect. | No check constraint |
| String | comment | (Optional) Comment for the column. This is only used if table generation is in effect. | No comment |
| String | options | (Optional) A SQL fragment appended to the generated DDL. | Nothing appended. |

Example 1:

@ManyToOne


```
@JoinColumn(name="ADDR_ID")
public Address getAddress() { return address; }
```

Example 2: Unidirectional One-to-Many association using a foreign key mapping.

In Customer class:

```
@OneToMany
@JoinColumn(name="CUST_ID") // join column is in table for Order
public Set<Order> getOrders() { return orders; }
```

11.1.27. JoinColumns Annotation

Composite foreign keys are supported by means of the `JoinColumns` annotation. The `JoinColumns` annotation groups `JoinColumn` annotations for the same relationship.

When the `JoinColumns` annotation is used, both the name and the `referencedColumnName` elements must be specified in each of the grouped `JoinColumn` annotations.

The `foreignKey` annotation element is used to specify or control the generation of a foreign key constraint when schema generation is in effect. If both this element and the `foreignKey` element of any of the `JoinColumn` elements referenced by the value element are specified, the behavior is undefined. If no `foreignKey` annotation element is specified in either location, the persistence provider's default foreign key strategy will apply.

```
@Target({METHOD, FIELD})
@Retention(RUNTIME)
public @interface JoinColumns {
    JoinColumn[] value();
    ForeignKey foreignKey() default @ForeignKey(PROVIDER_DEFAULT);
}
```

Table 25 lists the annotation elements that may be specified for the `JoinColumns` annotation.

Table 25. *JoinColumns Annotation Elements*

| Type | Name | Description | Default |
|---------------------------|------------|---|--------------------|
| <code>JoinColumn[]</code> | value | (Required) The join columns that map the relationship. | |
| <code>ForeignKey</code> | foreignKey | (Optional) The foreign key constraint specification for the join columns. This is used only if table generation is in effect. | Provider's default |

Example:

```
@ManyToOne
@JoinColumns({
    @JoinColumn(name="ADDR_ID", referencedColumnName="ID"),
    @JoinColumn(name="ADDR_ZIP", referencedColumnName="ZIP")
})
public Address getAddress() { return address; }
```

11.1.28. JoinTable Annotation

The `JoinTable` annotation is used in the mapping of entity associations. A `JoinTable` annotation is specified on the owning side of the association. A join table is typically used in the mapping of many-to-many and unidirectional one-to-many associations. It may also be used to map bidirectional many-to-one/one-to-many associations, unidirectional many-to-one relationships, and one-to-one associations (both bidirectional and unidirectional).

Table 26 lists the annotation elements that may be specified for the `JoinTable` annotation and their default values.

If the `JoinTable` annotation is not explicitly specified for the mapping of a many-to-many or unidirectional one-to-many relationship, the default values of the annotation elements apply.

The name of the join table is assumed to be the table names of the associated primary tables concatenated together (owning side first) using an underscore.

The `foreignKey` element is used to specify or control the generation of a foreign key constraint for the columns corresponding to the `joinColumns` element when table generation is in effect. If both this element and the `foreignKey` element of any of the `joinColumns` elements are specified, the behavior is undefined. If no `foreignKey` annotation element is specified in either location, the persistence provider's default foreign key strategy will apply. The `inverseForeignKey` element applies to the generation of a foreign key constraint for the columns corresponding to the `inverseJoinColumns` element, and similar rules apply.

When a join table is used in mapping a relationship with an embeddable class on the owning side of the relationship, the containing entity rather than the embeddable class is considered the owner of the relationship.

This annotation may not be applied to a persistent field or property not annotated `@ManyToOne`, `@OneToOne`, `@ManyToMany`, or `@OneToMany`.

```
@Target({METHOD, FIELD})
@Retention(RUNTIME)
public @interface JoinTable {
    String name() default "";
    String catalog() default "";
    String schema() default "";
    JoinColumn[] joinColumns() default {};
    JoinColumn[] inverseJoinColumns() default {};
    ForeignKey foreignKey() default @ForeignKey(PROVIDER_DEFAULT);
    ForeignKey inverseForeignKey() default @ForeignKey(PROVIDER_DEFAULT);
    UniqueConstraint[] uniqueConstraints() default {};
    Index[] indexes() default {};
    CheckConstraint[] check() default {};
    String comment() default "";
    String options() default "";
}
```

Table 26. *JoinTable* Annotation Elements

| Type | Name | Description | Default |
|--------|---------|--|---|
| String | name | (Optional) The name of the join table. | The concatenated names of the two associated primary entity tables (owning side first), separated by an underscore. |
| String | catalog | (Optional) The catalog of the table. | Default catalog. |

| Type | Name | Description | Default |
|--------------------|--------------------|--|--------------------------------------|
| String | schema | (Optional) The schema of the table. | Default schema for user. |
| JoinColumn[] | joinColumns | (Optional) The foreign key columns of the join table which reference the primary table of the entity owning the association (i.e. the owning side of the association). | The same defaults as for JoinColumn. |
| JoinColumn[] | inverseJoinColumns | (Optional) The foreign key columns of the join table which reference the primary table of the entity that does not own the association (i.e. the inverse side of the association). | The same defaults as for JoinColumn. |
| ForeignKey | foreignKey | (Optional) The foreign key constraint specification for the join columns. This is used only if table generation is in effect. | Provider's default. |
| ForeignKey | inverseForeignKey | (Optional) The foreign key constraint specification for the inverse join columns. This is used only if table generation is in effect. | Provider's default. |
| UniqueConstraint[] | uniqueConstraints | (Optional) Unique constraints that are to be placed on the table. These are only used if table generation is in effect. | No additional constraints |
| Index[] | indexes | (Optional) Indexes for the table. These are only used if table generation is in effect. | No additional indexes |
| CheckConstraint[] | check | (Optional) Check constraints for the table. These are only used if table generation is in effect. | No check constraint |
| String | comment | (Optional) Comment for the table. This is only used if table generation is in effect. | No comment |

| Type | Name | Description | Default |
|--------|---------|--|-------------------|
| String | options | (Optional) A SQL fragment appended to the generated DDL. | Nothing appended. |

Example:

```
@JoinTable(
    name="CUST_PHONE",
    joinColumns=@JoinColumn(name="CUST_ID", referencedColumnName="ID"),
    inverseJoinColumns=@JoinColumn(name="PHONE_ID", referencedColumnName="ID")
)
```

11.1.29. Lob Annotation

A Lob annotation specifies that a persistent property or field should be persisted as a large object to a database-supported large object type. Portable applications should use the Lob annotation when mapping to a database Lob type. The Lob annotation may be used in conjunction with the Basic annotation or with the ElementCollection^[14] annotation when the element collection value is of basic type. A Lob may be either a binary or character type. The Lob type is inferred from the type of the persistent field or property and, except for string and character types, defaults to Blob.

```
@Target({METHOD, FIELD})
@Retention(RUNTIME)
public @interface Lob {
}
```

Example 1:

```
@Lob
@Basic(fetch=EAGER)
@Column(name="REPORT")
protected String report;
```

Example 2:

```
@Lob @Basic(fetch=LAZY)
@Column(name="EMP_PIC", columnDefinition="BLOB NOT NULL")
protected byte[] pic;
```

11.1.30. ManyToMany Annotation

A ManyToMany annotation defines a many-valued association with many-to-many multiplicity. If the collection is defined using generics to specify the element type, the associated target entity class does not need to be specified; otherwise it must be specified.

Every many-to-many association has two sides, the owning side and the non-owning, or inverse, side. If the association is bidirectional, either side may be designated as the owning side. If the relationship is bidirectional, the non-owning side must use the mappedBy element of the ManyToMany annotation to specify the relationship field or property of the owning side.

The join table for the relationship, if not defaulted, is specified on the owning side.

The ManyToMany annotation may be used within an embeddable class contained within an entity class to specify a

relationship to a collection of entities^[15]. If the relationship is bidirectional and the entity containing the embeddable class is the owner of the relationship, the non-owning side must use the `mappedBy` element of the `ManyToMany` annotation to specify the relationship field or property of the embeddable class. The dot (".") notation syntax must be used in the `mappedBy` element to indicate the relationship attribute within the embedded attribute. The value of each identifier used with the dot notation is the name of the respective embedded field or property.

Table 27 lists these annotation elements that may be specified for the `ManyToMany` annotation and their default values.

The `cascade` element specifies the set of cascadable operations that are propagated to the associated entity. The operations that are cascadable are defined by the `CascadeType` enum:

```
public enum CascadeType {ALL, PERSIST, MERGE, REMOVE, REFRESH, DETACH};
```

The value `cascade=ALL` is equivalent to `cascade={PERSIST, MERGE, REMOVE, REFRESH, DETACH}`.

When the collection is a `java.util.Map`, the `cascade` element applies to the map value.

```
@Target({METHOD, FIELD})
@Retention(RUNTIME)
public @interface ManyToMany {
    Class targetEntity() default void.class;
    CascadeType[] cascade() default {};
    FetchType fetch() default LAZY;
    String mappedBy() default "";
}
```

The `EAGER` strategy is a requirement on the persistence provider runtime that the associated entity must be eagerly fetched. The `LAZY` strategy is a hint to the persistence provider runtime that the associated entity should be fetched lazily when it is first accessed. The implementation is permitted to eagerly fetch associations for which the `LAZY` strategy hint has been specified.

Table 27. `ManyToMany` Annotation Elements

| Type | Name | Description | Default |
|----------------------------|---------------------------|--|---|
| Class | <code>targetEntity</code> | (Optional) The entity class that is the target of the association. Optional only if the collection-valued relationship property is defined using Java generics. Must be specified otherwise. | The parameterized type of the collection when defined using generics. |
| <code>CascadeType[]</code> | <code>cascade</code> | (Optional) The operations that must be cascaded to the target of the association. | No operations are cascaded. |

| Type | Name | Description | Default |
|-----------|----------|---|---------|
| FetchType | fetch | (Optional) Whether the association should be lazily loaded or must be eagerly fetched. The EAGER strategy is a requirement on the persistence provider runtime that the associated entities must be eagerly fetched. The LAZY strategy is a hint to the persistence provider runtime. | LAZY |
| String | mappedBy | The field or property that owns the relationship. Required unless the relationship is unidirectional. | |

Example 1:

In Customer class:

```
@ManyToMany
@JoinTable(name="CUST_PHONES")
public Set<PhoneNumber> getPhones() { return phones; }
```

In PhoneNumber class:

```
@ManyToMany(mappedBy="phones")
public Set<Customer> getCustomers() { return customers; }
```

Example 2:

In Customer class:

```
@ManyToMany(targetEntity=com.acme.PhoneNumber.class)
public Set getPhones() { return phones; }
```

In PhoneNumber class:

```
@ManyToMany(targetEntity=com.acme.Customer.class, mappedBy="phones")
public Set getCustomers() { return customers; }
```

Example 3:

In Customer class:

```
@ManyToMany
@JoinTable(
    name="CUST_PHONE",
    joinColumns=@JoinColumn(name="CUST_ID", referencedColumnName="ID"),
    inverseJoinColumns=@JoinColumn(name="PHONE_ID", referencedColumnName="ID")
)
public Set<PhoneNumber> getPhones() { return phones; }
```

In PhoneNumberClass:

```
@ManyToMany(mappedBy="phones")
public Set<Customer> getCustomers() { return customers; }
```

Example 4:

Embeddable class used by the Employee entity specifies a many-to-many relationship.

```
@Entity
public class Employee {
    @Id
    int id;

    @Embedded
    ContactInfo contactInfo;

    // ...
}

@Embeddable
public class ContactInfo {
    @ManyToOne
    Address address; // Unidirectional

    @ManyToMany
    List<PhoneNumber> phoneNumbers; // Bidirectional
}

@Entity
public class PhoneNumber {
    @Id
    int phNumber;

    @ManyToMany(mappedBy="contactInfo.phoneNumbers")
    Collection<Employee> employees;
}
```

11.1.31. ManyToOne Annotation

The `ManyToOne` annotation defines a single-valued association to another entity class that has many-to-one multiplicity. It is not normally necessary to specify the target entity explicitly since it can usually be inferred from the type of the object being referenced.

The `ManyToOne` annotation may be used within an embeddable class to specify a relationship from the embeddable class to an entity class. If the relationship is bidirectional, the non-owning `OneToMany` entity side must use the `mappedBy` element of the `OneToMany` annotation to specify the relationship field or property of the embeddable field or property on the owning side of the relationship. The dot (“.”) notation syntax must be used in the `mappedBy` element to indicate the relationship attribute within the embedded attribute. The value of each identifier used with the dot notation is the name of the respective embedded field or property.

Table 28 lists the annotation elements that may be specified for the `ManyToOne` annotation and their default values.

```
@Target({METHOD, FIELD})
@Retention(RUNTIME)
public @interface ManyToOne {
    Class targetEntity() default void.class;
    CascadeType[] cascade() default {};
    FetchType fetch() default EAGER;
    boolean optional() default true;
}
```

```
}
```

The operations that can be cascaded are defined by the `CascadeType` enum, defined in [Section 11.1.30](#).

The `EAGER` strategy is a requirement on the persistence provider runtime that the associated entity must be eagerly fetched. The `LAZY` strategy is a hint to the persistence provider runtime that the associated entity should be fetched lazily when it is first accessed. The implementation is permitted to eagerly fetch associations for which the `LAZY` strategy hint has been specified.

Table 28. ManyToOne Annotation Elements

| Type | Name | Description | Default |
|----------------------------|---------------------------|---|--|
| Class | <code>targetEntity</code> | (Optional) The entity class that is the target of the association. | The type of the field or property that stores the association. |
| <code>CascadeType[]</code> | <code>cascade</code> | (Optional) The operations that must be cascaded to the target of the association. | No operations are cascaded. |
| <code>FetchType</code> | <code>fetch</code> | (Optional) Whether the association should be lazily loaded or must be eagerly fetched. The <code>EAGER</code> strategy is a requirement on the persistence provider runtime that the associated entity must be eagerly fetched. The <code>LAZY</code> strategy is a hint to the persistence provider runtime. | <code>EAGER</code> |
| boolean | <code>optional</code> | (Optional) Whether the association is optional. If set to false then a non-null relationship must always exist. | <code>true</code> |

Example 1:

```
@ManyToOne(optional=false)
@JoinColumn(name="CUST_ID", nullable=false, updatable=false)
public Customer getCustomer() { return customer; }
```

Example 2:

```
@Entity
public class Employee {
    @Id
    int id;

    @Embedded
    JobInfo jobInfo;

    // ...
}
```



```

}

@Embeddable
public class JobInfo {
    String jobDescription;

    @ManyToOne
    ProgramManager pm; // Bidirectional
}

@Entity
public class ProgramManager {
    @Id
    int id;

    @OneToMany(mappedBy="jobInfo.pm")
    Collection<Employee> manages;
}

```

11.1.32. MapKey Annotation

The `MapKey` annotation is used to specify the map key for associations of type `java.util.Map` when the map key is itself the primary key or a persistent field or property of the entity that is the value of the map.

```

@Target({METHOD, FIELD})
@Retention(RUNTIME)
public @interface MapKey {
    String name() default "";
}

```

The `name` element designates the name of the persistent field or property of the associated entity that is used as the map key. If the `name` element is not specified, the primary key of the associated entity is used as the map key. If the primary key is a composite primary key and is mapped as `IdClass`, an instance of the primary key class is used as the key.

If a persistent field or property other than the primary key is used as a map key, it is expected to be unique within the context of the relationship.

The `MapKeyClass` annotation is not used when `MapKey` is specified and vice versa.

Table 29 lists the annotation elements that may be specified for the `MapKey` annotation.

Table 29. *MapKey* Annotation Elements

| Type | Name | Description | Default |
|--------|------|--|---|
| String | name | (Optional) The name of the persistent field or property that is used as the map key. | The primary key is used as the map key. |

Example 1:

```

@Entity
public class Department {

    // ...

    @OneToMany(mappedBy="department")
    @MapKey // map key is primary key
    public Map<Integer, Employee> getEmployees() { ... }
}

```

```

    // ...
}

@Entity
public class Employee {

    // ...

    @Id public Integer getEmpId() { ... }
    @ManyToOne
    @JoinColumn(name="dept_id")
    public Department getDepartment() { ... }

    // ...
}

```

Example 2:

```

@Entity
public class Department {
    // ...

    @OneToMany(mappedBy="department")
    @MapKey(name="name")
    public Map<String, Employee> getEmployees() { ... }

    // ...
}

@Entity
public class Employee {
    @Id
    public Integer getEmpId() { ... }

    // ...

    public String getName() { ... }

    // ...

    @ManyToOne
    @JoinColumn(name="dept_id")
    public Department getDepartment() { ... }

    // ...
}

```

11.1.33. MapKeyClass Annotation

The `MapKeyClass` annotation is used to specify the type of the map key for associations of type `java.util.Map`. The map key can be a basic type, an embeddable class, or an entity. If the map is specified using Java generics, the `MapKeyClass` annotation and associated type need not be specified; otherwise they must be specified.

```

@Target({METHOD, FIELD})
@Retention(RUNTIME)
public @interface MapKeyClass {
    Class value();
}

```

The `MapKeyClass` annotation is used in conjunction with `ElementCollection` or one of the collection-valued relationship annotations (`OneToMany` or `ManyToMany`).

The `MapKey` annotation is not used when `MapKeyClass` is specified and vice versa.

Table 30 lists the annotation elements that may be specified for the `MapKeyClass` annotation.

Table 30. `MapKeyClass` Annotation Elements

| Type | Name | Description | Default |
|-------|-------|-------------------------------------|---------|
| Class | value | (Required) The type of the map key. | |

Example 1:

```
@Entity
public class Item {
    @Id
    int id;

    // ...

    @ElementCollection(targetClass=String.class)
    @MapKeyClass(String.class)
    Map images; // map from image name to image filename

    // ...
}
```

Example 2:

```
// MapKeyClass and target type of relationship can be defaulted
@Entity
public class Item {
    @Id
    int id;

    // ...

    @ElementCollection
    Map<String, String> images;

    // ...
}
```

Example 3:

```
@Entity
public class Company {
    @Id
    int id;

    // ...

    @OneToMany(targetEntity=com.example.VicePresident.class)
    @MapKeyClass(com.example.Division.class)
    Map organization;
}
```

Example 4:

```
// MapKeyClass and target type of relationship are defaulted
@Entity
public class Company {
```

```

@Id
int id;

// ...

@OneToMany
Map<Division, VicePresident> organization;
}

```

11.1.34. MapKeyColumn Annotation

The `MapKeyColumn` annotation is used to specify the mapping for the key column of a map whose map key is a basic type. If the `name` element is not specified, it defaults to the concatenation of the following: the name of the referencing relationship field or property; “_”; “KEY”.

```

@Target({METHOD, FIELD})
@Retention(RUNTIME)
public @interface MapKeyColumn {
    String name() default "";
    boolean unique() default false;
    boolean nullable() default false;
    boolean insertable() default true;
    boolean updatable() default true;
    String columnDefinition() default "";
    String options() default "";
    String table() default "";
    int length() default 255;
    int precision() default 0; // decimal precision
    int scale() default 0; // decimal scale
}

```

If no `MapKeyColumn` annotation is specified, the default values in [Table 31](#) apply.

Table 31. MapKeyColumn Annotation Elements

| Type | Name | Description | Default |
|---------|------------|---|---|
| String | name | (Optional) The name of the map key column. The table in which it is found depends upon the context. If the map key is for an element collection, the map key column is in the collection table for the map value. If the map key is for a ManyToMany entity relationship or for a OneToMany entity relationship using a join table, the map key column is in a join table. If the map key is for a OneToMany entity relationship using a foreign key mapping strategy, the map key column is in the table of the entity that is the value of the map. | The concatenation of the following: the name of the referencing property or field name; " _ "; " KEY ". |
| boolean | unique | (Optional) Whether the column is a unique key. This is a shortcut for the UniqueConstraint annotation at the table level and is useful for when the unique key constraint corresponds to only a single column. This constraint applies in addition to any constraint entailed by primary key mapping and to constraints specified at the table level. | false |
| boolean | nullable | (Optional) Whether the database column is nullable. | true |
| boolean | insertable | (Optional) Whether the column is included in SQL INSERT statements generated by the persistence provider. | true |

| Type | Name | Description | Default |
|---------|------------------|--|--|
| boolean | updatable | (Optional) Whether the column is included in SQL UPDATE statements generated by the persistence provider. | true |
| String | columnDefinition | (Optional) The SQL fragment that is used when generating the DDL for the column. | Generated SQL to create a column of the inferred type. |
| String | options | (Optional) A SQL fragment appended to the generated DDL. | Nothing appended. |
| String | table | (Optional) The name of the table that contains the column. | If the map key is for an element collection, the name of the collection table for the map value. If the map key is for a OneToMany or ManyToMany entity relationship using a join table, the name of the join table for the map. If the map key is for a OneToMany entity relationship using a foreign key mapping strategy, the name of the primary table of the entity that is the value of the map. |
| int | length | (Optional) The column length Applies only to columns whose type is parameterized by length, for example, varchar or varbinary types. | 255 |
| int | precision | (Optional) The precision of a column of SQL type decimal or numeric, or of similar database-native type. Applies only to columns of exact numeric type. The default value 0 indicates that a provider-determined precision should be inferred. | 0 |

| Type | Name | Description | Default |
|------|-------|--|---------|
| int | scale | <p>(Optional) The scale of a column of SQL type <code>decimal</code> or <code>numeric</code>, or of similar database-native type.</p> <p>Applies only to columns of exact numeric type.</p> <p>The default value <code>0</code> indicates that a provider-determined scale should be inferred.</p> | 0 |

Example:

```

@Entity
public class Item {
    @Id
    int id;

    // ...

    @ElementCollection
    @MapKeyColumn(name="IMAGE_NAME")
    @Column(name="IMAGE_FILENAME")
    @CollectionTable(name="IMAGE_MAPPING")
    Map<String, String> images; // map from image name to filename

    // ...
}

```

11.1.35. MapKeyEnumerated Annotation

The `MapKeyEnumerated` annotation is used to specify the enum type for a map key whose basic type is an enumerated type.

The `MapKeyEnumerated` annotation can be applied to an element collection or relationship of type `java.util.Map`, in conjunction with the `ElementCollection`, `OneToMany`, or `ManyToMany` annotation. If the map is specified using Java generics, the `MapKeyClass` annotation and associated type need not be specified; otherwise they must be specified.

If the enumerated type is not specified or the `MapKeyEnumerated` annotation is not used, the enumerated type is assumed to be `ORDINAL`.

```

@Target({METHOD, FIELD})
@Retention(RUNTIME)
public @interface MapKeyEnumerated {
    EnumType value() default ORDINAL;
}

```

Table 32 lists the annotation elements that may be specified for the `MapKeyEnumerated` annotation and their default values. The `EnumType` enum is defined in Section 11.1.18.

Table 32. *MapKeyEnumerated Annotation Elements*

| Type | Name | Description | Default |
|----------|-------|---|---------|
| EnumType | value | (Optional) The type used in mapping an enum type. | ORDINAL |

11.1.36. MapKeyJoinColumn Annotation

The `MapKeyJoinColumn` annotation is used to specify a mapping to an entity that is a map key. The map key join column is in the collection table, join table, or table of the target entity that is used to represent the map.

```

@Target({METHOD, FIELD})
@Retention(RUNTIME)
@Repeatable(MapKeyJoinColumns.class)
public @interface MapKeyJoinColumn {
    String name() default "";
    String referencedColumnName() default "";
    boolean unique() default false;
    boolean nullable() default false;
    boolean insertable() default true;
    boolean updatable() default true;
    String columnDefinition() default "";
    String options() default "";
    String table() default "";
    ForeignKey foreignKey() default @ForeignKey(PROVIDER_DEFAULT);
}

```

Table 33 lists the annotation elements that may be specified for the `MapKeyJoinColumn` annotation and their default values.

If no `MapKeyJoinColumn` annotation is specified, a single join column is assumed and the default values described below (and in **Table 33**) apply.

The `name` annotation element defines the name of the foreign key column. The remaining annotation elements (other than `referencedColumnName`) refer to this column.

If there is a single map key join column, and if the `name` annotation member is missing, the map key join column name is formed as the concatenation of the following: the name of the referencing relationship property or field of the referencing entity or embeddable; " _ "; " KEY ".

If the `referencedColumnName` element is missing, the foreign key is assumed to refer to the primary key of the referenced table. Support for referenced columns that are not primary key columns of the referenced table is optional. Applications that use such mappings will not be portable.

The `foreignKey` element is used to specify or control the generation of a foreign key constraint for the map key join column when table generation is in effect. If the `foreignKey` element is not specified, the persistence provider's default foreign key strategy will be used.

If more than one `MapKeyJoinColumn` annotation is applied to a field or property, both the `name` and the `referencedColumnName` elements must be specified in each such `MapKeyJoinColumn` annotation.

Table 33. MapKeyJoinColumn Annotation Elements

| Type | Name | Description | Default |
|---------|----------------------|--|---|
| String | name | (Optional) The name of the foreign key column for the map key. The table in which it is found depends upon the context. If the join is for a map key for an element collection, the foreign key column is in the collection table for the map value. If the join is for a map key for a ManyToMany entity relationship or for a OneToMany entity relationship using a join table, the foreign key column is in a join table. If the join is for a OneToMany entity relationship using a foreign key mapping strategy, the foreign key column for the map key is in the table of the entity that is the value of the map. | (Default only applies if a single join column is used.) The concatenation of the following: the name of the referencing relationship property or field of the referencing entity or embeddable class; “_”; "KEY". |
| String | referencedColumnName | (Optional) The name of the column referenced by this foreign key column. The referenced column is in the table of the target entity. | (Default only applies if single join column is being used.) The same name as the primary key column of the referenced table. |
| boolean | unique | (Optional) Whether the property is a unique key. This is a shortcut for the UniqueConstraint annotation at the table level and is useful for when the unique key constraint is only a single field. | false |
| boolean | nullable | (Optional) Whether the foreign key column is nullable. | true |
| boolean | insertable | (Optional) Whether the column is included in SQL INSERT statements generated by the persistence provider. | true |

| Type | Name | Description | Default |
|------------|------------------|---|--|
| boolean | updatable | (Optional) Whether the column is included in SQL UPDATE statements generated by the persistence provider. | true |
| String | columnDefinition | (Optional) The SQL fragment that is used when generating the DDL for the column. | Generated SQL for the column. |
| String | options | (Optional) A SQL fragment appended to the generated DDL. | Nothing appended. |
| String | table | (Optional) The name of the table that contains the foreign key column. If the join is for a map key for an element collection, the foreign key column is in the collection table for the map value. If the join is for a map key for a ManyToMany entity relationship or for a OneToMany entity relationship using a join table, the foreign key column is in a join table. If the join is for a OneToMany entity relationship using a foreign key mapping strategy, the foreign key column for the map key is in the table of the entity that is the value of the map. | If the map is for an element collection, the name of the collection table for the map value. If the map is for a OneToMany or ManyToMany entity relationship using a join table, the name of the join table for the map. If the map is for a OneToMany entity relationship using a foreign key mapping strategy, the name of the primary table of the entity that is the value of the map. |
| ForeignKey | foreignKey | (Optional) The foreign key constraint specification for the join column. This is used only if table generation is in effect. | Provider's default |

Example 1:

```

@Entity
public class Company {
    @Id
    int id;

    // ...

    @OneToMany // unidirectional

```

```

@JoinTable(
    name="COMPANY_ORGANIZATION",
    joinColumns=@JoinColumn(name="COMPANY"),
    inverseJoinColumns=@JoinColumn(name="VICEPRESIDENT")
)
@MapKeyJoinColumn(name="DIVISION")
Map<Division, VicePresident> organization;
}

```

Example 2:

```

@Entity
public class VideoStore {
    @Id
    int id;

    String name;

    Address location;

    // ...

    @ElementCollection
    @CollectionTable(name="INVENTORY", joinColumns=@JoinColumn(name="STORE"))
    @Column(name="COPIES_IN_STOCK")
    @MapKeyJoinColumn(name="MOVIE", referencedColumnName="ID")
    Map<Movie, Integer> videoInventory;

    // ...
}

@Entity
public class Movie {
    @Id
    long id;

    String title;

    // ...
}

```

Example 3:

```

@Entity
public class Student {
    @Id
    int studentId;

    // ...

    @ManyToMany // students and courses are also many-many
    @JoinTable(
        name="ENROLLMENTS",
        joinColumns=@JoinColumn(name="STUDENT"),
        inverseJoinColumns=@JoinColumn(name="SEMESTER")
    )
    @MapKeyJoinColumn(name="COURSE")
    Map<Course, Semester> enrollment;

    // ...
}

```

11.1.37. MapKeyJoinColumns Annotation

Composite map keys referencing entities are supported by means of the `MapKeyJoinColumns` annotation. The `MapKeyJoinColumns` annotation groups `MapKeyJoinColumn` annotations.

When the `MapKeyJoinColumns` annotation is used, both the name and the `referencedColumnName` elements must be specified in each of the grouped `MapKeyJoinColumn` annotations.

The `foreignKey` element is used to specify or control the generation of a foreign key constraint for the columns corresponding to the `MapKeyJoinColumn` elements referenced by the `value` element when table generation is in effect. If both this element and the `foreignKey` element of any of the `MapKeyJoinColumn` elements are specified, the behavior is undefined. If no `foreignKey` annotation element is specified in either location, the persistence provider's default foreign key strategy will apply.

```
@Target({METHOD, FIELD})
@Retention(RUNTIME)
public @interface MapKeyJoinColumns {
    MapKeyJoinColumn[] value();
    ForeignKey foreignKey() default @ForeignKey(PROVIDER_DEFAULT);
}
```

Table 34 lists the annotation elements that may be specified for the `MapKeyJoinColumns` annotation.

Table 34. *MapKeyJoinColumns Annotation Elements*

| Type | Name | Description | Default |
|---------------------------------|-------------------------|---|--------------------|
| <code>MapKeyJoinColumn[]</code> | <code>value</code> | (Required) The map key join columns that are used to map to the entity that is the map key. | |
| <code>ForeignKey</code> | <code>foreignKey</code> | (Optional) The foreign key constraint specification for the join columns. This is used only if table generation is in effect. | Provider's default |

11.1.38. MapKeyTemporal Annotation

The `MapKeyTemporal` annotation is used to specify the temporal type for a map key whose basic type is a temporal type.

The `MapKeyTemporal` annotation can be applied to an element collection or relationship of type `java.util.Map`, in conjunction with the `ElementCollection`, `OneToMany`, or `ManyToMany` annotation. If the map is specified using Java generics, the `MapKeyClass` annotation and associated type need not be specified; otherwise they must be specified.

```
@Target({METHOD, FIELD})
@Retention(RUNTIME)
public @interface MapKeyTemporal {
    TemporalType value();
}
```

The `MapKeyTemporal` enum is deprecated, and its use in newly-written code is strongly discouraged.

Table 35 lists the annotation elements that may be specified for the `MapKeyTemporal` annotation and their default values. The `TemporalType` enum is defined in Section 11.1.54.

Table 35. *MapKeyTemporal* Annotation Elements

| Type | Name | Description | Default |
|--------------|-------|---|---------|
| TemporalType | value | (Required) The type used in mapping java.util.Date or java.util.Calendar. | |

11.1.39. MappedSuperclass Annotation

The `MappedSuperclass` annotation designates a class whose mapping information is applied to the entities that inherit from it. A mapped superclass has no separate table defined for it.

A class designated with the `MappedSuperclass` annotation can be mapped in the same way as an entity except that the mappings will apply only to its subclasses since no table exists for the mapped superclass itself. When applied to the subclasses the inherited mappings will apply in the context of the subclass tables. Mapping information may be overridden in such subclasses by using the `AttributeOverride`, `AttributeOverrides`, `AssociationOverride`, and `AssociationOverrides` annotations.

```
@Documented
@Target(TYPE)
@Retention(RUNTIME)
public @interface MappedSuperclass {}
```

11.1.40. MapsId Annotation

The `MapsId` annotation is used to designate a `ManyToOne` or `OneToOne` relationship attribute that provides the mapping for an `EmbeddedId` primary key, an attribute within an `EmbeddedId` primary key, or a simple primary key of the parent entity.

The `value` element specifies the attribute within a composite key to which the relationship attribute corresponds. If the entity's primary key is of the same Java type as the primary key of the entity referenced by the relationship, the `value` attribute is not specified.

```
@Target({METHOD, FIELD})
@Retention(RUNTIME)
public @interface MapsId {
    String value() default "";
}
```

Table 36 lists the annotation elements that may be specified for the `MapsId` annotation.

Table 36. *MapsId* Annotation Elements

| Type | Name | Description | Default |
|--------|-------|--|---|
| String | value | (Optional) The name of the attribute within the composite key to which the relationship attribute corresponds. | The relationship maps the entity's primary key. |

Example:

```
// parent entity has simple primary key
@Entity
```

```

public class Employee {
    @Id
    long empId;

    String name;

    // ...
}

// dependent entity uses EmbeddedId for composite key
@Embeddable
public class DependentId {
    String name;
    long empId; // corresponds to PK type of Employee
}

@Entity
public class Dependent {
    @EmbeddedId
    DependentId id;

    // ...

    @MapsId("empId") // maps the empId attribute of embedded id
    @ManyToOne
    Employee emp;
}

```

11.1.41. OneToMany Annotation

A `OneToMany` annotation defines a many-valued association with one-to-many multiplicity.

[Table 37](#) lists the annotation elements that may be specified for the `OneToMany` annotation and their default values.

If the collection is defined using generics to specify the element type, the associated target entity class need not be specified; otherwise it must be specified.

The `OneToMany` annotation may be used within an embeddable class contained within an entity class to specify a relationship to a collection of entities^[16]. If the relationship is bidirectional, the `mappedBy` element must be used to specify the relationship field or property of the entity that is the owner of the relationship.

```

@Target({METHOD, FIELD})
@Retention(RUNTIME)
public @interface OneToMany {
    Class targetEntity() default void.class;
    CascadeType[] cascade() default {};
    FetchType fetch() default LAZY;
    String mappedBy() default "";
    boolean orphanRemoval() default false;
}

```

The operations that can be cascaded are defined by the `CascadeType` enum, defined in [Section 11.1.30](#).

When the collection is a `java.util.Map`, the `cascade` element and the `orphanRemoval` element apply to the map value.

If `orphanRemoval` is `true` and an entity that is the target of the relationship is removed from the relationship (either by removal from the collection or by setting the relationship to null), the remove operation will be applied to the entity being orphaned. If the entity being orphaned is a detached, new, or removed entity, the semantics of `orphanRemoval` do not apply.

If `orphanRemoval` is `true` and the remove operation is applied to the source entity, the remove operation will be cascaded

to the relationship target in accordance with the rules of [Section 3.3.3](#), (and hence it is not necessary to specify `cascade=REMOVE` for the relationship)^[17].

The remove operation is applied at the time of the flush operation. The `orphanRemoval` functionality is intended for entities that are privately "owned" by their parent entity. Portable applications must otherwise not depend upon a specific order of removal, and must not reassign an entity that has been orphaned to another relationship or otherwise attempt to persist it.

The default mapping for unidirectional one-to-many relationships uses a join table as is described in [Section 2.12.5](#). Unidirectional one-to-many relationships may be implemented using one-to-many foreign key mappings, using the `JoinColumn` and `JoinColumns` annotations.

Table 37. OneToMany Annotation Elements

| Type | Name | Description | Default |
|----------------------------|----------------------------|---|---|
| Class | <code>targetEntity</code> | (Optional) The entity class that is the target of the association. Optional only if the collection-valued relationship property is defined using Java generics. Must be specified otherwise. | The parameterized type of the collection when defined using generics. |
| <code>CascadeType[]</code> | <code>cascade</code> | (Optional) The operations that must be cascaded to the target of the association. | No operations are cascaded. |
| <code>FetchType</code> | <code>fetch</code> | (Optional) Whether the association should be lazily loaded or must be eagerly fetched. The <code>EAGER</code> strategy is a requirement on the persistence provider runtime that the associated entities must be eagerly fetched. The <code>LAZY</code> strategy is a hint to the persistence provider runtime. | <code>LAZY</code> |
| String | <code>mappedBy</code> | The field or property that owns the relationship. Required unless the relationship is unidirectional. | |
| boolean | <code>orphanRemoval</code> | (Optional) Whether to apply the remove operation to entities that have been removed from the relationship and to cascade the remove operation to those entities. | <code>false</code> |

Example 1: One-to-Many association using generics

In Customer class:

```
@OneToMany(cascade=ALL, mappedBy="customer", orphanRemoval=true)
public Set<Order> getOrders() { return orders; }
```

In Order class:

```
@ManyToOne
@JoinColumn(name="CUST_ID", nullable=false)
public Customer getCustomer() { return customer; }
```

Example 2: One-to-Many association without using generics

In Customer class:

```
@OneToMany(
    targetEntity=com.acme.Order.class,
    cascade=ALL,
    mappedBy="customer",
    orphanRemoval=true
)
public Set getOrders() { return orders; }
```

In Order class:

```
@ManyToOne
@JoinColumn(name="CUST_ID", nullable=false)
protected Customer customer;
```

Example 3: Unidirectional One-to-Many association using a foreign key mapping

In Customer class:

```
@OneToMany(orphanRemoval=true)
@JoinColumn(name="CUST_ID") // join column is in table for Order
public Set<Order> getOrders() { return orders; }
```

11.1.42. OneToOne Annotation

The `OneToOne` annotation defines a single-valued association to another entity that has one-to-one multiplicity. It is not normally necessary to specify the associated target entity explicitly since it can usually be inferred from the type of the object being referenced.

If the relationship is bidirectional, the `mappedBy` element must be used to specify the relationship field or property of the entity that is the owner of the relationship.

The `OneToOne` annotation may be used within an embeddable class to specify a relationship from the embeddable class to an entity class. If the relationship is bidirectional and the entity containing the embeddable class is on the owning side of the relationship, the non-owning side must use the `mappedBy` element of the `OneToOne` annotation to specify the relationship field or property of the embeddable class. The dot (“.”) notation syntax must be used in the `mappedBy` element to indicate the relationship attribute within the embedded attribute. The value of each identifier used with the dot notation is the name of the respective embedded field or property.

Table 38 lists the annotation elements that may be specified for the `OneToOne` annotation and their default values.


```

@Target({METHOD, FIELD})
@Retention(RUNTIME)
public @interface OneToOne {
    Class targetEntity() default void.class;
    CascadeType[] cascade() default {};
    FetchType fetch() default EAGER;
    boolean optional() default true;
    String mappedBy() default "";
    boolean orphanRemoval() default false;
}

```

The operations that can be cascaded are defined by the `CascadeType` enum, defined in [Section 11.1.30](#).

If `orphanRemoval` is `true` and an entity that is the target of the relationship is removed from the relationship (by setting the relationship to null), the remove operation will be applied to the entity being orphaned. If the entity being orphaned is a detached, new, or removed entity, the semantics of `orphanRemoval` do not apply.

If `orphanRemoval` is `true` and the remove operation is applied to the source entity, the remove operation will be cascaded to the relationship target in accordance with the rules of [Section 3.3.3](#), (and hence it is not necessary to specify `cascade=REMOVE` for the relationship)^[18].

The remove operation is applied at the time of the flush operation. The `orphanRemoval` functionality is intended for entities that are privately "owned" by their parent entity. Portable applications must otherwise not depend upon a specific order of removal, and must not reassign an entity that has been orphaned to another relationship or otherwise attempt to persist it.

Table 38. *OneToOne* Annotation Elements

| Type | Name | Description | Default |
|---------------|--------------|---|--|
| Class | targetEntity | (Optional) The entity class that is the target of the association. | The type of the field or property that stores the association. |
| CascadeType[] | cascade | (Optional) The operations that must be cascaded to the target of the association. | No operations are cascaded. |
| FetchType | fetch | (Optional) Whether the association should be lazily loaded or must be eagerly fetched. The EAGER strategy is a requirement on the persistence provider runtime that the associated entity must be eagerly fetched. The LAZY strategy is a hint to the persistence provider runtime. | EAGER |
| boolean | optional | (Optional) Whether the association is optional. If set to false then a non-null relationship must always exist. | true |

| Type | Name | Description | Default |
|---------|---------------|--|---------|
| String | mappedBy | (Optional) The field or property that owns the relationship. The mappedBy element is only specified on the inverse (non-owning) side of the association. | |
| boolean | orphanRemoval | (Optional) Whether to apply the remove operation to entities that have been removed from the relationship and to cascade the remove operation to those entities. | false |

Example 1: One-to-one association that maps a foreign key column.

On Customer class:

```
@OneToOne(optional=false)
@JoinColumn(name="CUSTREC_ID", unique=true, nullable=false, updatable=false)
public CustomerRecord getCustomerRecord() { return customerRecord; }
```

On CustomerRecord class:

```
@OneToOne(optional=false, mappedBy="customerRecord")
public Customer getCustomer() { return customer; }
```

Example 2: One-to-one association where both source and target share the same primary key values.

On Employee class:

```
@Entity
public class Employee {
    @Id
    Integer id;

    @OneToOne(orphanRemoval=true)
    @MapsId
    EmployeeInfo info;

    // ...
}
```

On EmployeeInfo class:

```
@Entity
public class EmployeeInfo {
    @Id
    Integer id;

    //...
}
```

Example 3: One-to-one association from an embeddable class to another entity.

```

@Entity
public class Employee {
    @Id
    int id;

    @Embedded
    LocationDetails location;

    // ...
}

@Embeddable
public class LocationDetails {
    int officeNumber;

    @OneToOne
    ParkingSpot parkingSpot;

    // ...
}

@Entity
public class ParkingSpot {
    @Id
    int id;

    String garage;

    @OneToOne(mappedBy="location.parkingSpot")
    Employee assignedTo;

    // ...
}

```

11.1.43. OrderBy Annotation

The `OrderBy` annotation specifies the ordering the elements of a collection-valued association or element collection are to have when the association or collection is retrieved.

```

@Target({METHOD, FIELD})
@Retention(RUNTIME)
public @interface OrderBy {
    String value() default "";
}

```

The syntax of the value ordering element is an `orderby_list`, as follows:

```

orderby_list ::= orderby_item [,orderby_item]*
orderby_item ::= [property_or_field_name] [ASC | DESC]

```

If `orderby_list` is not specified or if `ASC` or `DESC` is not specified, `ASC` (ascending order) is assumed.

If the ordering element is not specified for an entity association, ordering by the primary key of the associated entity is assumed.^[19]

A property or field name specified as an `orderby_item` must correspond to a basic persistent property or field of the associated class or embedded class within it. The properties or fields used in the ordering must correspond to columns for which comparison operators are supported.

The dot (".") notation is used to refer to an attribute within an embedded attribute. The value of each identifier used with the dot notation is the name of the respective embedded field or property.

The `OrderBy` annotation may be applied to an element collection. When `OrderBy` is applied to an element collection of basic type, the ordering will be by value of the basic objects and the `property_or_field_name` is not used.^[20] When specifying an ordering over an element collection of embeddable type, the dot notation must be used to specify the attribute or attributes that determine the ordering.

The `OrderBy` annotation is not used when an order column is specified. See [Section 11.1.44](#).

[Table 39](#) lists the annotation elements that may be specified for the `OrderBy` annotation.

Table 39. OrderBy Annotation Elements

| Type | Name | Description | Default |
|--------|-------|--|--|
| String | value | (Optional) The list of attributes (optionally qualified with ASC or DESC) whose values are used in the ordering. | Ascending ordering by the primary key. |

Example 1:

```
@Entity
public class Course {
    // ...

    @ManyToMany
    @OrderBy("lastname ASC")
    public List<Student> getStudents() { ... };

    // ...
}
```

Example 2:

```
@Entity
public class Student {
    // ...

    @ManyToMany(mappedBy="students")
    @OrderBy // PK is assumed
    public List<Course> getCourses() { ... };

    // ...
}
```

Example 3:

```
@Entity
public class Person {
    // ...

    @ElementCollection
    @OrderBy("zipcode.zip, zipcode.plusFour")
    public Set<Address> getResidences() { ... };

    // ...
}

@Embeddable
public class Address {
    protected String street;
```

```

protected String city;
protected String state;

@Embedded
protected Zipcode zipcode;
}

@Embeddable
public class Zipcode {
    protected String zip;
    protected String plusFour;
}

```

11.1.44. OrderColumn Annotation

The `OrderColumn` annotation specifies a column that is used to maintain the persistent order of a list. The persistence provider is responsible for maintaining the order upon retrieval and in the database. The persistence provider is responsible for updating the ordering upon flushing to the database to reflect any insertion, deletion, or reordering affecting the list. The `OrderColumn` annotation may be specified on a one-to-many or many-to-many relationship or on an element collection. The `OrderColumn` annotation is specified on the side of the relationship that references the collection that is to be ordered. The order column is not visible as part of the state of the entity or embeddable class.^[21]

The `OrderBy` annotation is not used when `OrderColumn` is specified.

Table 40 lists the annotation elements that may be specified for the `OrderColumn` annotation and their default values.

```

@Target({METHOD, FIELD})
@Retention(RUNTIME)
public @interface OrderColumn {
    String name() default "";
    boolean nullable() default true;
    boolean insertable() default true;
    boolean updatable() default true;
    String columnDefinition() default "";
    String options() default "";
}

```

If `name` is not specified, the column name is the concatenation of the following: the name of the referencing relationship property or field of the referencing entity or embeddable class; " _ "; " ORDER ".

The order column must be of integral type. The persistence provider must maintain a contiguous (non-sparse) ordering of the values of the order column when updating the association or element collection. The order column value for the first element of the list must be 0.

Table 40. OrderColumn Annotation Elements

| Type | Name | Description | Default |
|---------|----------|---|---|
| String | name | (Optional) The name of the ordering column. | The concatenation of the name of the referencing property or field; " _ "; " ORDER ". |
| boolean | nullable | (Optional) Whether the database column is nullable. | true |

| Type | Name | Description | Default |
|---------|------------------|---|--|
| boolean | insertable | (Optional) Whether the column is included in SQL INSERT statements generated by the persistence provider. | true |
| boolean | updatable | (Optional) Whether the column is included in SQL UPDATE statements generated by the persistence provider. | true |
| String | columnDefinition | (Optional) The SQL fragment that is used when generating the DDL for the column. | Generated SQL to create a column of the inferred type. |
| String | options | (Optional) A SQL fragment appended to the generated DDL. | Nothing appended. |

Example 1:

```

@Entity
public class CreditCard {
    @Id
    long ccNumber;

    @OneToMany // unidirectional
    @JoinColumn
    List<CardTransaction> transactionHistory;

    // ...
}

```

Example 2:

```

@Entity
public class Course {
    // ...

    @ManyToMany
    @JoinTable(name="COURSE_ENROLLMENT")
    public Set<Student> getStudents() { ... };

    // ...

    @ManyToMany // unidirectional
    @JoinTable(name="WAIT_LIST")
    @JoinColumn(name="WAITLIST_ORDER")
    public List<Student> getWaitList() { ... }
}

@Entity
public class Student {
    // ...

    @ManyToMany(mappedBy="students")

```

```

    public Set<Course> getCourses() { ... };

    // ...
}

```

Example of querying the ordered list:

```

SELECT w
FROM course c JOIN c.waitlist w
WHERE c.name = "geometry" AND INDEX(w) = 0

```

11.1.45. PrimaryKeyJoinColumn Annotation

The `PrimaryKeyJoinColumn` annotation specifies a primary key column that is used as a foreign key to join to another table.

The `PrimaryKeyJoinColumn` annotation is used to join the primary table of an entity subclass in the `JOINED` mapping strategy to the primary table of its superclass; it is used within a `SecondaryTable` annotation to join a secondary table to a primary table; and it may be used in a `OneToOne` mapping in which the primary key of the referencing entity is used as a foreign key^[22] to the referenced entity^[23].

The `foreignKey` element is used to specify or control the generation of a foreign key constraint for the primary key join column when table generation is in effect. If the `foreignKey` element is not specified, the persistence provider's default foreign key strategy will apply.

[Table 41](#) lists the annotation elements that may be specified for the `PrimaryKeyJoinColumn` annotation and their default values.

If no `PrimaryKeyJoinColumn` annotation is specified for a subclass in the `JOINED` mapping strategy, the foreign key columns are assumed to have the same names as the primary key columns of the primary table of the superclass.

```

@Target({TYPE, METHOD, FIELD})
@Retention(RUNTIME)
@Repeatable(PrimaryKeyJoinColumns.class)
public @interface PrimaryKeyJoinColumn {
    String name() default "";
    String referencedColumnName() default "";
    String columnDefinition() default "";
    String options() default "";
    ForeignKey foreignKey() default @ForeignKey(PROVIDER_DEFAULT);
}

```

Table 41. PrimaryKeyJoinColumn Annotation Elements

| Type | Name | Description | Default |
|------------|----------------------|---|--|
| String | name | (Optional) The name of the primary key column of the current table. | The same name as the primary key column of the primary table of the superclass (JOINED mapping strategy); the same name as the primary key column of the primary table (SecondaryTable mapping); or the same name as the primary key column for the table for the referencing entity (OneToOne mapping). |
| String | referencedColumnName | (Optional) The name of the primary key column of the table being joined to. | The same name as the primary key column of the primary table of the superclass (JOINED mapping strategy); the same name as the primary key column of the primary table (SecondaryTable mapping); or the same name as the primary key column of the table for the referenced entity (OneToOne mapping). |
| String | columnDefinition | (Optional) The SQL fragment that is used when generating the DDL for the column. This should not be specified for a OneToOne primary key association. | Generated SQL to create a column of the inferred type. |
| String | options | (Optional) A SQL fragment appended to the generated DDL. | Nothing appended. |
| ForeignKey | foreignKey | (Optional) The foreign key constraint specification for the join column. This is used only if table generation is in effect. | Provider's default |

Example: Customer and ValuedCustomer subclass

```

@Entity
@Table(name="CUST")
@Inheritance(strategy=JOINED)
@DiscriminatorValue("CUST")
public class Customer { ... }

@Entity

```



```

@Table(name="VCUST")
@DiscriminatorValue("VCUST")
@PrimaryKeyJoinColumn(name="CUST_ID")
public class ValuedCustomer extends Customer { ... }

```

11.1.46. PrimaryKeyJoinColumn Annotation

Composite foreign keys are supported by means of the `PrimaryKeyJoinColumn` annotation. The `PrimaryKeyJoinColumn` annotation groups `PrimaryKeyJoinColumn` annotations.

```

@Target({TYPE, METHOD, FIELD})
@Retention(RUNTIME)
public @interface PrimaryKeyJoinColumn {
    PrimaryKeyJoinColumn[] value();
    ForeignKey foreignKey() default @ForeignKey(PROVIDER_DEFAULT);
}

```

The `foreignKey` element is used to specify or control the generation of a foreign key constraint for the columns corresponding to the `PrimaryKeyJoinColumn` elements referenced by the `value` element when table generation is in effect. If both this element and the `foreignKey` element of any of the `PrimaryKeyJoinColumn` elements are specified, the behavior is undefined. If no `foreignKey` annotation element is specified in either location, the persistence provider's default foreign key strategy will apply.

Table 42 lists the annotation elements that may be specified for the `PrimaryKeyJoinColumn` annotation.

Table 42. *PrimaryKeyJoinColumn Annotation Elements*

| Type | Name | Description | Default |
|-------------------------------------|-------------------------|---|--------------------|
| <code>PrimaryKeyJoinColumn[]</code> | <code>value</code> | (Required) The primary key join columns. | |
| <code>ForeignKey</code> | <code>foreignKey</code> | (Optional) The foreign key constraint specification for the join columns. This is used only if table generation is in effect. | Provider's default |

Example 1: ValuedCustomer subclass

```

@Entity
@Table(name="VCUST")
@DiscriminatorValue("VCUST")
@PrimaryKeyJoinColumn({
    @PrimaryKeyJoinColumn(name="CUST_ID", referencedColumnName="ID"),
    @PrimaryKeyJoinColumn(name="CUST_TYPE", referencedColumnName="TYPE")
})
public class ValuedCustomer extends Customer { ... }

```

Example 2: OneToOne relationship between Employee and EmployeeInfo classes.^[24]

```

public class EmpPK {
    public Integer id;
    public String name;
}

@Entity
@IdClass(com.acme.EmpPK.class)

```

```

public class Employee {
    @Id
    Integer id;

    @Id
    String name;

    @OneToOne
    @PrimaryKeyJoinColumn({
        @PrimaryKeyJoinColumn(name="ID", referencedColumnName="EMP_ID"),
        @PrimaryKeyJoinColumn(name="NAME", referencedColumnName="EMP_NAME")
    })
    EmployeeInfo info;

    // ...
}

@Entity
@IdClass({com.acme.EmpPK.class})
public class EmployeeInfo {
    @Id
    @Column(name="EMP_ID")
    Integer id;

    @Id
    @Column(name="EMP_NAME")
    String name;

    // ...
}

```

11.1.47. SecondaryTable Annotation

The `SecondaryTable` annotation is used to specify a secondary table for the annotated entity class.

If no `SecondaryTable` annotation is specified, it is assumed that all persistent fields or properties of the entity are mapped to the primary table. Specifying one or more secondary tables indicates that the data for the entity class is stored across multiple tables.

[Table 43](#) lists the annotation elements that may be specified for the `SecondaryTable` annotation and their default values.

If no primary key join columns are specified, the join columns are assumed to reference the primary key columns of the primary table, and have the same names and types as the referenced primary key columns of the primary table.

The `foreignKey` element is used to specify or control the generation of a foreign key constraint for the columns corresponding to the `pkJoinColumns` element when table generation is in effect. If both this element and the `foreignKey` element of any of the `pkJoinColumns` elements are specified, the behavior is undefined. If no `foreignKey` annotation element is specified in either location, the persistence provider's default foreign key strategy will apply.

This annotation may not be applied to a class annotated `@MappedSuperclass` or `@Embeddable`.

```

@Target({TYPE})
@Retention(RUNTIME)
@Repeatable(SecondaryTables.class)
public @interface SecondaryTable {
    String name();
    String catalog() default "";
    String schema() default "";
    PrimaryKeyJoinColumn[] pkJoinColumns() default {};
    ForeignKey foreignKey() default @ForeignKey(PROVIDER_DEFAULT);
    UniqueConstraint[] uniqueConstraints() default {};
    Index[] indexes() default {};
}

```

```

    CheckConstraint[] check() default {};
    String comment() default "";
    String options() default "";
}

```

Table 43. SecondaryTable Annotation Elements

| Type | Name | Description | Default |
|------------------------|-------------------|---|---|
| String | name | (Required) The name of the table. | |
| String | catalog | (Optional) The catalog of the table. | Default catalog |
| String | schema | (Optional) The schema of the table. | Default schema for user |
| PrimaryKeyJoinColumn[] | pkJoinColumns | (Optional) The columns that are used to join with the primary table. | Column(s) of the same name(s) as the primary key column(s) in the primary table |
| ForeignKey | foreignKey | (Optional) The foreign key constraint for the join column. This is used only if table generation is in effect. | Provider's default |
| UniqueConstraint[] | uniqueConstraints | (Optional) Unique constraints that are to be placed on the table. These are typically only used if table generation is in effect. These constraints apply in addition to any constraints specified by the Column and JoinColumn annotations and constraints entailed by primary key mappings. | No additional constraints |
| Index[] | indexes | (Optional) Indexes for the table. These are only used if table generation is in effect. | No additional indexes |
| CheckConstraint[] | check | (Optional) Check constraints for the table. These are only used if table generation is in effect. | No check constraint |
| String | comment | (Optional) Comment for the table. This is only used if table generation is in effect. | No comment |

| Type | Name | Description | Default |
|--------|---------|--|-------------------|
| String | options | (Optional) A SQL fragment appended to the generated DDL. | Nothing appended. |

Example 1: Single secondary table with a single primary key column.

```
@Entity
@Table(name="CUSTOMER")
@SecondaryTable(
    name="CUST_DETAIL",
    pkJoinColumns=@PrimaryKeyJoinColumn(name="CUST_ID")
)
public class Customer { ... }
```

Example 2: Single secondary table with multiple primary key columns.

```
@Entity
@Table(name="CUSTOMER")
@SecondaryTable(
    name="CUST_DETAIL",
    pkJoinColumns={
        @PrimaryKeyJoinColumn(name="CUST_ID"),
        @PrimaryKeyJoinColumn(name="CUST_TYPE")
    })
public class Customer { ... }
```

11.1.48. SecondaryTables Annotation

The SecondaryTables annotation can be used to specify multiple secondary tables for an entity.

```
@Target({TYPE})
@Retention(RUNTIME)
public @interface SecondaryTables {
    SecondaryTable[] value();
}
```

Table 44 lists the annotation elements that may be specified for the SecondaryTables annotation.

Table 44. SecondaryTables Annotation Elements

| Type | Name | Description | Default |
|------------------|-------|--|---------|
| SecondaryTable[] | value | (Required) The secondary tables that are used to map the entity class. | |

Example 1: Multiple secondary tables assuming primary key columns are named the same in all tables.

```
@Entity
@Table(name="EMPLOYEE")
@SecondaryTables({
    @SecondaryTable(name="EMP_DETAIL"),
    @SecondaryTable(name="EMP_HIST")
})
public class Employee { ... }
```

Example 2: Multiple secondary tables with differently named primary key columns.

```

@Entity
@Table(name="EMPLOYEE")
@SecondaryTables({
    @SecondaryTable(
        name="EMP_DETAIL",
        pkJoinColumns=@PrimaryKeyJoinColumn(name="EMPL_ID")),
    @SecondaryTable(
        name="EMP_HIST",
        pkJoinColumns=@PrimaryKeyJoinColumn(name="EMPLOYEE_ID"))
})
public class Employee { ... }

```

11.1.49. SequenceGenerator Annotation

The `SequenceGenerator` annotation defines a primary key generator that may be referenced by name when a generator element is specified for the `GeneratedValue` annotation. A sequence generator may be specified on the entity class or on the primary key field or property. The scope of the generator name is global to the persistence unit (across all generator types).

If no name is explicitly specified by the `SequenceGenerator` annotation, and the annotation occurs on an entity class or primary key attribute of an entity class, then the name defaults to the name of the entity. Otherwise, if the annotation occurs elsewhere, the behavior is undefined.

If no name is explicitly specified by the `SequenceGenerator` annotation, and the annotation occurs on a package descriptor, then the annotation defines a recipe for producing a default generator when a `GeneratedValue` annotation of any program element in the annotated package has `strategy=SEQUENCE` and a defaulted generator name. The name of this default generator is the defaulted generator name, and its other properties are determined by the members of the package-level `SequenceGenerator` annotation.

Table 45 lists the annotation elements that may be specified for the `SequenceGenerator` annotation and their default values.

```

@Target({TYPE, METHOD, FIELD, PACKAGE})
@Retention(RUNTIME)
@Repeatable(SequenceGenerators.class)
public @interface SequenceGenerator {
    String name() default "";
    String sequenceName() default "";
    String catalog() default "";
    String schema() default "";
    int initialValue() default 1;
    int allocationSize() default 50;
    String options() default "";
}

```

Table 45. *SequenceGenerator* Annotation Elements

| Type | Name | Description | Default |
|--------|------|--|----------------|
| String | name | (Optional) A unique generator name that can be referenced by one or more classes to be the generator for primary key values. | See text above |

| Type | Name | Description | Default |
|--------|----------------|--|---------------------------------|
| String | sequenceName | (Optional) The name of the database sequence object from which to obtain primary key values. | A provider-chosen sequence name |
| String | catalog | (Optional) The catalog of the sequence generator. | Default catalog |
| String | schema | (Optional) The schema of the sequence generator. | Default schema for user |
| int | initialValue | (Optional) The value from which the sequence object is to start generating. | 1 |
| int | allocationSize | (Optional) The amount to increment by when allocating sequence numbers from the sequence. | 50 |
| String | options | (Optional) A SQL fragment appended to the generated DDL. | Nothing appended. |

Example:

```
@SequenceGenerator(name="EMP_SEQ", allocationSize=25)
```

11.1.50. SequenceGenerators Annotation

The SequenceGenerators annotation can be used to specify multiple sequence generators.

```
@Target({TYPE, METHOD, FIELD, PACKAGE})
@Retention(RUNTIME)
public @interface SequenceGenerators {
    SequenceGenerator[] value();
}
```

Table 46. SequenceGenerators Annotation Elements

| Type | Name | Description | Default |
|---------------------|-------|--|---------|
| SequenceGenerator[] | value | (Required) The sequence generator mappings | |

11.1.51. Table Annotation

The Table annotation specifies the primary table for the annotated entity. Additional tables may be specified by using the SecondaryTable or SecondaryTables annotation.^[25]

Table 47 lists the annotation elements that may be specified for the Table annotation and their default values.

If no Table annotation is specified for an entity class, the default values defined in [Table 47](#) apply.

This annotation may not be applied to a class annotated `@MappedSuperclass` or `@Embeddable`.

```

@Target({TYPE})
@Retention(RUNTIME)
public @interface Table {
    String name() default "";
    String catalog() default "";
    String schema() default "";
    UniqueConstraint[] uniqueConstraints() default {};
    Index[] indexes() default {};
    CheckConstraint[] check() default {};
    String comment() default "";
    String options() default "";
}

```

Table 47. Table Annotation Elements

| Type | Name | Description | Default |
|--------------------|-------------------|---|---------------------------|
| String | name | (Optional) The name of the table. | Entity name |
| String | catalog | (Optional) The catalog of the table. | Default catalog |
| String | schema | (Optional) The schema of the table. | Default schema for user |
| UniqueConstraint[] | uniqueConstraints | (Optional) Unique constraints that are to be placed on the table. These are only used if table generation is in effect. These constraints apply in addition to any constraints specified by the Column and JoinColumn annotations and constraints entailed by primary key mappings. | No additional constraints |
| Index[] | indexes | (Optional) Indexes for the table. These are only used if table generation is in effect. | No additional indexes |
| CheckConstraint[] | check | (Optional) Check constraints for the table. These are only used if table generation is in effect. | No check constraint |
| String | comment | (Optional) Comment for the table. This is only used if table generation is in effect. | No comment |

| Type | Name | Description | Default |
|--------|---------|--|-------------------|
| String | options | (Optional) A SQL fragment appended to the generated DDL. | Nothing appended. |

Example:

```
@Entity
@Table(name="CUST", schema="RECORDS")
public class Customer { ... }
```

11.1.52. TableGenerator Annotation

The TableGenerator annotation defines a primary key generator that may be referenced by name when a generator element is specified for the GeneratedValue annotation. A table generator may be specified on the entity class or on the primary key field or property. The scope of the generator name is global to the persistence unit (across all generator types).

If no name is explicitly specified by the TableGenerator annotation, and the annotation occurs on an entity class or primary key attribute of an entity class, then the name defaults to the name of the entity. Otherwise, if the annotation occurs elsewhere, the behavior is undefined.

If no name is explicitly specified by the TableGenerator annotation, and the annotation occurs on a package descriptor, then the annotation defines a recipe for producing a default generator when a GeneratedValue annotation of any program element in the annotated package has strategy=TABLE and a defaulted generator name. The name of this default generator is the defaulted generator name, and its other properties are determined by the members of the package-level TableGenerator annotation.

Table 48 lists the annotation elements that may be specified for the TableGenerator annotation and their default values.

The table element specifies the name of the table that is used by the persistence provider to store generated primary key values for entities. An entity type will typically use its own row in the table for the generation of primary key values. The primary key values are normally positive integers.

```
@Target({TYPE, METHOD, FIELD, PACKAGE})
@Retention(RUNTIME)
@Repeatable(TableGenerators.class)
public @interface TableGenerator {
    String name() default "";
    String table() default "";
    String catalog() default "";
    String schema() default "";
    String pkColumnName() default "";
    String valueColumnName() default "";
    String pkColumnValue() default "";
    int initialValue() default 0;
    int allocationSize() default 50;
    UniqueConstraint[] uniqueConstraints() default {};
    Index[] indexes() default {};
    String options() default "";
}
```

Table 48. TableGenerator Annotation Elements

| Type | Name | Description | Default |
|--------------------|-------------------|---|---|
| String | name | (Optional) A unique generator name that can be referenced by one or more classes to be the generator for primary key values. | See text above |
| String | table | (Optional) Name of table that stores the generated primary key values. | A provider-chosen table name |
| String | catalog | (Optional) The catalog of the table. | Default catalog |
| String | schema | (Optional) The schema of the table. | Default schema for user |
| String | pkColumnName | (Optional) Name of the primary key column in the table. | A provider-chosen name |
| String | valueColumnName | (Optional) Name of the column that stores the last value generated. | A provider-chosen name |
| String | pkColumnValue | (Optional) The primary key value in the generator table that distinguishes this set of generated values from others that may be stored in the table. | A provider-chosen value to store in the primary key column of the generator table |
| int | initialValue | (Optional) The value used to initialize the column that stores the last value generated. | 0 |
| int | allocationSize | (Optional) The amount to increment by when allocating numbers from the generator. | 50 |
| UniqueConstraint[] | uniqueConstraints | (Optional) Unique constraints that are to be placed on the table. These are only used if table generation is in effect. These constraints apply in addition to primary key constraints. | No additional constraints |

| Type | Name | Description | Default |
|---------|---------|---|-----------------------|
| Index[] | indexes | (Optional) Indexes for the table. These are only used if table generation is in effect. | No additional indexes |
| String | options | (Optional) A SQL fragment appended to the generated DDL. | Nothing appended. |

Example 1:

```

@Entity
public class Employee {
    // ...

    @TableGenerator(
        name="empGen",
        table="ID_GEN",
        pkColumnName="GEN_KEY",
        valueColumnName="GEN_VALUE",
        pkColumnValue="EMP_ID",
        allocationSize=1)
    @Id
    @GeneratedValue(strategy=TABLE, generator="empGen")
    int id;

    // ...
}

```

Example 2:

```

@Entity
public class Address {
    // ...

    @TableGenerator(
        name="addressGen",
        table="ID_GEN",
        pkColumnName="GEN_KEY",
        valueColumnName="GEN_VALUE",
        pkColumnValue="ADDR_ID")
    @Id
    @GeneratedValue(strategy=TABLE, generator="addressGen")
    int id;

    // ...
}

```

11.1.53. TableGenerators Annotation

The TableGenerators annotation can be used to specify multiple table generators.

```

@Target({TYPE, METHOD, FIELD, PACKAGE})
@Retention(RUNTIME)
public @interface TableGenerators {
    TableGenerator[] value();
}

```

Table 49. TableGenerators Annotation Elements

| Type | Name | Description | Default |
|------------------|-------|---|---------|
| TableGenerator[] | value | (Required) The table generator mappings | |

11.1.54. Temporal Annotation

The `Temporal` annotation must be specified for persistent fields or properties of type `java.util.Date` and `java.util.Calendar` unless a converter is being applied. It may only be specified for fields or properties of these types.

The `Temporal` annotation may be used in conjunction with the `Basic` annotation, the `Id` annotation, or the `ElementCollection`^[26] annotation (when the element collection value is of such a temporal type).

The `TemporalType` enum defines the mapping for these temporal types.

```
public enum TemporalType {
    DATE, //java.sql.Date
    TIME, //java.sql.Time
    TIMESTAMP //java.sql.Timestamp
}

@Target({METHOD, FIELD})
@Retention(RUNTIME)
public @interface Temporal {
    TemporalType value();
}
```

The `Temporal` annotation and `TemporalType` enum are deprecated, and their use in newly-written code is strongly discouraged.

Table 50 lists the annotation elements that may be specified for the `Temporal` annotation and their default values.

Table 50. Temporal Annotation Elements

| Type | Name | Description | Default |
|--------------|-------|--|---------|
| TemporalType | value | (Required) The type used in mapping <code>java.util.Date</code> or <code>java.util.Calendar</code> . | |

Example:

```
@Embeddable
public class EmploymentPeriod {
    @Temporal(DATE)
    java.util.Date startDate;

    @Temporal(DATE)
    java.util.Date endDate;

    // ...
}
```

11.1.55. Transient Annotation

The `Transient` annotation is used to annotate a property or field of an entity class, mapped superclass, or embeddable class. It specifies that the property or field is not persistent.

```

@Target({METHOD, FIELD})
@Retention(RUNTIME)
public @interface Transient {}

```

Example:

```

@Entity
public class Employee {
    @Id
    int id;

    @Transient
    User currentUser;

    // ...
}

```

11.1.56. UniqueConstraint Annotation

The UniqueConstraint annotation is used to specify that a unique constraint is to be included in the generated DDL for a primary or secondary table.

Table 51 lists the annotation elements that may be specified for the UniqueConstraint annotation.

```

@Target({})
@Retention(RUNTIME)
public @interface UniqueConstraint {
    String name() default "";
    String[] columnNames();
    String options() default "";
}

```

Table 51. UniqueConstraint Annotation Elements

| Type | Name | Description | Default |
|----------|-------------|--|-------------------------|
| String | name | (Optional) Constraint name. | A provider-chosen name. |
| String[] | columnNames | (Required) An array of the column names that make up the constraint. | |
| String | options | (Optional) A SQL fragment appended to the generated DDL. | Nothing appended. |

Example:

```

@Entity
@Table(
    name="EMPLOYEE",
    uniqueConstraints=@UniqueConstraint(columnNames={"EMP_ID", "EMP_NAME"})
)
public class Employee { ... }

```

11.1.57. Version Annotation

The `Version` annotation declares the version field or property of an entity class, as defined in [Section 2.5](#). The version is used to ensure integrity when performing the merge operation, and for optimistic concurrency control, as specified in [Section 3.5.2](#).

The `Version` field or property should be mapped to the primary table of the entity; an application which maps the `Version` property to a table other than the primary table is not portable.

```
@Target({METHOD, FIELD})
@Retention(RUNTIME)
public @interface Version {}
```

Example:

```
@Version
@Column(name="OPTLOCK")
protected int getVersionNum() { return versionNum; }
```

11.2. Object/Relational Metadata Used in Schema Generation

The following annotations and XML elements define or control the generation of database objects. If schema generation is in effect, the persistence provider must observe the mapping information specified by these annotations and their corresponding XML elements. Unless otherwise specified, all elements of these annotations are observed in the schema generation process.

- `CollectionTable`
- `Column`
- `DiscriminatorColumn`
- `EmbeddedId`
- `Enumerated`, `MapKeyEnumerated`
- `ForeignKey`
- `GeneratedValue`
- `Id`
- `Index`
- `Inheritance`
- `JoinColumn`
- `JoinTable`
- `Lob`
- `MapKeyColumn`
- `MapKeyJoinColumn`
- `OrderColumn`
- `PrimaryKeyJoinColumn`
- `SecondaryTable`
- `SequenceGenerator`
- `Table`
- `TableGenerator`
- `Temporal`, `MapKeyTemporal`
- `UniqueConstraint`

- Version

In some cases, these annotations and elements may be specified explicitly, while in other cases they may be implied by the default values of other annotations or elements. For example, by default a table is generated corresponding to an entity and bears the same name as that assigned to the entity (which in turn may have been defaulted from the name of the entity class).

The naming of database objects is determined by the defaulting rules and the explicit names used in annotations and/or XML. The names of database objects must be treated in conformance with the requirements of [Section 2.15](#).

The metadata annotations and corresponding XML elements that result in generated objects are as follows.

11.2.1. Table-level elements

The following annotations (and corresponding XML elements) specify the creation of tables. The rules for their naming, columns, and other properties are defined in the referenced sections of this specification:

11.2.1.1. Table

By default, a table is created for every top-level entity and, by default, includes columns corresponding to the basic and embedded attributes of the entity and the foreign keys to the tables of related entities. These columns include columns that result from the use of mapped superclasses, if any. The `SecondaryTable` annotation, in conjunction with the use of the `table` element of the `Column` and `JoinColumn` annotations, is used to override this mapping to partition the state of an entity across multiple tables.

The mapping of the columns of a table is controlled by the `Column` and `JoinColumn` annotations. When entity state is inherited from a mapped superclass, the `AttributeOverride` and `AssociationOverride` annotations may be used to further control the column-level mapping of inherited state. The ordering of the columns is not defined by this specification. When it is desirable to control the ordering of columns, DDL scripts should be provided.

See [Section 11.1.50](#) for additional rules that apply to the generation of tables. For the treatment of column-level mappings, see further below.

11.2.1.2. Inheritance

The `Inheritance` annotation defines the inheritance strategy for an entity hierarchy. The inheritance strategy determines whether the table for a top-level entity includes columns for entities that inherit from the entity and whether it includes a discriminator column, or whether separate tables are created for each entity type that inherits from the top-level entity. See [Section 2.14](#) and [Section 11.1.25](#) for rules pertaining to the treatment of entity inheritance.

11.2.1.3. SecondaryTable

A secondary table is created to partition the mapping of entity state across multiple tables. See [Section 11.1.47](#) for the rules that apply to the generation of secondary tables.

11.2.1.4. CollectionTable

A collection table is created for the mapping of an element collection. See [Section 11.1.8](#) for the rules that apply to the generation of collection tables. The `Column`, `AttributeOverride`, and `AssociationOverride` annotations may be used to override `CollectionTable` mappings, as described in [Section 11.1.9](#), [Section 11.1.4](#), and [Section 11.1.2](#) respectively.

11.2.1.5. JoinTable

By default, join tables are created for the mapping of many-to-many relationships and unidirectional one-to-many relationships. See [Section 2.12.4](#), [Section 2.12.5.1](#), and [Section 2.12.5.2](#) for the defaults that apply in such cases. Join tables may also be used to map bidirectional many-to-one/one-to-many associations, unidirectional many-to-one relationships, and one-to-one relationships (both bidirectional and unidirectional). See [Section 11.1.28](#) for the rules that apply to the generation of join tables. The `AssociationOverride` annotation may be used to override join table mappings.

11.2.1.6. TableGenerator

Table generator tables are used to store generated primary key values. See [Section 11.1.52](#) for the rules pertaining to table generators.

11.2.2. Column-level elements

The following annotations and corresponding XML elements control the mapping of columns in generated tables.

The exact mapping of Java language types to database-specific types is not defined by this specification, as databases vary in the specific types that they support. In general, however, an implementation of this specification should conform to the “Standard Mapping from Java Types to JDBC Types” as defined by the JDBC specification [3]. Unless otherwise explicitly specified, however, VARCHAR and VARBINARY mappings should be used in preference to CHAR and BINARY mappings. Applications that are sensitive to the exact database mappings that are generated should use the `columnDefinition` element of the `Column` annotation or include DDL files that specify how the database schema is to be generated.

11.2.2.1. Column

The following elements of the `Column` annotation are used in schema generation:

- name
- unique
- nullable
- columnDefinition
- table
- length (string-valued columns only)
- precision (exact numeric (decimal/numeric) columns only)
- scale (exact numeric (decimal/numeric) columns only)

See [Section 11.1.9](#) for the rules that apply to these elements and column creation. The `AttributeOverride` annotation may be used to override column mappings.

11.2.2.2. MapKeyColumn

The `MapKeyColumn` annotation specifies the mapping for a key column of a map when the key is of basic type. The following elements of the `MapKeyColumn` annotation are used in schema generation:

- name
- unique
- nullable
- columnDefinition

- table
- length (string-valued columns only)
- precision (exact numeric (decimal/numeric) columns only)
- scale (exact numeric (decimal/numeric) columns only)

See [Section 11.1.34](#) for the rules that apply to these elements and map key column creation. The `AttributeOverride` annotation may be used to override map key column mappings.

11.2.2.3. Enumerated, MapKeyEnumerated

The `Enumerated` and `MapKeyEnumerated` annotations control whether string- or integer-valued columns are generated for basic attributes of enumerated types and therefore impact the default column mappings for these types. See [Section 11.1.18](#) and [Section 11.1.35](#). The `Column` and `MapKeyColumn` annotations may be used to further control the column mappings for attributes of enumerated types.

11.2.2.4. Temporal, MapKeyTemporal

The `Temporal` and `MapKeyTemporal` annotations control whether date-, time-, or timestamp-value columns are generated for basic attributes of temporal types, and therefore impact the default column mappings for these types. See [Section 11.1.54](#) and [Section 11.1.38](#). The `Column` and `MapKeyColumn` annotations may be used to further control the column mappings for attributes of temporal types.

11.2.2.5. Lob

The `Lob` annotation specifies that a persistent attribute is to be persisted to a database large object type. See [Section 11.1.29](#). In general, however, the treatment of the `Lob` annotation is provider-dependent. Applications that are sensitive to the exact mapping that is used should use the `columnDefinition` element of the `Column` annotation or include DDL files that specify how the database schema is to be generated.

11.2.2.6. OrderColumn

The `OrderColumn` annotation specifies the generation of a column that is used to maintain the persistent ordering of a list that is represented in an element collection, one-to-many, or many-to-many relationship.

The following elements of the `OrderColumn` annotation are used in schema generation:

- name
- nullable
- columnDefinition

See [Section 11.1.44](#) for the rules that pertain to the generation of order columns.

11.2.2.7. DiscriminatorColumn

A discriminator column is generated for the `SINGLE_TABLE` mapping strategy and may optionally be generated by the provider for use with the `JOINED` inheritance strategy. The `DiscriminatorColumn` annotation may be used to control the mapping of the discriminator column. See [Section 11.1.12](#) for the rules that pertain to discriminator columns.

11.2.2.8. Version

The `Version` annotation specifies the generation of a column to serve as an entity's optimistic lock. See [Section 11.1.57](#)

for rules that pertain to the version column. The `Column` annotation may be used to further control the column mapping for a version attribute.

11.2.3. Primary Key mappings

Primary keys may be represented by basic or embedded attributes and/or may correspond to foreign key attributes. The `Id` and `EmbeddedId` annotations define attributes whose corresponding columns are the constituents of database primary keys.

11.2.3.1. Id

The `Id` annotation (which may be used in conjunction with the `IdClass` annotation) is used to specify attributes whose database columns correspond to a primary key. Use of the `Id` annotation results in the creation of a primary key consisting of the corresponding column or columns. Rules for the `Id` annotation are described in [Section 11.1.22](#) and [Section 2.4](#).

The `Column` annotation may be used to further control the column mapping for an `Id` attribute that is applied to a basic type. If the `Id` column was defined in a mapped superclass, the `AttributeOverride` annotation may be used to control the column mapping.

The `JoinColumn` annotation may be used to further control the column mappings for an `Id` attribute that is applied to a relationship that corresponds to a foreign key. If the `Id` attribute was defined in a mapped superclass, the `AssociationOverride` annotation may be used to control the column mapping.

11.2.3.2. EmbeddedId

The `EmbeddedId` annotation specifies an embedded attribute whose corresponding columns correspond to a database primary key. Use of the `EmbeddedId` annotation results in the creation of a primary key consisting of the corresponding columns. Rules for the `EmbeddedId` annotation are described in [Section 11.1.17](#) and [Section 2.4](#).

The `Column` annotation may be used to control the column mapping for an embeddable class. If the `EmbeddedId` attribute is defined in a mapped superclass, the `AttributeOverride` annotation may be used to control the column mappings.

If an `EmbeddedId` attribute corresponds to a relationship attribute, the `MapsId` annotation must be used, and the column mapping is determined by the join column for the relationship. See [Section 2.4.2](#).

11.2.3.3. GeneratedValue

The `GeneratedValue` annotation indicates a primary key whose value is to be generated by the provider. If a strategy is indicated, the provider must use it if it is supported by the target database. Note that specification of the `AUTO` strategy may result in the provider creating a database object for `Id` generation (e.g., a database sequence). Rules for the `GeneratedValue` annotation are described in [Section 11.1.21](#). The `GeneratedValue` annotation may only be portably used for simple (i.e., non-composite) primary keys.

11.2.4. Foreign Key Column Mappings

11.2.4.1. JoinColumn

The `JoinColumn` annotation is typically used in specifying a foreign key mapping. In general, the foreign key definitions created will be provider-dependent and database-dependent. Applications that are sensitive to the exact mapping that is used should use the `foreignKey` element of the `JoinColumn` annotation or include DDL files that specify how the database schemas are to be generated.

The following elements of the `JoinColumn` annotation are used in schema generation:

- `name`
- `referencedColumnName`
- `unique`
- `nullable`
- `columnDefinition`
- `table`
- `foreignKey`

See [Section 11.1.26](#) for rules that apply to these elements and join column creation, and sections [Section 2.12](#) and [Section 11.1.8](#) for the rules that apply for the default mappings of foreign keys for relationships and element collections. The `AssociationOverride` annotation may be used to override relationship mappings. The `PrimaryKeyJoinColumn` annotation is used to join secondary tables and may be used in the mapping of one-to-one relationships. See [Section 11.2.4.3](#) below.

11.2.4.2. `MapKeyJoinColumn`

The `MapKeyJoinColumn` annotation is to specify foreign key mappings to entities that are map keys in map-valued element collections or relationships. In general, the foreign key definitions created should be expected to be provider-dependent and database-dependent. Applications that are sensitive to the exact mapping that is used should use the `foreignKey` element of the `MapKeyJoinColumn` annotation or include DDL files that specify how the database schemas are to be generated.

The following elements of the `MapKeyJoinColumn` annotation are used in schema generation:

- `name`
- `referencedColumnName`
- `unique`
- `nullable`
- `columnDefinition`
- `table`
- `foreignKey`

See [Section 11.1.36](#) for rules that apply to these elements and map key join column creation. The `AssociationOverride` annotation may be used to override such mappings.

11.2.4.3. `PrimaryKeyJoinColumn`

The `PrimaryKeyJoinColumn` annotation specifies that a primary key column is to be used as a foreign key. This annotation is used in the specification of the `JOINED` mapping strategy and for joining a secondary table to a primary table in a `OneToOne` relationship mapping. In general, the foreign key definitions created should be expected to be provider-dependent and database-dependent. Applications that are sensitive to the exact mapping that is used should use the `foreignKey` element of the `PrimaryKeyJoinColumn` annotation or include DDL files that specify how the database schemas are to be generated. See [Section 11.1.45](#) for rules pertaining to the `PrimaryKeyJoinColumn` annotation.

11.2.4.4. `ForeignKey`

The `ForeignKey` annotation may be used within the `JoinColumn`, `JoinColumns`, `MapKeyJoinColumn`, `MapKeyJoinColumns`, `PrimaryKeyJoinColumn`, `PrimaryKeyJoinColumns`, `CollectionTable`, `JoinTable`, `SecondaryTable`, and `AssociationOverride` annotations

to specify or override a foreign key constraint. See [Section 11.1.20](#).

11.2.5. Other Elements

11.2.5.1. SequenceGenerator

The `SequenceGenerator` annotation creates a database sequence to be used for Id generation. The use of generators is limited to those databases that support them. See [Section 11.1.49](#).

11.2.5.2. Index

The `Index` annotation generates an index consisting of the specified columns. The ordering of the names in the `columnList` element specified in the `Index` annotation must be observed by the provider when creating the index. See [Section 11.1.24](#).

11.2.5.3. UniqueConstraint

The `UniqueConstraint` annotation generates a unique constraint for the given table. Databases typically implement unique constraints by creating unique indexes. The ordering of the `columnNames` specified in the `UniqueConstraint` annotation must be observed by the provider when creating the constraint. See [Section 11.1.56](#). The unique element of the `Column`, `JoinColumn`, `MapKeyColumn`, and `MapKeyJoinColumn` annotations is equivalent to the use of the `UniqueConstraint` annotation when only one column is to be included in the constraint.

11.3. Examples of the Application of Annotations for Object/Relational Mapping

This example shows some simple mappings:

```
@Entity
public class Customer {
    @Id
    @GeneratedValue(strategy = AUTO)
    Long id;

    @Version
    protected int version;

    @ManyToOne
    Address address;

    @Basic
    String description;

    @OneToMany(targetEntity = com.acme.Order.class,
        mappedBy = "customer")
    Collection orders = new Vector();

    @ManyToMany(mappedBy = "customers")
    Set<DeliveryService> serviceOptions = new HashSet();

    public Long getId() {
        return id;
    }

    public Address getAddress() {
        return address;
    }

    public void setAddress(Address addr) {
```

```

        this.address = addr;
    }

    public String getDescription() {
        return description;
    }

    public void setDescription(String desc) {
        this.description = desc;
    }

    public Collection getOrders() {
        return orders;
    }

    public Set<DeliveryService> getServiceOptions() {
        return serviceOptions;
    }
}

```

@Entity

```

public class Address {
    private Long id;
    private int version;
    private String street;

    @Id
    @GeneratedValue(strategy = AUTO)
    public Long getId() {
        return id;
    }

    protected void setId(Long id) {
        this.id = id;
    }

    @Version
    public int getVersion() {
        return version;
    }

    protected void setVersion(int version) {
        this.version = version;
    }

    public String getStreet() {
        return street;
    }

    public void setStreet(String street) {
        this.street = street;
    }
}

```

@Entity

```

public class Order {
    private Long id;
    private int version;
    private String itemName;
    private int quantity;
    private Customer cust;

    @Id
    @GeneratedValue(strategy = AUTO)
    public Long getId() {
        return id;
    }
}

```

```

public void setId(Long id) {
    this.id = id;
}

@Version
protected int getVersion() {
    return version;
}

protected void setVersion(int version) {
    this.version = version;
}

public String getItemName() {
    return itemName;
}

public void setItemName(String itemName) {
    this.itemName = itemName;
}

public int getQuantity() {
    return quantity;
}

public void setQuantity(int quantity) {
    this.quantity = quantity;
}

@ManyToOne
public Customer getCustomer() {
    return cust;
}

public void setCustomer(Customer cust) {
    this.cust = cust;
}
}

@Entity
@Table(name = "DLVY_SVC")
public class DeliveryService {
    private String serviceName;
    private int priceCategory;
    private Collection customers;

    @Id
    public String getServiceName() {
        return serviceName;
    }

    public void setServiceName(String serviceName) {
        this.serviceName = serviceName;
    }

    public int getPriceCategory() {
        return priceCategory;
    }

    public void setPriceCategory(int priceCategory) {
        this.priceCategory = priceCategory;
    }

    @ManyToMany(targetEntity = com.acme.Customer.class)
    @JoinTable(name = "CUST_DLVR")
    public Collection getCustomers() {

```

```

        return customers;
    }

    public setCustomers(Collection customers) {
        this.customers = customers;
    }
}

```

Next, we have a more complex example:

```

/***** Employee class *****/
@Entity
@Table(name = "EMPL")
@SecondaryTable(name = "EMP_SALARY",
    pkJoinColumns = @PrimaryKeyJoinColumn(name = "EMP_ID", referencedColumnName = "ID"))
public class Employee implements Serializable {
    private Long id;
    private int version;
    private String name;
    private Address address;
    private Collection phoneNumbers;
    private Collection<Project> projects;
    private Long salary;
    private EmploymentPeriod period;

    @Id
    @GeneratedValue(strategy = TABLE)
    public Integer getId() {
        return id;
    }

    protected void setId(Integer id) {
        this.id = id;
    }

    @Version
    @Column(name = "EMP_VERSION", nullable = false)
    public int getVersion() {
        return version;
    }

    protected void setVersion(int version) {
        this.version = version;
    }

    @Column(name = "EMP_NAME", length = 80)
    public String getName() {
        return name;
    }

    public void setName(String name) {
        this.name = name;
    }

    @ManyToOne(cascade = PERSIST, optional = false)
    @JoinColumn(name = "ADDR_ID", referencedColumnName = "ID", nullable = false)
    public Address getAddress() {
        return address;
    }

    public void setAddress(Address address) {
        this.address = address;
    }

    @OneToMany(targetEntity = com.acme.PhoneNumber.class,
        cascade = ALL,

```

```

        mappedBy = "employee")
public Collection getPhoneNumbers() {
    return phoneNumbers;
}

public void setPhoneNumbers(Collection phoneNumbers) {
    this.phoneNumbers = phoneNumbers;
}

@ManyToMany(cascade = PERSIST, mappedBy = "employees")
@JoinTable(
    name = "EMP_PROJ",
    joinColumns = @JoinColumn(name = "EMP_ID", referencedColumnName = "ID"),
    inverseJoinColumns = @JoinColumn(name = "PROJ_ID", referencedColumnName = "ID"))
public Collection<Project> getProjects() {
    return projects;
}

public void setProjects(Collection<Project> projects) {
    this.projects = projects;
}

@Column(name = "EMP_SAL", table = "EMP_SALARY")
public Long getSalary() {
    return salary;
}

public void setSalary(Long salary) {
    this.salary = salary;
}

@Embedded
@AttributeOverrides({
    @AttributeOverride(name = "startDate",
        column = @Column(name = "EMP_START")),
    @AttributeOverride(name = "endDate",
        column = @Column(name = "EMP_END"))
})
public EmploymentPeriod getEmploymentPeriod() {
    return period;
}

public void setEmploymentPeriod(EmploymentPeriod period) {
    this.period = period;
}
}

/***** Address class *****/
@Entity
public class Address implements Serializable {
    private Integer id;
    private int version;
    private String street;
    private String city;

    @Id
    @GeneratedValue(strategy = IDENTITY)
    public Integer getId() {
        return id;
    }

    protected void setId(Integer id) {
        this.id = id;
    }

    @Version
    @Column(name = "VERS", nullable = false)

```

```

public int getVersion() {
    return version;
}

protected void setVersion(int version) {
    this.version = version;
}

@Column(name = "RUE")
public String getStreet() {
    return street;
}

public void setStreet(String street) {
    this.street = street;
}

@Column(name = "VILLE")
public String getCity() {
    return city;
}

public void setCity(String city) {
    this.city = city;
}
}

/***** PhoneNumber class *****/
@Entity
@Table(name = "PHONE")
public class PhoneNumber implements Serializable {
    private String number;
    private int phoneType;
    private Employee employee;

    @Id
    public String getNumber() {
        return number;
    }

    public void setNumber(String number) {
        this.number = number;
    }

    @Column(name = "PTYPE")
    public int getPhonetype() {
        return phonetype;
    }

    public void setPhoneType(int phoneType) {
        this.phoneType = phoneType;
    }

    @ManyToOne(optional = false)
    @JoinColumn(name = "EMP_ID", nullable = false)
    public Employee getEmployee() {
        return employee;
    }

    public void setEmployee(Employee employee) {
        this.employee = employee;
    }
}

/***** Project class *****/
@Entity
@Inheritance(strategy = JOINED)

```



```

@DiscriminatorValue("Proj")
@DiscriminatorColumn(name = "DISC")
public class Project implements Serializable {
    private Integer projId;
    private int version;
    private String name;
    private Set<Employee> employees;

    @Id
    @GeneratedValue(strategy = TABLE)
    public Integer getId() {
        return projId;
    }

    protected void setId(Integer id) {
        this.projId = id;
    }

    @Version
    public int getVersion() {
        return version;
    }

    protected void setVersion(int version) {
        this.version = version;
    }

    @Column(name = "PROJ_NAME")
    public String getName() {
        return name;
    }

    public void setName(String name) {
        this.name = name;
    }

    @ManyToMany(mappedBy = "projects")
    public Set<Employee> getEmployees() {
        return employees;
    }

    public void setEmployees(Set<Employee> employees) {
        this.employees = employees;
    }
}

/***** GovernmentProject subclass *****/
@Entity
@Table(name = "GOVT_PROJECT")
@DiscriminatorValue("GovtProj")
@PrimaryKeyJoinColumn(name = "GOV_PROJ_ID", referencedColumnName = "ID")
public class GovernmentProject extends Project {
    private String fileInfo;

    @Column(name = "INFO")
    public String getFileInfo() {
        return fileInfo;
    }

    public void setFileInfo(String fileInfo) {
        this.fileInfo = fileInfo;
    }
}

/***** CovertProject subclass *****/
@Entity
@Table(name = "C_PROJECT")

```

```

@DiscriminatorValue("CovProj")
@PrimaryKeyJoinColumn(name = "COV_PROJ_ID", referencedColumnName = "ID")
public class CovertProject extends Project {
    private String classified;

    public CovertProject() {
        super();
    }

    public CovertProject(String classified) {
        this();
        this.classified = classified;
    }

    @Column(updatable = false)
    public String getClassified() {
        return classified;
    }

    protected void setClassified(String classified) {
        this.classified = classified;
    }
}

/***** EmploymentPeriod class *****/
@Embeddable
public class EmploymentPeriod implements Serializable {
    private Date start;
    private Date end;

    @Column(nullable = false)
    public Date getStartDate() {
        return start;
    }

    public void setStartDate(Date start) {
        this.start = start;
    }

    public Date getEndDate() {
        return end;
    }

    public void setEndDate(Date end) {
        this.end = end;
    }
}

```

- [1] The use of map keys that contain embeddables that reference entities is not permitted.
- [2] Note that either the `joinColumns` element or the `joinTable` element of the `AssociationOverride` annotation is specified for overriding a given relationship (but never both).
- [3] The combination of inheritance strategies within a single entity inheritance hierarchy is not defined by this specification.
- [4] If it is not specified, the rules of [Section 2.10](#) apply.
- [5] If the embeddable class is used as a primary key, the `EmbeddedId` rather than the `Embedded` annotation is used.
- [6] Use of the `Embedded` annotation is not required. See [Section 2.10](#).
- [7] Note that the `Id` annotation is not used in the embeddable class.
- [8] If the element collection is a `Map`, this applies to the map value.
- [9] Mapping of stateful enum values is not supported.
- [10] Portable applications should not use the `GeneratedValue` annotation on other persistent fields or properties.

- [11] Note that `SEQUENCE` and `IDENTITY` are not portable across all databases.
- [12] A primary key with a type not listed is not portable.
- [13] In general, floating point types should never be used in primary keys.
- [14] If the element collection is a `Map`, this applies to the map value.
- [15] The `ManyToMany` annotation must not be used within an embeddable class used in an element collection.
- [16] The `OneToMany` annotation must not be used within an embeddable class used in an element collection.
- [17] If the parent is detached or new or was previously removed before the orphan was associated with it, the remove operation is not applied to the entity being orphaned.
- [18] If the parent is detached or new or was previously removed before the orphan was associated with it, the remove operation is not applied to the entity being orphaned.
- [19] If the primary key is a composite primary key, the precedence of ordering among the attributes within the primary key is not further defined. To assign such a precedence within these attributes, each of the individual attributes must be specified as an `orderBy_item`.
- [20] In all other cases when `OrderBy` is applied to an element collection, the `property_or_field_name` must be specified.
- [21] The `OrderBy` annotation should be used for ordering that is visible as persistent state and maintained by the application.
- [22] It is not expected that a database foreign key be defined for the `OneToOne` mapping, as the `OneToOne` relationship may be defined as “optional=true”.
- [23] The derived id mechanisms described in [Section 2.4.2.1](#) are now to be preferred over `PrimaryKeyJoinColumn` for the `OneToOne` mapping case.
- [24] Note that the derived identity mechanisms described in [Section 2.4.2.1](#) is now preferred to the use of `PrimaryKeyJoinColumn` for this case.
- [25] When a joined inheritance strategy is used, the `Table` annotation is used to specify a primary table for the subclass-specific state if the default is not used.
- [26] If the element collection is a `Map`, this applies to the map value.

Chapter 12. XML Object/Relational Mapping Descriptor

The XML object/relational mapping descriptor serves as both an alternative to and an overriding mechanism for Java language metadata annotations.

12.1. Use of the XML Descriptor

The XML schema for the object relational/mapping descriptor is contained in [Section 12.3](#). The root element of this schema is the `entity-mappings` element. The absence or present of the `xml-mapping-metadata-complete` subelement contained in the `persistence-unit-defaults` subelement of the `entity-mappings` element controls whether the XML object/relational mapping descriptor is used to selectively override annotation values or whether it serves as a complete alternative to Java language metadata annotations.

If the `xml-mapping-metadata-complete` subelement is specified, the complete set of mapping metadata for the persistence unit is contained in the XML mapping files for the persistence unit, and any persistence annotations on the classes are ignored.

If `xml-mapping-metadata-complete` is specified and XML elements are omitted, the default values apply. These default values are the same as the corresponding defaults when annotations are used, except in the cases specified in [Section 12.2](#) below. When the `xml-mapping-metadata-complete` element is specified, any `metadata-complete` attributes specified within the `entity`, `mapped-superclass`, and `embeddable` elements are ignored.

If the `xml-mapping-metadata-complete` subelement is not specified, the XML descriptor overrides the values set or defaulted by the use of annotations, as described below.

The mapping files used by the application developer must conform to the XML schema defined in [Section 12.3](#) or to the previous versions of the XML schema, `orm_3_1.xsd`, `orm_3_0.xsd` or `orm_2_2.xsd`, defined in a previous version of this specification [1] in accordance with the version specified by the `orm.xml` file.

The Jakarta Persistence persistence provider may support use of older versions of the object/relational mapping schema as well as the object/relational mapping schema defined in [Section 12.3](#), whether singly or in combination when multiple mapping files are used.

12.2. XML Overriding Rules

This section defines the rules that apply when the XML descriptor is used to override annotations, and the rules pertaining to the interaction of XML elements specified as subelements of the `persistence-unit-defaults`, `entity-mappings`, `entity`, `mapped-superclass`, and `embeddable` elements.

12.2.1. persistence-unit-defaults Subelements

12.2.1.1. schema

The `schema` subelement applies to all entities, tables, secondary tables, join tables, collection tables, table generators, and sequence generators in the persistence unit.

The `schema` subelement is overridden by any `schema` subelement of the `entity-mappings` element; any `schema` element explicitly specified in the `Table` or `SecondaryTable` annotation on an entity or any `schema` attribute on any `table` or `secondary-table` subelement defined within an `entity` element; any `schema` element explicitly specified in a `TableGenerator` annotation or `table-generator` subelement; any `schema` element explicitly specified in a `SequenceGenerator` annotation or `sequence-generator` subelement; any `schema` element explicitly specified in a `JoinTable` annotation or `join-table` subelement; and any `schema` element explicitly specified in a `CollectionTable` annotation or `collection-table` subelement.

12.2.1.2. catalog

The `catalog` subelement applies to all entities, tables, secondary tables, join tables, collection tables, table generators, and sequence generators in the persistence unit.

The `catalog` subelement is overridden by any `catalog` subelement of the `entity-mappings` element; any `catalog` element explicitly specified in the `Table` or `SecondaryTable` annotation on an entity or any `catalog` attribute on any `table` or `secondary-table` subelement defined within an entity XML element; any `catalog` element explicitly specified in a `TableGenerator` annotation or `table-generator` subelement; any `catalog` element explicitly specified in a `SequenceGenerator` annotation or `sequence-generator` subelement; any `catalog` element explicitly specified in a `JoinTable` annotation or `join-table` subelement; and any `catalog` element explicitly specified in a `CollectionTable` annotation or `collection-table` subelement.

12.2.1.3. delimited-identifiers

The `delimited-identifiers` subelement applies to the naming of database objects, as described in [Section 2.15](#). It specifies that all database table-, schema-, and column-level identifiers in use for the persistence unit be treated as delimited identifiers.

The `delimited-identifiers` subelement cannot be overridden in this release.

12.2.1.4. access

The `access` subelement applies to all managed classes in the persistence unit.

The `access` subelement is overridden by the use of any annotations specifying mapping information on the fields or properties of the entity class; by any `Access` annotation on the entity class, mapped superclass, or embeddable class; by any `access` subelement of the `entity-mappings` element; by any `Access` annotation on a field or property of an entity class, mapped superclass, or embeddable class; by any `access` attribute defined within an `entity`, `mapped-superclass`, or `embeddable` XML element, or by any `access` attribute defined within an `id`, `embedded-id`, `version`, `basic`, `embedded`, `many-to-one`, `one-to-one`, `one-to-many`, `many-to-many`, or `element-collection` element.

12.2.1.5. cascade-persist

The `cascade-persist` subelement applies to all relationships in the persistence unit.

Specifying this subelement adds the `cascade persist` option to all relationships in addition to any settings specified in annotations or XML.

The `cascade-persist` subelement cannot be overridden in this release.



The ability to override the `cascade-persist` of the `persistence-unit-defaults` element will be added in a future release of this specification.

12.2.1.6. entity-listeners

The `entity-listeners` subelement defines default entity listeners for the persistence unit. These entity listeners are called before any other entity listeners for an entity unless the `entity listener order` is overridden within a `mapped-superclass` or `entity` element, or the `ExcludeDefaultListeners` annotation is present on the entity or mapped superclass or the `exclude-default-listeners` subelement is specified within the corresponding `entity` or `mapped-superclass` XML element.

12.2.2. Other Subelements of the entity-mappings element

12.2.2.1. package

The package subelement specifies the package of the classes listed within the subelements and attributes of the same mapping file only. The package subelement is overridden if the fully qualified class name is specified for a class and the two disagree.

12.2.2.2. schema

The schema subelement applies only to the entities, tables, secondary tables, join tables, collection tables, table generators, and sequence generators listed within the same mapping file.

The schema subelement is overridden by any schema element explicitly specified in the `Table`, `SecondaryTable`, `JoinTable`, or `CollectionTable` annotation on an entity listed within the mapping file or any schema attribute on any table or secondary-table subelement defined within the entity element for such an entity, or by any schema attribute on any join-table or collection-table subelement of an attribute defined within the `attributes` subelement of the entity element for such an entity, or by the schema attribute of any table-generator or sequence-generator element within the mapping file.

12.2.2.3. catalog

The catalog subelement applies only to the entities, tables, secondary tables, join tables, collection tables, table generators, and sequence generators listed within the same mapping file.

The catalog subelement is overridden by any catalog element explicitly specified in the `Table`, `SecondaryTable`, `JoinTable`, or `CollectionTable` annotation on an entity listed within the mapping file or any catalog attribute on any table or secondary-table subelement defined within the entity element for such an entity, or by any catalog attribute on any join-table or collection-table subelement of an attribute defined within the `attributes` subelement of the entity element for such an entity, or by the catalog attribute of any table-generator or sequence-generator element within the mapping file.

12.2.2.4. access

The access subelement applies to the managed classes listed within the same mapping file.

The access subelement is overridden by the use of any annotations specifying mapping information on the fields or properties of the entity class; by any `Access` annotation on the entity class, mapped superclass, or embeddable class; by any `Access` annotation on a field or property of an entity class, mapped superclass, or embeddable class; by any access attribute defined within an entity, mapped-superclass, or embeddable XML element, or by any access attribute defined within an `id`, `embedded-id`, `version`, `basic`, `embedded`, `many-to-one`, `one-to-one`, `one-to-many`, `many-to-many`, or `element-collection` element.

12.2.2.5. sequence-generator

The generator defined by the sequence-generator subelement applies to the persistence unit. It is undefined if multiple mapping files for the persistence unit contain generators of the same name.

The generator defined is added to any generators defined in annotations. If a generator of the same name is defined in annotations, the generator defined by this subelement overrides that definition.

12.2.2.6. table-generator

The generator defined by the table-generator subelement applies to the persistence unit. It is undefined if multiple

mapping files for the persistence unit contain generators of the same name.

The generator defined is added to any generators defined in annotations. If a generator of the same name is defined in annotations, the generator defined by this subelement overrides that definition.

12.2.2.7. named-query

The named query defined by the `named-query` subelement applies to the persistence unit. It is undefined if multiple mapping files for the persistence unit contain named queries of the same name.

The named query defined is added to the named queries defined in annotations. If a named query of the same name is defined in annotations, the named query defined by this subelement overrides that definition.

12.2.2.8. named-native-query

The named native query defined by the `named-native-query` subelement applies to the persistence unit. It is undefined if multiple mapping files for the persistence unit contain named queries of the same name.

The named native query defined is added to the named native queries defined in annotations. If a named query of the same name is defined in annotations, the named query defined by this subelement overrides that definition.

12.2.2.9. named-stored-procedure-query

The named stored procedure query defined by the `named-stored-procedure-query` subelement applies to the persistence unit. It is undefined if multiple mapping files for the persistence unit contain named stored procedure queries of the same name.

The named stored procedure query defined is added to the named stored procedure queries defined in annotations. If a named stored procedure query of the same name is defined in annotations, the named stored procedure query defined by this subelement overrides that definition.

12.2.2.10. sql-result-set-mapping

The SQL result set mapping defined by the `sql-result-set-mapping` subelement applies to the persistence unit. It is undefined if multiple mapping files for the persistence unit contain SQL result set mappings of the same name.

The SQL result set mapping defined is added to the SQL result set mappings defined in annotations. If a SQL result set mapping of the same name is defined in annotations, the SQL result set mapping defined by this subelement overrides that definition.

12.2.2.11. entity

The `entity` subelement defines an entity of the persistence unit. It is undefined if multiple mapping files for the persistence unit contain entries for the same entity.

The entity class may or may not have been annotated as `Entity`. The subelements and attributes of the `entity` element override as specified in [Section 12.2.3](#).

12.2.2.12. mapped-superclass

The `mapped-superclass` subelement defines a mapped superclass of the persistence unit. It is undefined if multiple mapping files for the persistence unit contain entries for the same mapped superclass.

The mapped superclass may or may not have been annotated as `MappedSuperclass`. The subelements and attributes of the

mapped-superclass element override as specified in [Section 12.2.4](#).

12.2.2.13. embeddable

The `embeddable` subelement defines an embeddable class of the persistence unit. It is undefined if multiple mapping files for the persistence unit contain entries for the same embeddable class.

The `embeddable` class may or may not have been annotated as `Embeddable`. The subelements and attributes of the `embeddable` element override as specified in [Section 12.2.5](#).

12.2.2.14. converter

The `converter` defined by the `converter` subelement applies to the persistence unit. It is undefined if multiple mapping files for the persistence unit contain converters for the same target type.

The `converter` defined is added to the converters defined in annotations. If a `converter` for the same target type is defined in annotations, the `converter` defined by this subelement overrides that definition.

12.2.3. entity Subelements and Attributes

These apply only to the entity for which they are subelements or attributes, unless otherwise specified below.

12.2.3.1. metadata-complete

If the `metadata-complete` attribute of the `entity` element is specified as `true`, any annotations on the entity class (and its fields and properties) are ignored. When `metadata-complete` is specified as `true` and XML attributes or sub-elements of the `entity` element are omitted, the default values for those attributes and elements are applied.

12.2.3.2. access

The `access` attribute defines the access type for the entity. The `access` attribute overrides any access type specified by the `persistence-unit-defaults` element or `entity-mappings` element for the given entity. The access type for a field or property of the entity may be overridden by specifying by overriding the mapping for that field or property using the appropriate XML subelement, as described in [Section 12.2.3.26](#) below.

Caution must be exercised in overriding an access type that was specified or defaulted using annotations, as doing so may cause applications to break.

12.2.3.3. cacheable

The `cacheable` attribute defines whether the entity should be cached or must not be cached when the `shared-cache-mode` element of the `persistence.xml` file is specified as `ENABLE_SELECTIVE` or `DISABLE_SELECTIVE`. If the `Cacheable` annotation was specified for the entity, its value is overridden by this attribute. The value of the `cacheable` attribute is inherited by subclasses (unless otherwise overridden for a subclass by the `Cacheable` annotation or `cacheable` XML attribute).

12.2.3.4. name

The `name` attribute defines the entity name. The `name` attribute overrides the value of the entity name defined by the `name` element of the `Entity` annotation (whether explicitly specified or defaulted). Caution must be exercised in overriding the entity name, as doing so may cause applications to break.

12.2.3.5. table

The `table` subelement overrides any `Table` annotation (including defaulted `Table` values) on the entity. If a `table` subelement is present, and attributes or subelements of that `table` subelement are not explicitly specified, their default values are applied.

12.2.3.6. secondary-table

The `secondary-table` subelement overrides all `SecondaryTable` and `SecondaryTables` annotations (including defaulted `SecondaryTable` values) on the entity. If a `secondary-table` subelement is present, and attributes or subelements of that `secondary-table` subelement are not explicitly specified, their default values are applied.

12.2.3.7. primary-key-join-column

The `primary-key-join-column` subelement of the entity element specifies a primary key column that is used to join the table of an entity subclass to the primary table for the entity when the joined strategy is used. The `primary-key-join-column` subelement overrides all `PrimaryKeyJoinColumn` and `PrimaryKeyJoinColumns` annotations (including defaulted `PrimaryKeyJoinColumn` values) on the entity. If a `primary-key-join-column` subelement is present, and attributes or subelements of that `primary-key-join-column` subelement are not explicitly specified, their default values are applied.

12.2.3.8. id-class

The `id-class` subelement overrides any `IdClass` annotation specified on the entity.

12.2.3.9. inheritance

The `inheritance` subelement overrides any `Inheritance` annotation (including defaulted `Inheritance` values) on the entity. If an `inheritance` subelement is present, and the `strategy` attribute is not explicitly specified, its default value is applied.

This element applies to the entity and its subclasses (unless otherwise overridden for a subclass by an annotation or XML element).

Support for the combination of inheritance strategies is not required by this specification. Portable applications should use only a single inheritance strategy within an entity hierarchy.

12.2.3.10. discriminator-value

The `discriminator-value` subelement overrides any `DiscriminatorValue` annotations (including defaulted `DiscriminatorValue` values) on the entity.

12.2.3.11. discriminator-column

The `discriminator-column` subelement overrides any `DiscriminatorColumn` annotation (including defaulted `DiscriminatorColumn` values) on the entity. If a `discriminator-column` subelement is present, and attributes of that `discriminator-column` subelement are not explicitly specified, their default values are applied.

This element applies to the entity and its subclasses (unless otherwise overridden for a subclass by an annotation or XML element).

12.2.3.12. sequence-generator

The generator defined by the `sequence-generator` subelement is added to any generators defined in annotations and any

other generators defined in XML. If a generator of the same name is defined in annotations, the generator defined by this subelement overrides that definition. If a sequence-generator subelement is present, and attributes or subelements of that sequence-generator subelement are not explicitly specified, their default values are applied.

The generator defined by the sequence-generator subelement applies to the persistence unit. It is undefined if multiple mapping files for the persistence unit contain generators of the same name.

12.2.3.13. table-generator

The generator defined by the table-generator subelement is added to any generators defined in annotations and any other generators defined in XML. If a generator of the same name is defined in annotations, the generator defined by this subelement overrides that definition. If a table-generator subelement is present, and attributes or subelements of that table-generator subelement are not explicitly specified, their default values are applied.

The generator defined by the table-generator subelement applies to the persistence unit. It is undefined if multiple mapping files for the persistence unit contain generators of the same name.

12.2.3.14. attribute-override

The attribute-override subelement is additive to any `AttributeOverride` or `AttributeOverrides` annotations on the entity. It overrides any `AttributeOverride` elements for the same attribute name. If an attribute-override subelement is present, and attributes or subelements of that attribute-override subelement are not explicitly specified, their default values are applied.

12.2.3.15. association-override

The association-override subelement is additive to any `AssociationOverride` or `AssociationOverrides` annotations on the entity. It overrides any `AssociationOverride` elements for the same attribute name. If an association-override subelement is present, and attributes or subelements of that association-override subelement are not explicitly specified, their default values are applied.

12.2.3.16. convert

The convert subelement is additive to any `Convert` or `Converts` annotations on the entity. It overrides any `Convert` annotation for the same attribute name. If a convert subelement is present, and attributes or subelements of that convert subelement are not explicitly specified, their default values are applied.

12.2.3.17. named-entity-graph

The named-entity-graph subelement is additive to any `NamedEntityGraph` annotations on the entity. It overrides any `NamedEntityGraph` annotation with the same name.

12.2.3.18. named-query

The named query defined by the named-query subelement is added to any named queries defined in annotations, and any other named queries defined in XML. If a named query of the same name is defined in annotations, the named query defined by this subelement overrides that definition. If a named-query subelement is present, and attributes or subelements of that named-query subelement are not explicitly specified, their default values are applied.

The named query defined by the named-query subelement applies to the persistence unit. It is undefined if multiple mapping files for the persistence unit contain named queries of the same name.

12.2.3.19. named-native-query

The named query defined by the `named-native-query` subelement is added to any named queries defined in annotations, and any other named queries defined in XML. If a named query of the same name is defined in annotations, the named query defined by this subelement overrides that definition. If a `named-native-query` subelement is present, and attributes or subelements of that `named-native-query` subelement are not explicitly specified, their default values are applied.

The named native query defined by the `named-native-query` subelement applies to the persistence unit. It is undefined if multiple mapping files for the persistence unit contain named queries of the same name.

12.2.3.20. named-stored-procedure-query

The named stored procedure query defined by the `named-stored-procedure-query` subelement is added to any named stored procedure queries defined in annotations, and any other named stored procedure queries defined in XML. If a named stored procedure query of the same name is defined in annotations, the named stored procedure query defined by this subelement overrides that definition. If a `named-stored-procedure-query` subelement is present, and attributes or subelements of that `named-stored-procedure-query` subelement are not explicitly specified, their default values are applied.

The named stored procedure query defined by the `named-stored-procedure-query` subelement applies to the persistence unit. It is undefined if multiple mapping files for the persistence unit contain named stored procedure queries of the same name.

12.2.3.21. sql-result-set-mapping

The SQL result set mapping defined by the `sql-result-set-mapping` is added to the SQL result set mappings defined in annotations, and any other SQL result set mappings defined in XML. If a SQL result set mapping of the same name is defined in annotations, the SQL result set mapping defined by this subelement overrides that definition. If a `sql-result-set-mapping` subelement is present, and attributes or subelements of that `sql-result-set-mapping` subelement are not explicitly specified, their default values are applied.

The SQL result set mapping defined by the `sql-result-set-mapping` subelement applies to the persistence unit. It is undefined if multiple mapping files for the persistence unit contain SQL result set mappings of the same name.

12.2.3.22. exclude-default-listeners

The `exclude-default-listeners` subelement applies whether or not the `ExcludeDefaultListeners` annotation was specified on the entity.

This element causes the default entity listeners to be excluded for the entity and its subclasses.

12.2.3.23. exclude-superclass-listeners

The `exclude-superclass-listeners` subelement applies whether or not the `ExcludeSuperclassListeners` annotation was specified on the entity.

This element causes any superclass listeners to be excluded for the entity and its subclasses.

12.2.3.24. entity-listeners

The `entity-listeners` subelement overrides any `EntityListeners` annotation on the entity.

These listeners apply to the entity and its subclasses unless otherwise excluded.

12.2.3.25. **pre-persist, post-persist, pre-remove, post-remove, pre-update, post-update, post-load**

These subelements override any lifecycle callback methods defined by the corresponding annotations on the entity.

12.2.3.26. **attributes**

The `attributes` element groups the mapping subelements for the fields and properties of the entity. It may be sparsely populated to include only a subset of the fields and properties. If the value of `metadata-complete` is `true`, the remainder of the attributes will be defaulted according to the default rules. If `metadata-complete` is not specified, or is `false`, the mappings for only those properties and fields that are explicitly specified will be overridden.

id

The `id` subelement overrides the mapping for the specified field or property. If an `id` subelement is present, and attributes or subelements of that `id` subelement are not explicitly specified, their default values are applied.

embedded-id

The `embedded-id` subelement overrides the mapping for the specified field or property. If an `embedded-id` subelement is present, and attributes or subelements of that `embedded-id` subelement are not explicitly specified, their default values are applied.

basic

The `basic` subelement overrides the mapping for the specified field or property. If a `basic` subelement is present, and attributes or subelements of that `basic` subelement are not explicitly specified, their default values are applied.

version

The `version` subelement overrides the mapping for the specified field or property. If a `version` subelement is present, and attributes or subelements of that `version` subelement are not explicitly specified, their default values are applied.

many-to-one

The `many-to-one` subelement overrides the mapping for the specified field or property. If a `many-to-one` subelement is present, and attributes or subelements of that `many-to-one` subelement are not explicitly specified, their default values are applied.

one-to-many

The `one-to-many` subelement overrides the mapping for the specified field or property. If a `one-to-many` subelement is present, and attributes or subelements of that `one-to-many` subelement are not explicitly specified, their default values are applied.

one-to-one

The `one-to-one` subelement overrides the mapping for the specified field or property. If a `one-to-one` subelement is present, and attributes or subelements of that `one-to-one` subelement are not explicitly specified, their default values are applied.

many-to-many

The `many-to-many` subelement overrides the mapping for the specified field or property. If a `many-to-many` subelement is present, and attributes or subelements of that `many-to-many` subelement are not explicitly specified, their default values are applied.

element-collection

The `element-collection` subelement overrides the mapping for the specified field or property. If an `element-collection` subelement is present, and attributes or subelements of that `element-collection` subelement are not explicitly specified, their default values are applied.

embedded

The `embedded` subelement overrides the mapping for the specified field or property. If an `embedded` subelement is present, and attributes or subelements of that `embedded` subelement are not explicitly specified, their default values are applied.

transient

The `transient` subelement overrides the mapping for the specified field or property.

12.2.4. mapped-superclass Subelements and Attributes

These apply only to the `mapped-superclass` for which they are subelements or attributes, unless otherwise specified below.

12.2.4.1. metadata-complete

If the `metadata-complete` attribute of the `mapped-superclass` element is specified as `true`, any annotations on the mapped superclass (and its fields and properties) are ignored. When `metadata-complete` is specified as `true` and attributes or subelements of the `mapped-superclass` element are omitted, the default values for those attributes and elements are applied.

12.2.4.2. access

The `access` attribute defines the access type for the mapped superclass. The `access` attribute overrides any access type specified by the `persistence-unit-defaults` element or `entity-mappings` element for the given mapped superclass. The access type for a field or property of the mapped superclass may be overridden by specifying by overriding the mapping for that field or property using the appropriate XML subelement, as described in [Section 12.2.4.8](#) below.

Caution must be exercised in overriding an access type that was specified or defaulted using annotations, as doing so may cause applications to break.

12.2.4.3. id-class

The `id-class` subelement overrides any `IdClass` annotation specified on the mapped superclass.

12.2.4.4. exclude-default-listeners

The `exclude-default-listeners` subelement applies whether or not the `ExcludeDefaultListeners` annotation was specified on the mapped superclass.

This element causes the default entity listeners to be excluded for the mapped superclass and its subclasses.

12.2.4.5. exclude-superclass-listeners

The `exclude-superclass-listeners` subelement applies whether or not the `ExcludeSuperclassListeners` annotation was specified on the mapped superclass.

This element causes any superclass listeners to be excluded for the mapped superclass and its subclasses.

12.2.4.6. entity-listeners

The `entity-listeners` subelement overrides any `EntityListeners` annotation on the mapped superclass.

These listeners apply to the mapped superclass and its subclasses unless otherwise excluded.

12.2.4.7. pre-persist, post-persist, pre-remove, post-remove, pre-update, post-update, post-load

These subelements override any lifecycle callback methods defined by the corresponding annotations on the mapped superclass.

12.2.4.8. attributes

The `attributes` element groups the mapping subelements for the fields and properties defined by the mapped superclass. It may be sparsely populated to include only a subset of the fields and properties. If the value of `metadata-complete` is `true`, the remainder of the attributes will be defaulted according to the default rules. If `metadata-complete` is not specified, or is `false`, the mappings for only those properties and fields that are explicitly specified will be overridden.

id

The `id` subelement overrides the mapping for the specified field or property. If an `id` subelement is present, and `attributes` or subelements of that `id` subelement are not explicitly specified, their default values are applied.

embedded-id

The `embedded-id` subelement overrides the mapping for the specified field or property. If an `embedded-id` subelement is present, and `attributes` or subelements of that `embedded-id` subelement are not explicitly specified, their default values are applied.

basic

The `basic` subelement overrides the mapping for the specified field or property. If a `basic` subelement is present, and `attributes` or subelements of that `basic` subelement are not explicitly specified, their default values are applied.

version

The `version` subelement overrides the mapping for the specified field or property. If a `version` subelement is present, and `attributes` or subelements of that `version` subelement are not explicitly specified, their default values are applied.

many-to-one

The `many-to-one` subelement overrides the mapping for the specified field or property. If a `many-to-one` subelement is present, and attributes or subelements of that `many-to-one` subelement are not explicitly specified, their default values are applied.

one-to-many

The `one-to-many` subelement overrides the mapping for the specified field or property. If a `one-to-many` subelement is present, and attributes or subelements of that `one-to-many` subelement are not explicitly specified, their default values are applied.

one-to-one

The `one-to-one` subelement overrides the mapping for the specified field or property. If a `one-to-one` subelement is present, and attributes or subelements of that `one-to-one` subelement are not explicitly specified, their default values are applied.

many-to-many

The `many-to-many` subelement overrides the mapping for the specified field or property. If a `many-to-many` subelement is present, and attributes or subelements of that `many-to-many` subelement are not explicitly specified, their default values are applied.

element-collection

The `element-collection` subelement overrides the mapping for the specified field or property. If an `element-collection` subelement is present, and attributes or subelements of that `element-collection` subelement are not explicitly specified, their default values are applied.

embedded

The `embedded` subelement overrides the mapping for the specified field or property. If an `embedded` subelement is present, and attributes or subelements of that `embedded` subelement are not explicitly specified, their default values are applied.

transient

The `transient` subelement overrides the mapping for the specified field or property.

12.2.5. embeddable Subelements and Attributes

These apply only to the embeddable for which they are subelements or attributes.

12.2.5.1. metadata-complete

If the `metadata-complete` attribute of the `embeddable` element is specified as `true`, any annotations on the `embeddable` class (and its fields and properties) are ignored. When `metadata-complete` is specified as `true` and attributes and sub-elements of the `embeddable` element are omitted, the default values for those attributes and elements are applied.

12.2.5.2. access

The `access` attribute defines the access type for the embeddable class. The `access` attribute overrides any access type specified by the `persistence-unit-defaults` element or `entity-mappings` element for the given embeddable class. The access type for a field or property of the embeddable class may be overridden by specifying by overriding the mapping for that field or property using the appropriate XML subelement, as described in [Section 12.2.5.3](#) below.

Caution must be exercised in overriding an access type that was specified or defaulted using annotations, as doing so may cause applications to break.

12.2.5.3. attributes

The `attributes` element groups the mapping subelements for the fields and properties defined by the embeddable class. It may be sparsely populated to include only a subset of the fields and properties. If the value of `metadata-complete` is `true`, the remainder of the attributes will be defaulted according to the default rules. If `metadata-complete` is not specified, or is `false`, the mappings for only those properties and fields that are explicitly specified will be overridden.

basic

The `basic` subelement overrides the mapping for the specified field or property. If a `basic` subelement is present, and attributes or subelements of that `basic` subelement are not explicitly specified, their default values are applied.

many-to-one

The `many-to-one` subelement overrides the mapping for the specified field or property. If a `many-to-one` subelement is present, and attributes or subelements of that `many-to-one` subelement are not explicitly specified, their default values are applied.

one-to-many

The `one-to-many` subelement overrides the mapping for the specified field or property. If a `one-to-many` subelement is present, and attributes or subelements of that `one-to-many` subelement are not explicitly specified, their default values are applied.

one-to-one

The `one-to-one` subelement overrides the mapping for the specified field or property. If a `one-to-one` subelement is present, and attributes or subelements of that `one-to-one` subelement are not explicitly specified, their default values are applied.

many-to-many

The `many-to-many` subelement overrides the mapping for the specified field or property. If a `many-to-many` subelement is present, and attributes or subelements of that `many-to-many` subelement are not explicitly specified, their default values are applied.

element-collection

The `element-collection` subelement overrides the mapping for the specified field or property. If an `element-collection` subelement is present, and attributes or subelements of that `element-collection` subelement are not explicitly specified, their default values are applied.

embedded

The embedded subelement overrides the mapping for the specified field or property. If an embedded subelement is present, and attributes or subelements of that embedded subelement are not explicitly specified, their default values are applied.

transient

The transient subelement overrides the mapping for the specified field or property.

12.3. XML Schema

This section provides the XML object/relational mapping schema for use with the Persistence API.

```
<?xml version="1.0" encoding="UTF-8"?>

<!-- Jakarta Persistence API object/relational mapping file schema -->
<xsd:schema targetNamespace="https://jakarta.ee/xml/ns/persistence/orm"
  xmlns:orm="https://jakarta.ee/xml/ns/persistence/orm"
  xmlns:xsd="http://www.w3.org/2001/XMLSchema"
  elementFormDefault="qualified"
  attributeFormDefault="unqualified"
  version="3.2">
<xsd:annotation>
  <xsd:documentation><![CDATA[

    This is the XML Schema for the persistence object/relational mapping file.
    The file may be named "META-INF/orm.xml" in the persistence
    archive or it may be named some other name which would be
    used to locate the file as resource on the classpath.

    Object/relational mapping files must indicate the object/relational
    mapping file schema by using the persistence namespace:

    https://jakarta.ee/xml/ns/persistence/orm

    and indicate the version of the schema by
    using the version element as shown below:

    <entity-mappings xmlns="https://jakarta.ee/xml/ns/persistence/orm"
      xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
      xsi:schemaLocation="https://jakarta.ee/xml/ns/persistence/orm
        https://jakarta.ee/xml/ns/persistence/orm/orm_3_2.xsd"
      version="3.2">
      ...
    </entity-mappings>

  ]]></xsd:documentation>
</xsd:annotation>

<xsd:complexType name="emptyType"/>

<xsd:simpleType name="versionType">
  <xsd:restriction base="xsd:token">
    <xsd:pattern value="[0-9]+(\.[0-9]+)*"/>
  </xsd:restriction>
</xsd:simpleType>

<!-- ***** -->

<xsd:element name="entity-mappings">
  <xsd:complexType>
  <xsd:annotation>
```

```
<xsd:documentation>
```

The entity-mappings element is the root element of a mapping file. It contains the following four types of elements:

1. The persistence-unit-metadata element contains metadata for the entire persistence unit. It is undefined if this element occurs in multiple mapping files within the same persistence unit.
2. The package, schema, catalog and access elements apply to all of the entity, mapped-superclass and embeddable elements defined in the same file in which they occur.
3. The sequence-generator, table-generator, converter, named-query, named-native-query, named-stored-procedure-query, and sql-result-set-mapping elements are global to the persistence unit. It is undefined to have more than one sequence-generator or table-generator of the same name in the same or different mapping files in a persistence unit. It is undefined to have more than one named-query, named-native-query, sql-result-set-mapping, or named-stored-procedure-query of the same name in the same or different mapping files in a persistence unit. It is also undefined to have more than one converter for the same target type in the same or different mapping files in a persistence unit.
4. The entity, mapped-superclass and embeddable elements each define the mapping information for a managed persistent class. The mapping information contained in these elements may be complete or it may be partial.

```
</xsd:documentation>  
</xsd:annotation>  
<xsd:sequence>  
  <xsd:element name="description" type="xsd:string"  
    minOccurs="0"/>  
  <xsd:element name="persistence-unit-metadata"  
    type="orm:persistence-unit-metadata"  
    minOccurs="0"/>  
  <xsd:element name="package" type="xsd:string"  
    minOccurs="0"/>  
  <xsd:element name="schema" type="xsd:string"  
    minOccurs="0"/>  
  <xsd:element name="catalog" type="xsd:string"  
    minOccurs="0"/>  
  <xsd:element name="access" type="orm:access-type"  
    minOccurs="0"/>  
  <xsd:element name="sequence-generator" type="orm:sequence-generator"  
    minOccurs="0" maxOccurs="unbounded"/>  
  <xsd:element name="table-generator" type="orm:table-generator"  
    minOccurs="0" maxOccurs="unbounded"/>  
  <xsd:element name="named-query" type="orm:named-query"  
    minOccurs="0" maxOccurs="unbounded"/>  
  <xsd:element name="named-native-query" type="orm:named-native-query"  
    minOccurs="0" maxOccurs="unbounded"/>  
  <xsd:element name="named-stored-procedure-query"  
    type="orm:named-stored-procedure-query"  
    minOccurs="0" maxOccurs="unbounded"/>  
  <xsd:element name="sql-result-set-mapping"  
    type="orm:sql-result-set-mapping"  
    minOccurs="0" maxOccurs="unbounded"/>  
  <xsd:element name="mapped-superclass" type="orm:mapped-superclass"  
    minOccurs="0" maxOccurs="unbounded"/>  
  <xsd:element name="entity" type="orm:entity"  
    minOccurs="0" maxOccurs="unbounded"/>  
  <xsd:element name="embeddable" type="orm:embeddable"  
    minOccurs="0" maxOccurs="unbounded"/>  
  <xsd:element name="converter" type="orm:converter"
```

```

        minOccurs="0" maxOccurs="unbounded"/>
    </xsd:sequence>
    <xsd:attribute name="version" type="orm:versionType"
        fixed="3.2" use="required"/>
</xsd:complexType>
</xsd:element>

<!-- ***** -->

<xsd:complexType name="persistence-unit-metadata">
    <xsd:annotation>
        <xsd:documentation>

            Metadata that applies to the persistence unit and not just to
            the mapping file in which it is contained.

            If the xml-mapping-metadata-complete element is specified,
            the complete set of mapping metadata for the persistence unit
            is contained in the XML mapping files for the persistence unit.

        </xsd:documentation>
    </xsd:annotation>
    <xsd:sequence>
        <xsd:element name="description" type="xsd:string" minOccurs="0"/>
        <xsd:element name="xml-mapping-metadata-complete" type="orm:emptyType"
            minOccurs="0"/>
        <xsd:element name="persistence-unit-defaults"
            type="orm:persistence-unit-defaults"
            minOccurs="0"/>
    </xsd:sequence>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="persistence-unit-defaults">
    <xsd:annotation>
        <xsd:documentation>

            These defaults are applied to the persistence unit as a whole
            unless they are overridden by local annotation or XML
            element settings.

            schema - Used as the schema for all tables, secondary tables, join
            tables, collection tables, sequence generators, and table
            generators that apply to the persistence unit
            catalog - Used as the catalog for all tables, secondary tables, join
            tables, collection tables, sequence generators, and table
            generators that apply to the persistence unit
            delimited-identifiers - Used to treat database identifiers as
            delimited identifiers.
            access - Used as the access type for all managed classes in
            the persistence unit
            cascade-persist - Adds cascade-persist to the set of cascade options
            in all entity relationships of the persistence unit
            entity-listeners - List of default entity listeners to be invoked
            on each entity in the persistence unit.

        </xsd:documentation>
    </xsd:annotation>
    <xsd:sequence>
        <xsd:element name="description" type="xsd:string" minOccurs="0"/>
        <xsd:element name="schema" type="xsd:string"
            minOccurs="0"/>
        <xsd:element name="catalog" type="xsd:string"
            minOccurs="0"/>
        <xsd:element name="delimited-identifiers" type="orm:emptyType"
            minOccurs="0"/>
        <xsd:element name="access" type="orm:access-type"

```

```

        minOccurs="0"/>
    <xsd:element name="cascade-persist" type="orm:emptyType"
        minOccurs="0"/>
    <xsd:element name="entity-listeners" type="orm:entity-listeners"
        minOccurs="0"/>
</xsd:sequence>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="entity">
    <xsd:annotation>
        <xsd:documentation>

            Defines the settings and mappings for an entity. Is allowed to be
            sparsely populated and used in conjunction with the annotations.
            Alternatively, the metadata-complete attribute can be used to
            indicate that no annotations on the entity class (and its fields
            or properties) are to be processed. If this is the case then
            the defaulting rules for the entity and its subelements will
            be recursively applied.

            @Target(TYPE) @Retention(RUNTIME)
            public @interface Entity {
                String name() default "";
            }

        </xsd:documentation>
    </xsd:annotation>
    <xsd:sequence>
        <xsd:element name="description" type="xsd:string" minOccurs="0"/>
        <xsd:element name="table" type="orm:table"
            minOccurs="0"/>
        <xsd:element name="secondary-table" type="orm:secondary-table"
            minOccurs="0" maxOccurs="unbounded"/>
        <xsd:sequence>
            <xsd:element name="primary-key-join-column"
                type="orm:primary-key-join-column"
                minOccurs="0" maxOccurs="unbounded"/>
            <xsd:element name="primary-key-foreign-key"
                type="orm:foreign-key"
                minOccurs="0"/>
        </xsd:sequence>
        <xsd:element name="id-class" type="orm:id-class" minOccurs="0"/>
        <xsd:element name="inheritance" type="orm:inheritance" minOccurs="0"/>
        <xsd:element name="discriminator-value" type="orm:discriminator-value"
            minOccurs="0"/>
        <xsd:element name="discriminator-column"
            type="orm:discriminator-column"
            minOccurs="0"/>
        <xsd:element name="sequence-generator" type="orm:sequence-generator"
            minOccurs="0"/>
        <xsd:element name="table-generator" type="orm:table-generator"
            minOccurs="0"/>
        <xsd:element name="named-query" type="orm:named-query"
            minOccurs="0" maxOccurs="unbounded"/>
        <xsd:element name="named-native-query" type="orm:named-native-query"
            minOccurs="0" maxOccurs="unbounded"/>
        <xsd:element name="named-stored-procedure-query"
            type="orm:named-stored-procedure-query"
            minOccurs="0" maxOccurs="unbounded"/>
        <xsd:element name="sql-result-set-mapping"
            type="orm:sql-result-set-mapping"
            minOccurs="0" maxOccurs="unbounded"/>
        <xsd:element name="exclude-default-listeners" type="orm:emptyType"
            minOccurs="0"/>
        <xsd:element name="exclude-superclass-listeners" type="orm:emptyType"

```

```

        minOccurs="0"/>
<xsd:element name="entity-listeners" type="orm:entity-listeners"
minOccurs="0"/>
<xsd:element name="pre-persist" type="orm:pre-persist" minOccurs="0"/>
<xsd:element name="post-persist" type="orm:post-persist"
minOccurs="0"/>
<xsd:element name="pre-remove" type="orm:pre-remove" minOccurs="0"/>
<xsd:element name="post-remove" type="orm:post-remove" minOccurs="0"/>
<xsd:element name="pre-update" type="orm:pre-update" minOccurs="0"/>
<xsd:element name="post-update" type="orm:post-update" minOccurs="0"/>
<xsd:element name="post-load" type="orm:post-load" minOccurs="0"/>
<xsd:element name="attribute-override" type="orm:attribute-override"
minOccurs="0" maxOccurs="unbounded"/>
<xsd:element name="association-override"
type="orm:association-override"
minOccurs="0" maxOccurs="unbounded"/>
<xsd:element name="convert" type="orm:convert"
minOccurs="0" maxOccurs="unbounded"/>
<xsd:element name="named-entity-graph" type="orm:named-entity-graph"
minOccurs="0" maxOccurs="unbounded"/>
<xsd:element name="attributes" type="orm:attributes" minOccurs="0"/>
</xsd:sequence>
<xsd:attribute name="name" type="xsd:string"/>
<xsd:attribute name="class" type="xsd:string" use="required"/>
<xsd:attribute name="access" type="orm:access-type"/>
<xsd:attribute name="cacheable" type="xsd:boolean"/>
<xsd:attribute name="metadata-complete" type="xsd:boolean"/>
</xsd:complexType>

```

```
<!-- ***** -->
```

```

<xsd:simpleType name="access-type">
  <xsd:annotation>
    <xsd:documentation>

      This element determines how the persistence provider accesses the
      state of an entity or embedded object.

    </xsd:documentation>
  </xsd:annotation>
  <xsd:restriction base="xsd:token">
    <xsd:enumeration value="PROPERTY"/>
    <xsd:enumeration value="FIELD"/>
  </xsd:restriction>
</xsd:simpleType>

```

```
<!-- ***** -->
```

```

<xsd:complexType name="association-override">
  <xsd:annotation>
    <xsd:documentation>

      @Repeatable(AssociationOverrides.class)
      @Target({TYPE, METHOD, FIELD}) @Retention(RUNTIME)
      public @interface AssociationOverride {
        String name();
        JoinColumn[] joinColumns() default{};
        ForeignKey foreignKey() default @ForeignKey(PROVIDER_DEFAULT);
        JoinTable joinTable() default @JoinTable;
      }

    </xsd:documentation>
  </xsd:annotation>
  <xsd:sequence>
    <xsd:element name="description" type="xsd:string" minOccurs="0"/>
    <xsd:choice>
      <xsd:sequence>

```

```

        <xsd:element name="join-column" type="orm:join-column"
            minOccurs="0" maxOccurs="unbounded"/>
        <xsd:element name="foreign-key" type="orm:foreign-key"
            minOccurs="0"/>
    </xsd:sequence>
    <xsd:element name="join-table" type="orm:join-table"
        minOccurs="0"/>
</xsd:choice>
</xsd:sequence>
<xsd:attribute name="name" type="xsd:string" use="required"/>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="attribute-override">
    <xsd:annotation>
        <xsd:documentation>

            @Repeatable(AttributeOverrides.class)
            @Target({TYPE, METHOD, FIELD}) @Retention(RUNTIME)
            public @interface AttributeOverride {
                String name();
                Column column();
            }

        </xsd:documentation>
    </xsd:annotation>
    <xsd:sequence>
        <xsd:element name="description" type="xsd:string" minOccurs="0"/>
        <xsd:element name="column" type="orm:column"/>
    </xsd:sequence>
    <xsd:attribute name="name" type="xsd:string" use="required"/>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="attributes">
    <xsd:annotation>
        <xsd:documentation>

            This element contains the entity field or property mappings.
            It may be sparsely populated to include only a subset of the
            fields or properties. If metadata-complete for the entity is true
            then the remainder of the attributes will be defaulted according
            to the default rules.

        </xsd:documentation>
    </xsd:annotation>
    <xsd:sequence>
        <xsd:element name="description" type="xsd:string" minOccurs="0"/>
        <xsd:choice>
            <xsd:element name="id" type="orm:id"
                minOccurs="0" maxOccurs="unbounded"/>
            <xsd:element name="embedded-id" type="orm:embedded-id"
                minOccurs="0"/>
        </xsd:choice>
        <xsd:element name="basic" type="orm:basic"
            minOccurs="0" maxOccurs="unbounded"/>
        <xsd:element name="version" type="orm:version"
            minOccurs="0"/>
        <xsd:element name="many-to-one" type="orm:many-to-one"
            minOccurs="0" maxOccurs="unbounded"/>
        <xsd:element name="one-to-many" type="orm:one-to-many"
            minOccurs="0" maxOccurs="unbounded"/>
        <xsd:element name="one-to-one" type="orm:one-to-one"
            minOccurs="0" maxOccurs="unbounded"/>
        <xsd:element name="many-to-many" type="orm:many-to-many"

```

```

        minOccurs="0" maxOccurs="unbounded"/>
<xsd:element name="element-collection" type="orm:element-collection"
minOccurs="0" maxOccurs="unbounded"/>
<xsd:element name="embedded" type="orm:embedded"
minOccurs="0" maxOccurs="unbounded"/>
<xsd:element name="transient" type="orm:transient"
minOccurs="0" maxOccurs="unbounded"/>
</xsd:sequence>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="basic">
<xsd:annotation>
<xsd:documentation>

    @Target({METHOD, FIELD}) @Retention(RUNTIME)
    public @interface Basic {
        FetchType fetch() default FetchType.EAGER;
        boolean optional() default true;
    }

</xsd:documentation>
</xsd:annotation>
<xsd:sequence>
<xsd:element name="column" type="orm:column" minOccurs="0"/>
<xsd:choice>
<xsd:element name="lob" type="orm:lob" minOccurs="0"/>
<xsd:element name="temporal" type="orm:temporal" minOccurs="0"/>
<xsd:element name="enumerated" type="orm:enumerated" minOccurs="0"/>
<xsd:element name="convert" type="orm:convert" minOccurs="0"/>
</xsd:choice>
</xsd:sequence>
<xsd:attribute name="name" type="xsd:string" use="required"/>
<xsd:attribute name="fetch" type="orm:fetch-type"/>
<xsd:attribute name="optional" type="xsd:boolean"/>
<xsd:attribute name="access" type="orm:access-type"/>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="cascade-type">
<xsd:annotation>
<xsd:documentation>

    public enum CascadeType { ALL, PERSIST, MERGE, REMOVE, REFRESH, DETACH }

</xsd:documentation>
</xsd:annotation>
<xsd:sequence>
<xsd:element name="cascade-all" type="orm:emptyType"
minOccurs="0"/>
<xsd:element name="cascade-persist" type="orm:emptyType"
minOccurs="0"/>
<xsd:element name="cascade-merge" type="orm:emptyType"
minOccurs="0"/>
<xsd:element name="cascade-remove" type="orm:emptyType"
minOccurs="0"/>
<xsd:element name="cascade-refresh" type="orm:emptyType"
minOccurs="0"/>
<xsd:element name="cascade-detach" type="orm:emptyType"
minOccurs="0"/>
</xsd:sequence>
</xsd:complexType>

<!-- ***** -->

```

```

<xsd:complexType name="check-constraint">
  <xsd:annotation>
    <xsd:documentation>

      @Target({}) @Retention(RUNTIME)
      public @interface CheckConstraint {
        String name() default "";
        String constraint();
        String options() default "";
      }

    </xsd:documentation>
  </xsd:annotation>
  <xsd:attribute name="name" type="xsd:string"/>
  <xsd:attribute name="constraint" type="xsd:string" use="required"/>
  <xsd:attribute name="options" type="xsd:string"/>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="collection-table">
  <xsd:annotation>
    <xsd:documentation>

      @Target({METHOD, FIELD}) @Retention(RUNTIME)
      public @interface CollectionTable {
        String name() default "";
        String catalog() default "";
        String schema() default "";
        JoinColumn[] joinColumns() default {};
        ForeignKey foreignKey() default @ForeignKey(ConstraintMode.PROVIDER_DEFAULT);
        UniqueConstraint[] uniqueConstraints() default {};
        Index[] indexes() default {};
        String options() default "";
      }

    </xsd:documentation>
  </xsd:annotation>
  <xsd:sequence>
    <xsd:sequence>
      <xsd:element name="join-column" type="orm:join-column"
        minOccurs="0" maxOccurs="unbounded"/>
      <xsd:element name="foreign-key" type="orm:foreign-key"
        minOccurs="0"/>
    </xsd:sequence>
    <xsd:element name="unique-constraint" type="orm:unique-constraint"
      minOccurs="0" maxOccurs="unbounded"/>
    <xsd:element name="index" type="orm:index"
      minOccurs="0" maxOccurs="unbounded"/>
  </xsd:sequence>
  <xsd:attribute name="name" type="xsd:string"/>
  <xsd:attribute name="catalog" type="xsd:string"/>
  <xsd:attribute name="schema" type="xsd:string"/>
  <xsd:attribute name="options" type="xsd:string"/>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="column">
  <xsd:annotation>
    <xsd:documentation>

      @Target({METHOD, FIELD}) @Retention(RUNTIME)
      public @interface Column {
        String name() default "";
        boolean unique() default false;
      }
    </xsd:documentation>
  </xsd:annotation>
  <xsd:attribute name="name" type="xsd:string"/>
  <xsd:attribute name="unique" type="xsd:boolean" use="optional"/>
</xsd:complexType>

```



```

        boolean nullable() default true;
        boolean insertable() default true;
        boolean updatable() default true;
        String columnDefinition() default "";
        String options() default "";
        String table() default "";
        int length() default 255;
        int precision() default 0; // decimal precision
        int scale() default 0; // decimal scale
        int secondPrecision() default -1; //fractional second precision
        CheckConstraint[] check() default {};
        String comment() default "";
    }

    </xsd:documentation>
</xsd:annotation>
<xsd:sequence>
    <xsd:element name="comment" type="xsd:string" minOccurs="0" />
    <xsd:element name="check-constraint" type="orm:check-constraint"
        minOccurs="0" maxOccurs="unbounded"/>
</xsd:sequence>
<xsd:attribute name="name" type="xsd:string"/>
<xsd:attribute name="unique" type="xsd:boolean"/>
<xsd:attribute name="nullable" type="xsd:boolean"/>
<xsd:attribute name="insertable" type="xsd:boolean"/>
<xsd:attribute name="updatable" type="xsd:boolean"/>
<xsd:attribute name="column-definition" type="xsd:string"/>
<xsd:attribute name="options" type="xsd:string"/>
<xsd:attribute name="table" type="xsd:string"/>
<xsd:attribute name="length" type="xsd:int"/>
<xsd:attribute name="precision" type="xsd:int"/>
<xsd:attribute name="scale" type="xsd:int"/>
<xsd:attribute name="second-precision" type="xsd:int"/>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="column-result">
    <xsd:annotation>
        <xsd:documentation><![CDATA[

            @Target({}) @Retention(RUNTIME)
            public @interface ColumnResult {
                String name();
                Class<?> type() default void.class;
            }

        ]]></xsd:documentation>
    </xsd:annotation>
    <xsd:attribute name="name" type="xsd:string" use="required"/>
    <xsd:attribute name="class" type="xsd:string"/>
</xsd:complexType>

<!-- ***** -->

<xsd:simpleType name="constraint-mode">
    <xsd:annotation>
        <xsd:documentation>

            public enum ConstraintMode { CONSTRAINT, NO_CONSTRAINT, PROVIDER_DEFAULT }

        </xsd:documentation>
    </xsd:annotation>
    <xsd:restriction base="xsd:token">
        <xsd:enumeration value="CONSTRAINT"/>
        <xsd:enumeration value="NO_CONSTRAINT"/>
        <xsd:enumeration value="PROVIDER_DEFAULT"/>
    </xsd:restriction>
</xsd:simpleType>

```

```

    </xsd:restriction>
</xsd:simpleType>

<!-- ***** -->

<xsd:complexType name="constructor-result">
  <xsd:annotation>
    <xsd:documentation><![CDATA[

      @Target({}) @Retention(RUNTIME)
      public @interface ConstructorResult {
        Class<?> targetClass();
        ColumnResult[] columns();
      }

    ]]></xsd:documentation>
  </xsd:annotation>
  <xsd:sequence>
    <xsd:element name="column" type="orm:column-result"
      maxOccurs="unbounded"/>
  </xsd:sequence>
  <xsd:attribute name="target-class" type="xsd:string" use="required"/>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="convert">
  <xsd:annotation>
    <xsd:documentation><![CDATA[

      @Repeatable(Converts.class)
      @Target({TYPE, METHOD, FIELD}) @Retention(RUNTIME)
      public @interface Convert {
        Class<? extends AttributeConverter> converter() default AttributeConverter.class;
        String attributeName() default "";
        boolean disableConversion() default false;
      }

    ]]></xsd:documentation>
  </xsd:annotation>
  <xsd:sequence>
    <xsd:element name="description" type="xsd:string" minOccurs="0"/>
  </xsd:sequence>
  <xsd:attribute name="converter" type="xsd:string"/>
  <xsd:attribute name="attribute-name" type="xsd:string"/>
  <xsd:attribute name="disable-conversion" type="xsd:boolean"/>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="converter">
  <xsd:annotation>
    <xsd:documentation>

      @Target({TYPE}) @Retention(RUNTIME)
      public @interface Converter {
        boolean autoApply() default false;
      }

    </xsd:documentation>
  </xsd:annotation>
  <xsd:sequence>
    <xsd:element name="description" type="xsd:string" minOccurs="0"/>
  </xsd:sequence>
  <xsd:attribute name="class" type="xsd:string" use="required"/>
  <xsd:attribute name="auto-apply" type="xsd:boolean"/>

```

```

</xsd:complexType>
<!-- ***** -->
<xsd:complexType name="discriminator-column">
  <xsd:annotation>
    <xsd:documentation>

      @Target({TYPE}) @Retention(RUNTIME)
      public @interface DiscriminatorColumn {
        String name() default "DTYPE";
        DiscriminatorType discriminatorType() default STRING;
        String columnDefinition() default "";
        String options() default "";
        int length() default 31;
      }

    </xsd:documentation>
  </xsd:annotation>
  <xsd:attribute name="name" type="xsd:string"/>
  <xsd:attribute name="discriminator-type" type="orm:discriminator-type"/>
  <xsd:attribute name="column-definition" type="xsd:string"/>
  <xsd:attribute name="options" type="xsd:string"/>
  <xsd:attribute name="length" type="xsd:int"/>
</xsd:complexType>
<!-- ***** -->
<xsd:simpleType name="discriminator-type">
  <xsd:annotation>
    <xsd:documentation>

      public enum DiscriminatorType { STRING, CHAR, INTEGER }

    </xsd:documentation>
  </xsd:annotation>
  <xsd:restriction base="xsd:token">
    <xsd:enumeration value="STRING"/>
    <xsd:enumeration value="CHAR"/>
    <xsd:enumeration value="INTEGER"/>
  </xsd:restriction>
</xsd:simpleType>
<!-- ***** -->
<xsd:simpleType name="discriminator-value">
  <xsd:annotation>
    <xsd:documentation>

      @Target({TYPE}) @Retention(RUNTIME)
      public @interface DiscriminatorValue {
        String value();
      }

    </xsd:documentation>
  </xsd:annotation>
  <xsd:restriction base="xsd:string"/>
</xsd:simpleType>
<!-- ***** -->
<xsd:complexType name="element-collection">
  <xsd:annotation>
    <xsd:documentation><![CDATA[

      @Target({METHOD, FIELD}) @Retention(RUNTIME)
      public @interface ElementCollection {

```

```

    Class<?> targetClass() default void.class;
    FetchType fetch() default FetchType.LAZY;
}

]]></xsd:documentation>
</xsd:annotation>
<xsd:sequence>
  <xsd:choice>
    <xsd:element name="order-by" type="orm:order-by"
      minOccurs="0"/>
    <xsd:element name="order-column" type="orm:order-column"
      minOccurs="0"/>
  </xsd:choice>
  <xsd:choice>
    <xsd:element name="map-key" type="orm:map-key"
      minOccurs="0"/>
    <xsd:sequence>
      <xsd:element name="map-key-class" type="orm:map-key-class"
        minOccurs="0"/>
      <xsd:choice>
        <xsd:element name="map-key-temporal"
          type="orm:temporal"
          minOccurs="0"/>
        <xsd:element name="map-key-enumerated"
          type="orm:enumerated"
          minOccurs="0"/>
        <xsd:sequence>
          <xsd:element name="map-key-attribute-override"
            type="orm:attribute-override"
            minOccurs="0" maxOccurs="unbounded"/>
          <xsd:element name="map-key-convert" type="orm:convert"
            minOccurs="0" maxOccurs="unbounded"/>
        </xsd:sequence>
      </xsd:choice>
    </xsd:sequence>
  </xsd:choice>
  <xsd:choice>
    <xsd:element name="map-key-column"
      type="orm:map-key-column"
      minOccurs="0"/>
    <xsd:sequence>
      <xsd:element name="map-key-join-column"
        type="orm:map-key-join-column"
        minOccurs="0" maxOccurs="unbounded"/>
      <xsd:element name="map-key-foreign-key"
        type="orm:foreign-key"
        minOccurs="0"/>
    </xsd:sequence>
  </xsd:choice>
</xsd:sequence>
</xsd:choice>
<xsd:choice>
  <xsd:sequence>
    <xsd:element name="column" type="orm:column" minOccurs="0"/>
    <xsd:choice>
      <xsd:element name="temporal"
        type="orm:temporal"
        minOccurs="0"/>
      <xsd:element name="enumerated"
        type="orm:enumerated"
        minOccurs="0"/>
      <xsd:element name="lob"
        type="orm:lob"
        minOccurs="0"/>
    </xsd:choice>
  </xsd:sequence>
</xsd:sequence>
  <xsd:element name="attribute-override"
    type="orm:attribute-override"

```

```

        minOccurs="0" maxOccurs="unbounded"/>
    <xsd:element name="association-override"
        type="orm:association-override"
        minOccurs="0" maxOccurs="unbounded"/>
    <xsd:element name="convert" type="orm:convert"
        minOccurs="0" maxOccurs="unbounded"/>
</xsd:sequence>
</xsd:choice>
<xsd:element name="collection-table" type="orm:collection-table"
    minOccurs="0"/>
</xsd:sequence>
<xsd:attribute name="name" type="xsd:string" use="required"/>
<xsd:attribute name="target-class" type="xsd:string"/>
<xsd:attribute name="fetch" type="orm:fetch-type"/>
<xsd:attribute name="access" type="orm:access-type"/>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="embeddable">
    <xsd:annotation>
        <xsd:documentation>

            Defines the settings and mappings for embeddable objects. Is
            allowed to be sparsely populated and used in conjunction with
            the annotations. Alternatively, the metadata-complete attribute
            can be used to indicate that no annotations are to be processed
            in the class. If this is the case then the defaulting rules will
            be recursively applied.

            @Target({TYPE}) @Retention(RUNTIME)
            public @interface Embeddable {}

        </xsd:documentation>
    </xsd:annotation>
    <xsd:sequence>
        <xsd:element name="description" type="xsd:string" minOccurs="0"/>
        <xsd:element name="attributes" type="orm:embeddable-attributes"
            minOccurs="0"/>
    </xsd:sequence>
    <xsd:attribute name="class" type="xsd:string" use="required"/>
    <xsd:attribute name="access" type="orm:access-type"/>
    <xsd:attribute name="metadata-complete" type="xsd:boolean"/>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="embeddable-attributes">
    <xsd:sequence>
        <xsd:element name="basic" type="orm:basic"
            minOccurs="0" maxOccurs="unbounded"/>
        <xsd:element name="many-to-one" type="orm:many-to-one"
            minOccurs="0" maxOccurs="unbounded"/>
        <xsd:element name="one-to-many" type="orm:one-to-many"
            minOccurs="0" maxOccurs="unbounded"/>
        <xsd:element name="one-to-one" type="orm:one-to-one"
            minOccurs="0" maxOccurs="unbounded"/>
        <xsd:element name="many-to-many" type="orm:many-to-many"
            minOccurs="0" maxOccurs="unbounded"/>
        <xsd:element name="element-collection" type="orm:element-collection"
            minOccurs="0" maxOccurs="unbounded"/>
        <xsd:element name="embedded" type="orm:embedded"
            minOccurs="0" maxOccurs="unbounded"/>
        <xsd:element name="transient" type="orm:transient"
            minOccurs="0" maxOccurs="unbounded"/>
    </xsd:sequence>
</xsd:complexType>

```

```

<!-- ***** -->
<xsd:complexType name="embedded">
  <xsd:annotation>
    <xsd:documentation>

      @Target({METHOD, FIELD}) @Retention(RUNTIME)
      public @interface Embedded {}

    </xsd:documentation>
  </xsd:annotation>
  <xsd:sequence>
    <xsd:element name="attribute-override" type="orm:attribute-override"
      minOccurs="0" maxOccurs="unbounded"/>
    <xsd:element name="association-override"
      type="orm:association-override"
      minOccurs="0" maxOccurs="unbounded"/>
    <xsd:element name="convert" type="orm:convert"
      minOccurs="0" maxOccurs="unbounded"/>
  </xsd:sequence>
  <xsd:attribute name="name" type="xsd:string" use="required"/>
  <xsd:attribute name="access" type="orm:access-type"/>
</xsd:complexType>

<!-- ***** -->
<xsd:complexType name="embedded-id">
  <xsd:annotation>
    <xsd:documentation>

      @Target({METHOD, FIELD}) @Retention(RUNTIME)
      public @interface EmbeddedId {}

    </xsd:documentation>
  </xsd:annotation>
  <xsd:sequence>
    <xsd:element name="attribute-override" type="orm:attribute-override"
      minOccurs="0" maxOccurs="unbounded"/>
  </xsd:sequence>
  <xsd:attribute name="name" type="xsd:string" use="required"/>
  <xsd:attribute name="access" type="orm:access-type"/>
</xsd:complexType>

<!-- ***** -->
<xsd:complexType name="entity-listener">
  <xsd:annotation>
    <xsd:documentation>

      Defines an entity listener to be invoked at lifecycle events
      for the entities that list this listener.

    </xsd:documentation>
  </xsd:annotation>
  <xsd:sequence>
    <xsd:element name="description" type="xsd:string" minOccurs="0"/>
    <xsd:element name="pre-persist" type="orm:pre-persist" minOccurs="0"/>
    <xsd:element name="post-persist" type="orm:post-persist"
      minOccurs="0"/>
    <xsd:element name="pre-remove" type="orm:pre-remove" minOccurs="0"/>
    <xsd:element name="post-remove" type="orm:post-remove" minOccurs="0"/>
    <xsd:element name="pre-update" type="orm:pre-update" minOccurs="0"/>
    <xsd:element name="post-update" type="orm:post-update" minOccurs="0"/>
    <xsd:element name="post-load" type="orm:post-load" minOccurs="0"/>
  </xsd:sequence>
  <xsd:attribute name="class" type="xsd:string" use="required"/>

```

```

</xsd:complexType>
<!-- ***** -->
<xsd:complexType name="entity-listeners">
  <xsd:annotation>
    <xsd:documentation><![CDATA[
      @Target({TYPE}) @Retention(RUNTIME)
      public @interface EntityListeners {
        Class<?>[] value();
      }
    ]]></xsd:documentation>
  </xsd:annotation>
  <xsd:sequence>
    <xsd:element name="entity-listener" type="orm:entity-listener"
      minOccurs="0" maxOccurs="unbounded"/>
  </xsd:sequence>
</xsd:complexType>
<!-- ***** -->
<xsd:complexType name="entity-result">
  <xsd:annotation>
    <xsd:documentation><![CDATA[
      @Target({}) @Retention(RUNTIME)
      public @interface EntityResult {
        Class<?> entityClass();
        LockModeType lockMode() default LockModeType.OPTIMISTIC;
        FieldResult[] fields() default {};
        String discriminatorColumn() default "";
      }
    ]]></xsd:documentation>
  </xsd:annotation>
  <xsd:sequence>
    <xsd:element name="lock-mode" type="orm:lock-mode-type" minOccurs="0"/>
    <xsd:element name="field-result" type="orm:field-result"
      minOccurs="0" maxOccurs="unbounded"/>
  </xsd:sequence>
  <xsd:attribute name="entity-class" type="xsd:string" use="required"/>
  <xsd:attribute name="discriminator-column" type="xsd:string"/>
</xsd:complexType>
<!-- ***** -->
<xsd:simpleType name="enum-type">
  <xsd:annotation>
    <xsd:documentation>
      public enum EnumType { ORDINAL, STRING }
    </xsd:documentation>
  </xsd:annotation>
  <xsd:restriction base="xsd:token">
    <xsd:enumeration value="ORDINAL"/>
    <xsd:enumeration value="STRING"/>
  </xsd:restriction>
</xsd:simpleType>
<!-- ***** -->
<xsd:simpleType name="enumerated">
  <xsd:annotation>
    <xsd:documentation>

```

```

        @Target({METHOD, FIELD}) @Retention(RUNTIME)
        public @interface Enumerated {
            EnumType value() default ORDINAL;
        }

        </xsd:documentation>
    </xsd:annotation>
    <xsd:restriction base="orm:enum-type"/>
</xsd:simpleType>

<!-- ***** -->

<xsd:simpleType name="fetch-type">
    <xsd:annotation>
        <xsd:documentation>

            public enum FetchType { LAZY, EAGER }

        </xsd:documentation>
    </xsd:annotation>
    <xsd:restriction base="xsd:token">
        <xsd:enumeration value="LAZY"/>
        <xsd:enumeration value="EAGER"/>
    </xsd:restriction>
</xsd:simpleType>

<!-- ***** -->

<xsd:complexType name="field-result">
    <xsd:annotation>
        <xsd:documentation>

            @Target({}) @Retention(RUNTIME)
            public @interface FieldResult {
                String name();
                String column();
            }

        </xsd:documentation>
    </xsd:annotation>
    <xsd:attribute name="name" type="xsd:string" use="required"/>
    <xsd:attribute name="column" type="xsd:string" use="required"/>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="foreign-key">
    <xsd:annotation>
        <xsd:documentation>

            @Target({}) @Retention(RUNTIME)
            public @interface ForeignKey {
                String name() default "";
                ConstraintMode value() default CONSTRAINT;
                String foreign-key-definition() default "";
                String options() default "";
            }

            Note that the elements that embed the use of the annotation
            default this use as @ForeignKey(PROVIDER_DEFAULT).

        </xsd:documentation>
    </xsd:annotation>
    <xsd:sequence>
        <xsd:element name="description" type="xsd:string" minOccurs="0"/>
    </xsd:sequence>

```



```

<xsd:attribute name="name" type="xsd:string"/>
<xsd:attribute name="constraint-mode" type="orm:constraint-mode"/>
<xsd:attribute name="foreign-key-definition" type="xsd:string"/>
<xsd:attribute name="options" type="xsd:string"/>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="generated-value">
  <xsd:annotation>
    <xsd:documentation>

      @Target({METHOD, FIELD}) @Retention(RUNTIME)
      public @interface GeneratedValue {
        GenerationType strategy() default AUTO;
        String generator() default "";
      }

    </xsd:documentation>
  </xsd:annotation>
  <xsd:attribute name="strategy" type="orm:generation-type"/>
  <xsd:attribute name="generator" type="xsd:string"/>
</xsd:complexType>

<!-- ***** -->

<xsd:simpleType name="generation-type">
  <xsd:annotation>
    <xsd:documentation>

      public enum GenerationType { TABLE, SEQUENCE, IDENTITY, UUID, AUTO }

    </xsd:documentation>
  </xsd:annotation>
  <xsd:restriction base="xsd:token">
    <xsd:enumeration value="TABLE"/>
    <xsd:enumeration value="SEQUENCE"/>
    <xsd:enumeration value="IDENTITY"/>
    <xsd:enumeration value="UUID"/>
    <xsd:enumeration value="AUTO"/>
  </xsd:restriction>
</xsd:simpleType>

<!-- ***** -->

<xsd:complexType name="id">
  <xsd:annotation>
    <xsd:documentation>

      @Target({METHOD, FIELD}) @Retention(RUNTIME)
      public @interface Id {}

    </xsd:documentation>
  </xsd:annotation>
  <xsd:sequence>
    <xsd:element name="column" type="orm:column"
      minOccurs="0"/>
    <xsd:element name="generated-value" type="orm:generated-value"
      minOccurs="0"/>
    <xsd:element name="temporal" type="orm:temporal"
      minOccurs="0"/>
    <xsd:element name="table-generator" type="orm:table-generator"
      minOccurs="0"/>
    <xsd:element name="sequence-generator" type="orm:sequence-generator"
      minOccurs="0"/>
  </xsd:sequence>
  <xsd:attribute name="name" type="xsd:string" use="required"/>

```

```

    <xsd:attribute name="access" type="orm:access-type"/>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="id-class">
  <xsd:annotation>
    <xsd:documentation><![CDATA[

        @Target({TYPE}) @Retention(RUNTIME)
        public @interface IdClass {
            Class<?> value();
        }

        ]]></xsd:documentation>
  </xsd:annotation>
  <xsd:attribute name="class" type="xsd:string" use="required"/>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="index">
  <xsd:annotation>
    <xsd:documentation>

        @Target({}) @Retention(RUNTIME)
        public @interface Index {
            String name() default "";
            String columnList();
            boolean unique() default false;
            String options() default "";
        }

    </xsd:documentation>
  </xsd:annotation>
  <xsd:sequence>
    <xsd:element name="description" type="xsd:string" minOccurs="0"/>
  </xsd:sequence>
  <xsd:attribute name="name" type="xsd:string"/>
  <xsd:attribute name="column-list" type="xsd:string" use="required"/>
  <xsd:attribute name="unique" type="xsd:boolean"/>
  <xsd:attribute name="options" type="xsd:string"/>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="inheritance">
  <xsd:annotation>
    <xsd:documentation>

        @Target({TYPE}) @Retention(RUNTIME)
        public @interface Inheritance {
            InheritanceType strategy() default InheritanceType.SINGLE_TABLE;
        }

    </xsd:documentation>
  </xsd:annotation>
  <xsd:attribute name="strategy" type="orm:inheritance-type"/>
</xsd:complexType>

<!-- ***** -->

<xsd:simpleType name="inheritance-type">
  <xsd:annotation>
    <xsd:documentation>

        public enum InheritanceType { SINGLE_TABLE, TABLE_PER_CLASS, JOINED }

    </xsd:documentation>
  </xsd:annotation>
  <xsd:enumBaseRef base="java:enum" type="xsd:string" use="required"/>
</xsd:simpleType>

```

```

        </xsd:documentation>
    </xsd:annotation>
    <xsd:restriction base="xsd:token">
        <xsd:enumeration value="SINGLE_TABLE"/>
        <xsd:enumeration value="JOINED"/>
        <xsd:enumeration value="TABLE_PER_CLASS"/>
    </xsd:restriction>
</xsd:simpleType>

<!-- ***** -->

<xsd:complexType name="join-column">
    <xsd:annotation>
        <xsd:documentation>

            @Repeatable(JoinColumns.class)
            @Target({METHOD, FIELD}) @Retention(RUNTIME)
            public @interface JoinColumn {
                String name() default "";
                String referencedColumnName() default "";
                boolean unique() default false;
                boolean nullable() default true;
                boolean insertable() default true;
                boolean updatable() default true;
                String columnDefinition() default "";
                String options() default "";
                String table() default "";
                ForeignKey foreignKey() default @ForeignKey();
                CheckConstraint[] check() default {};
                String comment() default "";
            }

        </xsd:documentation>
    </xsd:annotation>
    <xsd:sequence>
        <xsd:element name="comment" type="xsd:string" minOccurs="0" />
        <xsd:element name="foreign-key" type="orm:foreign-key"
            minOccurs="0"/>
        <xsd:element name="check-constraint" type="orm:check-constraint"
            minOccurs="0" maxOccurs="unbounded"/>
    </xsd:sequence>
    <xsd:attribute name="name" type="xsd:string"/>
    <xsd:attribute name="referenced-column-name" type="xsd:string"/>
    <xsd:attribute name="unique" type="xsd:boolean"/>
    <xsd:attribute name="nullable" type="xsd:boolean"/>
    <xsd:attribute name="insertable" type="xsd:boolean"/>
    <xsd:attribute name="updatable" type="xsd:boolean"/>
    <xsd:attribute name="column-definition" type="xsd:string"/>
    <xsd:attribute name="options" type="xsd:string"/>
    <xsd:attribute name="table" type="xsd:string"/>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="join-table">
    <xsd:annotation>
        <xsd:documentation>

            @Target({METHOD, FIELD}) @Retention(RUNTIME)
            public @interface JoinTable {
                String name() default "";
                String catalog() default "";
                String schema() default "";
                JoinColumn[] joinColumns() default {};
                JoinColumn[] inverseJoinColumns() default {};
                ForeignKey foreignKey() default @ForeignKey(ConstraintMode.PROVIDER_DEFAULT);
            }

        </xsd:documentation>
    </xsd:annotation>

```

```

        ForeignKey inverseForeignKey() default @ForeignKey(ConstraintMode.PROVIDER_DEFAULT);
        UniqueConstraint[] uniqueConstraints() default {};
        Index[] indexes() default {};
        CheckConstraint[] check() default {};
        String comment() default "";
        String options() default "";
    }

    </xsd:documentation>
</xsd:annotation>
<xsd:sequence>
    <xsd:element name="comment" type="xsd:string" minOccurs="0" />
    <xsd:sequence>
        <xsd:element name="join-column" type="orm:join-column"
            minOccurs="0" maxOccurs="unbounded"/>
        <xsd:element name="foreign-key" type="orm:foreign-key"
            minOccurs="0"/>
    </xsd:sequence>
    <xsd:sequence>
        <xsd:element name="inverse-join-column" type="orm:join-column"
            minOccurs="0" maxOccurs="unbounded"/>
        <xsd:element name="inverse-foreign-key" type="orm:foreign-key"
            minOccurs="0"/>
    </xsd:sequence>
    <xsd:element name="unique-constraint" type="orm:unique-constraint"
        minOccurs="0" maxOccurs="unbounded"/>
    <xsd:element name="index" type="orm:index"
        minOccurs="0" maxOccurs="unbounded"/>
    <xsd:element name="check-constraint" type="orm:check-constraint"
        minOccurs="0" maxOccurs="unbounded"/>
</xsd:sequence>
<xsd:attribute name="name" type="xsd:string"/>
<xsd:attribute name="catalog" type="xsd:string"/>
<xsd:attribute name="schema" type="xsd:string"/>
<xsd:attribute name="options" type="xsd:string"/>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="lob">
    <xsd:annotation>
        <xsd:documentation>

            @Target({METHOD, FIELD}) @Retention(RUNTIME)
            public @interface Lob {}

        </xsd:documentation>
    </xsd:annotation>
</xsd:complexType>

<!-- ***** -->

<xsd:simpleType name="lock-mode-type">
    <xsd:annotation>
        <xsd:documentation>

            public enum LockModeType implements FindOption, RefreshOption { READ, WRITE, OPTIMISTIC,
            OPTIMISTIC_FORCE_INCREMENT, PESSIMISTIC_READ, PESSIMISTIC_WRITE, PESSIMISTIC_FORCE_INCREMENT, NONE}

        </xsd:documentation>
    </xsd:annotation>
    <xsd:restriction base="xsd:token">
        <xsd:enumeration value="READ"/>
        <xsd:enumeration value="WRITE"/>
        <xsd:enumeration value="OPTIMISTIC"/>
        <xsd:enumeration value="OPTIMISTIC_FORCE_INCREMENT"/>
        <xsd:enumeration value="PESSIMISTIC_READ"/>
    </xsd:restriction>
</xsd:simpleType>

```

```

<xsd:enumeration value="PESSIMISTIC_WRITE"/>
<xsd:enumeration value="PESSIMISTIC_FORCE_INCREMENT"/>
<xsd:enumeration value="NONE"/>

</xsd:restriction>
</xsd:simpleType>

<!-- ***** -->

<xsd:complexType name="many-to-many">
  <xsd:annotation>
    <xsd:documentation><![CDATA[

      @Target({METHOD, FIELD}) @Retention(RUNTIME)
      public @interface ManyToMany {
        Class<?> targetEntity() default void.class;
        CascadeType[] cascade() default {};
        FetchType fetch() default FetchType.LAZY;
        String mappedBy() default "";
      }

    ]]></xsd:documentation>
  </xsd:annotation>
  <xsd:sequence>
    <xsd:choice>
      <xsd:element name="order-by" type="orm:order-by"
        minOccurs="0"/>
      <xsd:element name="order-column" type="orm:order-column"
        minOccurs="0"/>
    </xsd:choice>
    <xsd:choice>
      <xsd:element name="map-key" type="orm:map-key"
        minOccurs="0"/>
      <xsd:sequence>
        <xsd:element name="map-key-class" type="orm:map-key-class"
          minOccurs="0"/>
        <xsd:choice>
          <xsd:element name="map-key-temporal"
            type="orm:temporal"
            minOccurs="0"/>
          <xsd:element name="map-key-enumerated"
            type="orm:enumerated"
            minOccurs="0"/>
        </xsd:choice>
        <xsd:sequence>
          <xsd:element name="map-key-attribute-override"
            type="orm:attribute-override"
            minOccurs="0" maxOccurs="unbounded"/>
          <xsd:element name="map-key-convert" type="orm:convert"
            minOccurs="0" maxOccurs="unbounded"/>
        </xsd:sequence>
        </xsd:choice>
      </xsd:choice>
      <xsd:element name="map-key-column" type="orm:map-key-column"
        minOccurs="0"/>
      <xsd:sequence>
        <xsd:element name="map-key-join-column"
          type="orm:map-key-join-column"
          minOccurs="0" maxOccurs="unbounded"/>
        <xsd:element name="map-key-foreign-key"
          type="orm:foreign-key"
          minOccurs="0"/>
      </xsd:sequence>
    </xsd:choice>
  </xsd:sequence>
  <xsd:element name="join-table" type="orm:join-table"
    minOccurs="0"/>

```

```

        <xsd:element name="cascade" type="orm:cascade-type"
            minOccurs="0"/>
    </xsd:sequence>
    <xsd:attribute name="name" type="xsd:string" use="required"/>
    <xsd:attribute name="target-entity" type="xsd:string"/>
    <xsd:attribute name="fetch" type="orm:fetch-type"/>
    <xsd:attribute name="access" type="orm:access-type"/>
    <xsd:attribute name="mapped-by" type="xsd:string"/>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="many-to-one">
    <xsd:annotation>
        <xsd:documentation><![CDATA[

            @Target({METHOD, FIELD}) @Retention(RUNTIME)
            public @interface ManyToOne {
                Class<?> targetEntity() default void.class;
                CascadeType[] cascade() default {};
                FetchType fetch() default FetchType.EAGER;
                boolean optional() default true;
            }

        ]]></xsd:documentation>
    </xsd:annotation>
    <xsd:sequence>
        <xsd:choice>
            <xsd:sequence>
                <xsd:element name="join-column" type="orm:join-column"
                    minOccurs="0" maxOccurs="unbounded"/>
                <xsd:element name="foreign-key" type="orm:foreign-key"
                    minOccurs="0"/>
            </xsd:sequence>
            <xsd:element name="join-table" type="orm:join-table"
                minOccurs="0"/>
        </xsd:choice>
        <xsd:element name="cascade" type="orm:cascade-type"
            minOccurs="0"/>
    </xsd:sequence>
    <xsd:attribute name="name" type="xsd:string" use="required"/>
    <xsd:attribute name="target-entity" type="xsd:string"/>
    <xsd:attribute name="fetch" type="orm:fetch-type"/>
    <xsd:attribute name="optional" type="xsd:boolean"/>
    <xsd:attribute name="access" type="orm:access-type"/>
    <xsd:attribute name="maps-id" type="xsd:string"/>
    <xsd:attribute name="id" type="xsd:boolean"/>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="map-key">
    <xsd:annotation>
        <xsd:documentation>

            @Target({METHOD, FIELD}) @Retention(RUNTIME)
            public @interface MapKey {
                String name() default "";
            }

        </xsd:documentation>
    </xsd:annotation>
    <xsd:attribute name="name" type="xsd:string"/>
</xsd:complexType>

<!-- ***** -->

```

```

<xsd:complexType name="map-key-class">
  <xsd:annotation>
    <xsd:documentation><![CDATA[

        @Target({METHOD, FIELD}) @Retention(RUNTIME)
        public @interface MapKeyClass {
            Class<?> value();
        }

        ]]></xsd:documentation>
  </xsd:annotation>
  <xsd:attribute name="class" type="xsd:string" use="required"/>
</xsd:complexType>

```

```

<!-- ***** -->

```

```

<xsd:complexType name="map-key-column">
  <xsd:annotation>
    <xsd:documentation>

        @Target({METHOD, FIELD}) @Retention(RUNTIME)
        public @interface MapKeyColumn {
            String name() default "";
            boolean unique() default false;
            boolean nullable() default false;
            boolean insertable() default true;
            boolean updatable() default true;
            String columnDefinition() default "";
            String options() default "";
            String table() default "";
            int length() default 255;
            int precision() default 0; // decimal precision
            int scale() default 0; // decimal scale
        }

    </xsd:documentation>
  </xsd:annotation>
  <xsd:attribute name="name" type="xsd:string"/>
  <xsd:attribute name="unique" type="xsd:boolean"/>
  <xsd:attribute name="nullable" type="xsd:boolean"/>
  <xsd:attribute name="insertable" type="xsd:boolean"/>
  <xsd:attribute name="updatable" type="xsd:boolean"/>
  <xsd:attribute name="column-definition" type="xsd:string"/>
  <xsd:attribute name="options" type="xsd:string"/>
  <xsd:attribute name="table" type="xsd:string"/>
  <xsd:attribute name="length" type="xsd:int"/>
  <xsd:attribute name="precision" type="xsd:int"/>
  <xsd:attribute name="scale" type="xsd:int"/>
</xsd:complexType>

```

```

<!-- ***** -->

```

```

<xsd:complexType name="map-key-join-column">
  <xsd:annotation>
    <xsd:documentation>

        @Repeatable(MapKeyJoinColumns.class)
        @Target({METHOD, FIELD}) @Retention(RUNTIME)
        public @interface MapKeyJoinColumn {
            String name() default "";
            String referencedColumnName() default "";
            boolean unique() default false;
            boolean nullable() default false;
            boolean insertable() default true;
            boolean updatable() default true;
            String columnDefinition() default "";
            String options() default "";
        }

```

```

        String table() default "";
        ForeignKey foreignKey() default @ForeignKey(ConstraintMode.PROVIDER_DEFAULT);
    }

    </xsd:documentation>
</xsd:annotation>
<xsd:sequence>
    <xsd:element name="foreign-key" type="orm:foreign-key"
        minOccurs="0"/>
</xsd:sequence>
<xsd:attribute name="name" type="xsd:string"/>
<xsd:attribute name="referenced-column-name" type="xsd:string"/>
<xsd:attribute name="unique" type="xsd:boolean"/>
<xsd:attribute name="nullable" type="xsd:boolean"/>
<xsd:attribute name="insertable" type="xsd:boolean"/>
<xsd:attribute name="updatable" type="xsd:boolean"/>
<xsd:attribute name="column-definition" type="xsd:string"/>
<xsd:attribute name="options" type="xsd:string"/>
<xsd:attribute name="table" type="xsd:string"/>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="mapped-superclass">
    <xsd:annotation>
        <xsd:documentation>

            Defines the settings and mappings for a mapped superclass. Is
            allowed to be sparsely populated and used in conjunction with
            the annotations. Alternatively, the metadata-complete attribute
            can be used to indicate that no annotations are to be processed
            If this is the case then the defaulting rules will be recursively
            applied.

            @Target(TYPE) @Retention(RUNTIME)
            public @interface MappedSuperclass {}

        </xsd:documentation>
    </xsd:annotation>
    <xsd:sequence>
        <xsd:element name="description" type="xsd:string" minOccurs="0"/>
        <xsd:element name="id-class" type="orm:id-class" minOccurs="0"/>
        <xsd:element name="exclude-default-listeners" type="orm:emptyType"
            minOccurs="0"/>
        <xsd:element name="exclude-superclass-listeners" type="orm:emptyType"
            minOccurs="0"/>
        <xsd:element name="entity-listeners" type="orm:entity-listeners"
            minOccurs="0"/>
        <xsd:element name="pre-persist" type="orm:pre-persist" minOccurs="0"/>
        <xsd:element name="post-persist" type="orm:post-persist"
            minOccurs="0"/>
        <xsd:element name="pre-remove" type="orm:pre-remove" minOccurs="0"/>
        <xsd:element name="post-remove" type="orm:post-remove" minOccurs="0"/>
        <xsd:element name="pre-update" type="orm:pre-update" minOccurs="0"/>
        <xsd:element name="post-update" type="orm:post-update" minOccurs="0"/>
        <xsd:element name="post-load" type="orm:post-load" minOccurs="0"/>
        <xsd:element name="attributes" type="orm:attributes" minOccurs="0"/>
    </xsd:sequence>
    <xsd:attribute name="class" type="xsd:string" use="required"/>
    <xsd:attribute name="access" type="orm:access-type"/>
    <xsd:attribute name="metadata-complete" type="xsd:boolean"/>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="named-attribute-node">

```



```

<xsd:annotation>
  <xsd:documentation>

    @Target({}) @Retention(RUNTIME)
    public @interface NamedAttributeNode {
      String value();
      String subgraph() default "";
      String keySubgraph() default "";
    }

  </xsd:documentation>
</xsd:annotation>
<xsd:attribute name="name" type="xsd:string" use="required"/>
<xsd:attribute name="subgraph" type="xsd:string"/>
<xsd:attribute name="key-subgraph" type="xsd:string"/>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="named-entity-graph">
  <xsd:annotation>
    <xsd:documentation>

      @Repeatable(NamedEntityGraphs.class)
      @Target({TYPE}) @Retention(RUNTIME)
      public @interface NamedEntityGraph {
        String name() default "";
        NamedAttributeNode[] attributeNodes() default {};
        boolean includeAllAttributes() default false;
        NamedSubgraph[] subgraphs() default {};
        NamedSubGraph[] subclassSubgraphs() default {};
      }

    </xsd:documentation>
  </xsd:annotation>
  <xsd:sequence>
    <xsd:element name="named-attribute-node"
      type="orm:named-attribute-node"
      minOccurs="0"
      maxOccurs="unbounded"/>
    <xsd:element name="subgraph"
      type="orm:named-subgraph"
      minOccurs="0"
      maxOccurs="unbounded"/>
    <xsd:element name="subclass-subgraph"
      type="orm:named-subgraph"
      minOccurs="0"
      maxOccurs="unbounded"/>
  </xsd:sequence>
  <xsd:attribute name="name" type="xsd:string"/>
  <xsd:attribute name="include-all-attributes" type="xsd:boolean"/>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="named-native-query">
  <xsd:annotation>
    <xsd:documentation><![CDATA[

      @Repeatable(NamedNativeQueries.class)
      @Target({TYPE}) @Retention(RUNTIME)
      public @interface NamedNativeQuery {
        String name();
        String query();
        QueryHint[] hints() default {};
        Class<?> resultClass() default void.class;
    ]]>
  </xsd:documentation>
  </xsd:annotation>
  <xsd:sequence>
    <xsd:element name="name" type="xsd:string"/>
    <xsd:element name="query" type="xsd:string"/>
    <xsd:element name="hints" type="xsd:string"/>
    <xsd:element name="result-class" type="xsd:string"/>
  </xsd:sequence>
</xsd:complexType>

```

```

        String resultSetMapping() default ""; //named SqlResultSetMapping
        EntityResult[] entities() default {};
        ConstructorResult[] classes() default {};
        ColumnResult[] columns() default {};
    }

    ]]></xsd:documentation>
</xsd:annotation>
<xsd:sequence>
    <xsd:element name="description" type="xsd:string" minOccurs="0"/>
    <xsd:element name="query" type="xsd:string"/>
    <xsd:element name="hint" type="orm:query-hint"
        minOccurs="0" maxOccurs="unbounded"/>
    <xsd:element name="entity-result" type="orm:entity-result"
        minOccurs="0" maxOccurs="unbounded"/>
    <xsd:element name="constructor-result" type="orm:constructor-result"
        minOccurs="0" maxOccurs="unbounded"/>
    <xsd:element name="column-result" type="orm:column-result"
        minOccurs="0" maxOccurs="unbounded"/>
</xsd:sequence>
<xsd:attribute name="name" type="xsd:string" use="required"/>
<xsd:attribute name="result-class" type="xsd:string"/>
<xsd:attribute name="result-set-mapping" type="xsd:string"/>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="named-query">
    <xsd:annotation>
        <xsd:documentation>

            @Repeatable(NamedQueries.class)
            @Target({TYPE}) @Retention(RUNTIME)
            public @interface NamedQuery {
                String name();
                String query();
                LockModeType lockMode() default LockModeType.NONE;
                QueryHint[] hints() default {};
            }

        </xsd:documentation>
    </xsd:annotation>
    <xsd:sequence>
        <xsd:element name="description" type="xsd:string" minOccurs="0"/>
        <xsd:element name="query" type="xsd:string"/>
        <xsd:element name="lock-mode" type="orm:lock-mode-type" minOccurs="0"/>
        <xsd:element name="hint" type="orm:query-hint"
            minOccurs="0" maxOccurs="unbounded"/>
    </xsd:sequence>
    <xsd:attribute name="name" type="xsd:string" use="required"/>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="named-stored-procedure-query">
    <xsd:annotation>
        <xsd:documentation>

            @Repeatable(NamedStoredProcedureQueries.class)
            @Target({TYPE}) @Retention(RUNTIME)
            public @interface NamedStoredProcedureQuery {
                String name();
                String procedureName();
                StoredProcedureParameter[] parameters() default {};
                Class[] resultClasses() default {};
                String[] resultSetMappings() default {};
                QueryHint[] hints() default {};
            }

        </xsd:documentation>
    </xsd:annotation>
    <xsd:sequence>
        <xsd:element name="description" type="xsd:string" minOccurs="0"/>
        <xsd:element name="query" type="xsd:string"/>
        <xsd:element name="lock-mode" type="orm:lock-mode-type" minOccurs="0"/>
        <xsd:element name="hint" type="orm:query-hint"
            minOccurs="0" maxOccurs="unbounded"/>
    </xsd:sequence>
    <xsd:attribute name="name" type="xsd:string" use="required"/>
</xsd:complexType>

```

```

    }

    </xsd:documentation>
</xsd:annotation>
<xsd:sequence>
  <xsd:element name="description" type="xsd:string" minOccurs="0"/>
  <xsd:element name="parameter"
    type="orm:stored-procedure-parameter"
    minOccurs="0" maxOccurs="unbounded"/>
  <xsd:element name="result-class" type="xsd:string"
    minOccurs="0" maxOccurs="unbounded"/>
  <xsd:element name="result-set-mapping" type="xsd:string"
    minOccurs="0" maxOccurs="unbounded"/>
  <xsd:element name="hint" type="orm:query-hint"
    minOccurs="0" maxOccurs="unbounded"/>
</xsd:sequence>
<xsd:attribute name="name" type="xsd:string" use="required"/>
<xsd:attribute name="procedure-name" type="xsd:string" use="required"/>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="named-subgraph">
  <xsd:annotation>
    <xsd:documentation><![CDATA[

      @Target({}) @Retention(RUNTIME)
      public @interface NamedSubgraph {
        String name();
        Class<?> type() default void.class;
        NamedAttributeNode[] attributeNodes();
      }

    ]]></xsd:documentation>
  </xsd:annotation>
  <xsd:sequence>
    <xsd:element name="named-attribute-node"
      type="orm:named-attribute-node"
      minOccurs="0"
      maxOccurs="unbounded"/>
  </xsd:sequence>
  <xsd:attribute name="name" type="xsd:string" use="required"/>
  <xsd:attribute name="class" type="xsd:string"/>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="one-to-many">
  <xsd:annotation>
    <xsd:documentation><![CDATA[

      @Target({METHOD, FIELD}) @Retention(RUNTIME)
      public @interface OneToMany {
        Class<?> targetEntity() default void.class;
        CascadeType[] cascade() default {};
        FetchType fetch() default FetchType.LAZY;
        String mappedBy() default "";
        boolean orphanRemoval() default false;
      }

    ]]></xsd:documentation>
  </xsd:annotation>
  <xsd:sequence>
    <xsd:choice>
      <xsd:element name="order-by" type="orm:order-by"
        minOccurs="0"/>
      <xsd:element name="order-column" type="orm:order-column"

```

```

        minOccurs="0"/>
</xsd:choice>
<xsd:choice>
  <xsd:element name="map-key" type="orm:map-key"
    minOccurs="0"/>
  <xsd:sequence>
    <xsd:element name="map-key-class" type="orm:map-key-class"
      minOccurs="0"/>
    <xsd:choice>
      <xsd:element name="map-key-temporal"
        type="orm:temporal"
        minOccurs="0"/>
      <xsd:element name="map-key-enumerated"
        type="orm:enumerated"
        minOccurs="0"/>
      <xsd:sequence>
        <xsd:element name="map-key-attribute-override"
          type="orm:attribute-override"
          minOccurs="0" maxOccurs="unbounded"/>
        <xsd:element name="map-key-convert" type="orm:convert"
          minOccurs="0" maxOccurs="unbounded"/>
      </xsd:sequence>
    </xsd:choice>
  </xsd:choice>
  <xsd:choice>
    <xsd:element name="map-key-column" type="orm:map-key-column"
      minOccurs="0"/>
    <xsd:sequence>
      <xsd:element name="map-key-join-column"
        type="orm:map-key-join-column"
        minOccurs="0" maxOccurs="unbounded"/>
      <xsd:element name="map-key-foreign-key"
        type="orm:foreign-key"
        minOccurs="0"/>
    </xsd:sequence>
  </xsd:choice>
</xsd:sequence>
</xsd:choice>
<xsd:choice>
  <xsd:element name="join-table" type="orm:join-table"
    minOccurs="0"/>
  <xsd:sequence>
    <xsd:element name="join-column" type="orm:join-column"
      minOccurs="0" maxOccurs="unbounded"/>
    <xsd:element name="foreign-key" type="orm:foreign-key"
      minOccurs="0"/>
  </xsd:sequence>
</xsd:choice>
<xsd:element name="cascade" type="orm:cascade-type"
  minOccurs="0"/>
</xsd:sequence>
<xsd:attribute name="name" type="xsd:string" use="required"/>
<xsd:attribute name="target-entity" type="xsd:string"/>
<xsd:attribute name="fetch" type="orm:fetch-type"/>
<xsd:attribute name="access" type="orm:access-type"/>
<xsd:attribute name="mapped-by" type="xsd:string"/>
<xsd:attribute name="orphan-removal" type="xsd:boolean"/>
</xsd:complexType>

```

```
<!-- ***** -->
```

```

<xsd:complexType name="one-to-one">
  <xsd:annotation>
    <xsd:documentation><![CDATA[

        @Target({METHOD, FIELD}) @Retention(RUNTIME)
        public @interface OneToOne {
            Class<?> targetEntity() default void.class;

```

```

        CascadeType[] cascade() default {};
        FetchType fetch() default FetchType.EAGER;
        boolean optional() default true;
        String mappedBy() default "";
        boolean orphanRemoval() default false;
    }

]]></xsd:documentation>
</xsd:annotation>
<xsd:sequence>
  <xsd:choice>
    <xsd:sequence>
      <xsd:element name="primary-key-join-column"
        type="orm:primary-key-join-column"
        minOccurs="0" maxOccurs="unbounded"/>
      <xsd:element name="primary-key-foreign-key"
        type="orm:foreign-key"
        minOccurs="0"/>
    </xsd:sequence>
    <xsd:sequence>
      <xsd:element name="join-column" type="orm:join-column"
        minOccurs="0" maxOccurs="unbounded"/>
      <xsd:element name="foreign-key" type="orm:foreign-key"
        minOccurs="0"/>
    </xsd:sequence>
    <xsd:element name="join-table" type="orm:join-table"
      minOccurs="0"/>
  </xsd:choice>
  <xsd:element name="cascade" type="orm:cascade-type"
    minOccurs="0"/>
</xsd:sequence>
<xsd:attribute name="name" type="xsd:string" use="required"/>
<xsd:attribute name="target-entity" type="xsd:string"/>
<xsd:attribute name="fetch" type="orm:fetch-type"/>
<xsd:attribute name="optional" type="xsd:boolean"/>
<xsd:attribute name="access" type="orm:access-type"/>
<xsd:attribute name="mapped-by" type="xsd:string"/>
<xsd:attribute name="orphan-removal" type="xsd:boolean"/>
<xsd:attribute name="maps-id" type="xsd:string"/>
<xsd:attribute name="id" type="xsd:boolean"/>
</xsd:complexType>

<!-- ***** -->

<xsd:simpleType name="order-by">
  <xsd:annotation>
    <xsd:documentation>

      @Target({METHOD, FIELD}) @Retention(RUNTIME)
      public @interface OrderBy {
        String value() default "";
      }

    </xsd:documentation>
  </xsd:annotation>
  <xsd:restriction base="xsd:string"/>
</xsd:simpleType>

<!-- ***** -->

<xsd:complexType name="order-column">
  <xsd:annotation>
    <xsd:documentation>

      @Target({METHOD, FIELD}) @Retention(RUNTIME)
      public @interface OrderColumn {
        String name() default "";
      }

    </xsd:documentation>
  </xsd:annotation>

```

```

        boolean nullable() default true;
        boolean insertable() default true;
        boolean updatable() default true;
        String columnDefinition() default "";
        String options() default "";
    }

    </xsd:documentation>
</xsd:annotation>
<xsd:attribute name="name" type="xsd:string"/>
<xsd:attribute name="nullable" type="xsd:boolean"/>
<xsd:attribute name="insertable" type="xsd:boolean"/>
<xsd:attribute name="updatable" type="xsd:boolean"/>
<xsd:attribute name="column-definition" type="xsd:string"/>
<xsd:attribute name="options" type="xsd:string"/>
</xsd:complexType>

<!-- ***** -->

<xsd:simpleType name="parameter-mode">
    <xsd:annotation>
        <xsd:documentation>

            public enum ParameterMode { IN, INOUT, OUT, REF_CURSOR }

        </xsd:documentation>
    </xsd:annotation>
    <xsd:restriction base="xsd:token">
        <xsd:enumeration value="IN"/>
        <xsd:enumeration value="INOUT"/>
        <xsd:enumeration value="OUT"/>
        <xsd:enumeration value="REF_CURSOR"/>
    </xsd:restriction>
</xsd:simpleType>

<!-- ***** -->

<xsd:complexType name="post-load">
    <xsd:annotation>
        <xsd:documentation>

            @Target({METHOD}) @Retention(RUNTIME)
            public @interface PostLoad {}

        </xsd:documentation>
    </xsd:annotation>
    <xsd:sequence>
        <xsd:element name="description" type="xsd:string" minOccurs="0"/>
    </xsd:sequence>
    <xsd:attribute name="method-name" type="xsd:string" use="required"/>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="post-persist">
    <xsd:annotation>
        <xsd:documentation>

            @Target({METHOD}) @Retention(RUNTIME)
            public @interface PostPersist {}

        </xsd:documentation>
    </xsd:annotation>
    <xsd:sequence>
        <xsd:element name="description" type="xsd:string" minOccurs="0"/>
    </xsd:sequence>
    <xsd:attribute name="method-name" type="xsd:string" use="required"/>

```

```

</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="post-remove">
  <xsd:annotation>
    <xsd:documentation>

      @Target({METHOD}) @Retention(RUNTIME)
      public @interface PostRemove {}

    </xsd:documentation>
  </xsd:annotation>
  <xsd:sequence>
    <xsd:element name="description" type="xsd:string" minOccurs="0"/>
  </xsd:sequence>
  <xsd:attribute name="method-name" type="xsd:string" use="required"/>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="post-update">
  <xsd:annotation>
    <xsd:documentation>

      @Target({METHOD}) @Retention(RUNTIME)
      public @interface PostUpdate {}

    </xsd:documentation>
  </xsd:annotation>
  <xsd:sequence>
    <xsd:element name="description" type="xsd:string" minOccurs="0"/>
  </xsd:sequence>
  <xsd:attribute name="method-name" type="xsd:string" use="required"/>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="pre-persist">
  <xsd:annotation>
    <xsd:documentation>

      @Target({METHOD}) @Retention(RUNTIME)
      public @interface PrePersist {}

    </xsd:documentation>
  </xsd:annotation>
  <xsd:sequence>
    <xsd:element name="description" type="xsd:string" minOccurs="0"/>
  </xsd:sequence>
  <xsd:attribute name="method-name" type="xsd:string" use="required"/>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="pre-remove">
  <xsd:annotation>
    <xsd:documentation>

      @Target({METHOD}) @Retention(RUNTIME)
      public @interface PreRemove {}

    </xsd:documentation>
  </xsd:annotation>
  <xsd:sequence>
    <xsd:element name="description" type="xsd:string" minOccurs="0"/>
  </xsd:sequence>

```

```

    <xsd:attribute name="method-name" type="xsd:string" use="required"/>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="pre-update">
  <xsd:annotation>
    <xsd:documentation>

        @Target({METHOD}) @Retention(RUNTIME)
        public @interface PreUpdate {}

    </xsd:documentation>
  </xsd:annotation>
  <xsd:sequence>
    <xsd:element name="description" type="xsd:string" minOccurs="0"/>
  </xsd:sequence>
  <xsd:attribute name="method-name" type="xsd:string" use="required"/>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="primary-key-join-column">
  <xsd:annotation>
    <xsd:documentation>

        @Repeatable(PrimaryKeyJoinColumns.class)
        @Target({TYPE, METHOD, FIELD}) @Retention(RUNTIME)
        public @interface PrimaryKeyJoinColumn {
            String name() default "";
            String referencedColumnName() default "";
            String columnDefinition() default "";
            String options() default "";
            ForeignKey foreignKey() default @ForeignKey(PROVIDER_DEFAULT);
        }

    </xsd:documentation>
  </xsd:annotation>
  <xsd:sequence>
    <xsd:element name="foreign-key" type="orm:foreign-key"
        minOccurs="0"/>
  </xsd:sequence>
  <xsd:attribute name="name" type="xsd:string"/>
  <xsd:attribute name="referenced-column-name" type="xsd:string"/>
  <xsd:attribute name="column-definition" type="xsd:string"/>
  <xsd:attribute name="options" type="xsd:string"/>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="query-hint">
  <xsd:annotation>
    <xsd:documentation>

        @Target({}) @Retention(RUNTIME)
        public @interface QueryHint {
            String name();
            String value();
        }

    </xsd:documentation>
  </xsd:annotation>
  <xsd:sequence>
    <xsd:element name="description" type="xsd:string" minOccurs="0"/>
  </xsd:sequence>
  <xsd:attribute name="name" type="xsd:string" use="required"/>
  <xsd:attribute name="value" type="xsd:string" use="required"/>

```



```
</xsd:complexType>
```

```
<!-- ***** -->
```

```
<xsd:complexType name="secondary-table">
```

```
<xsd:annotation>
```

```
<xsd:documentation>
```

```
@Repeatable(SecondaryTables.class)
@Target({TYPE}) @Retention(RUNTIME)
public @interface SecondaryTable {
    String name();
    String catalog() default "";
    String schema() default "";
    PrimaryKeyJoinColumn[] pkJoinColumns() default {};
    ForeignKey foreignKey() default @ForeignKey(ConstraintMode.PROVIDER_DEFAULT);
    UniqueConstraint[] uniqueConstraints() default {};
    Index[] indexes() default {};
    CheckConstraint[] check() default {};
    String comment() default "";
    String options() default "";
}
```

```
</xsd:documentation>
```

```
</xsd:annotation>
```

```
<xsd:sequence>
```

```
<xsd:sequence>
```

```
<xsd:element name="comment" type="xsd:string" minOccurs="0" />
```

```
<xsd:element name="primary-key-join-column"
    type="orm:primary-key-join-column"
    minOccurs="0" maxOccurs="unbounded"/>
```

```
<xsd:element name="primary-key-foreign-key"
    type="orm:foreign-key"
    minOccurs="0"/>
```

```
</xsd:sequence>
```

```
<xsd:element name="unique-constraint" type="orm:unique-constraint"
    minOccurs="0" maxOccurs="unbounded"/>
```

```
<xsd:element name="index" type="orm:index"
    minOccurs="0" maxOccurs="unbounded"/>
```

```
<xsd:element name="foreign-key" type="orm:foreign-key"
    minOccurs="0"/>
```

```
<xsd:element name="check-constraint" type="orm:check-constraint"
    minOccurs="0" maxOccurs="unbounded"/>
```

```
</xsd:sequence>
```

```
<xsd:attribute name="name" type="xsd:string" use="required"/>
```

```
<xsd:attribute name="catalog" type="xsd:string"/>
```

```
<xsd:attribute name="schema" type="xsd:string"/>
```

```
<xsd:attribute name="options" type="xsd:string"/>
```

```
</xsd:complexType>
```

```
<!-- ***** -->
```

```
<xsd:complexType name="sequence-generator">
```

```
<xsd:annotation>
```

```
<xsd:documentation>
```

```
@Repeatable(SequenceGenerators.class)
@Target({TYPE, METHOD, FIELD, PACKAGE}) @Retention(RUNTIME)
public @interface SequenceGenerator {
    String name() default "";
    String sequenceName() default "";
    String catalog() default "";
    String schema() default "";
    int initialValue() default 1;
    int allocationSize() default 50;
    String options() default "";
}
```

```

        </xsd:documentation>
    </xsd:annotation>
    <xsd:sequence>
        <xsd:element name="description" type="xsd:string" minOccurs="0"/>
    </xsd:sequence>
    <xsd:attribute name="name" type="xsd:string"/>
    <xsd:attribute name="sequence-name" type="xsd:string"/>
    <xsd:attribute name="catalog" type="xsd:string"/>
    <xsd:attribute name="schema" type="xsd:string"/>
    <xsd:attribute name="initial-value" type="xsd:int"/>
    <xsd:attribute name="allocation-size" type="xsd:int"/>
    <xsd:attribute name="options" type="xsd:string"/>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="sql-result-set-mapping">
    <xsd:annotation>
        <xsd:documentation>

            @Repeatable(SqlResultSetMappings.class)
            @Target({TYPE}) @Retention(RUNTIME)
            public @interface SqlResultSetMapping {
                String name();
                EntityResult[] entities() default {};
                ConstructorResult[] classes() default{};
                ColumnResult[] columns() default {};
            }

        </xsd:documentation>
    </xsd:annotation>
    <xsd:sequence>
        <xsd:element name="description" type="xsd:string" minOccurs="0"/>
        <xsd:element name="entity-result" type="orm:entity-result"
            minOccurs="0" maxOccurs="unbounded"/>
        <xsd:element name="constructor-result" type="orm:constructor-result"
            minOccurs="0" maxOccurs="unbounded"/>
        <xsd:element name="column-result" type="orm:column-result"
            minOccurs="0" maxOccurs="unbounded"/>
    </xsd:sequence>
    <xsd:attribute name="name" type="xsd:string" use="required"/>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="stored-procedure-parameter">
    <xsd:annotation>
        <xsd:documentation><![CDATA[

            @Target({}) @Retention(RUNTIME)
            public @interface StoredProcedureParameter {
                String name() default "";
                ParameterMode mode() default ParameterMode.IN;
                Class<?> type();
            }

        ]]></xsd:documentation>
    </xsd:annotation>
    <xsd:sequence>
        <xsd:element name="description" type="xsd:string"
            minOccurs="0"/>
    </xsd:sequence>
    <xsd:attribute name="name" type="xsd:string"/>
    <xsd:attribute name="class" type="xsd:string" use="required"/>
    <xsd:attribute name="mode" type="orm:parameter-mode"/>
</xsd:complexType>

```

```

<!-- ***** -->
<xsd:complexType name="table">
  <xsd:annotation>
    <xsd:documentation>

      @Target({TYPE}) @Retention(RUNTIME)
      public @interface Table {
        String name() default "";
        String catalog() default "";
        String schema() default "";
        UniqueConstraint[] uniqueConstraints() default {};
        Index[] indexes() default {};
        CheckConstraint[] check() default {};
        String comment() default "";
        String options() default "";
      }

    </xsd:documentation>
  </xsd:annotation>
  <xsd:sequence>
    <xsd:element name="comment" type="xsd:string" minOccurs="0" />
    <xsd:element name="unique-constraint" type="orm:unique-constraint"
      minOccurs="0" maxOccurs="unbounded"/>
    <xsd:element name="index" type="orm:index"
      minOccurs="0" maxOccurs="unbounded"/>
    <xsd:element name="check-constraint" type="orm:check-constraint"
      minOccurs="0" maxOccurs="unbounded"/>
  </xsd:sequence>
  <xsd:attribute name="name" type="xsd:string"/>
  <xsd:attribute name="catalog" type="xsd:string"/>
  <xsd:attribute name="schema" type="xsd:string"/>
  <xsd:attribute name="options" type="xsd:string"/>
</xsd:complexType>

<!-- ***** -->

<xsd:complexType name="table-generator">
  <xsd:annotation>
    <xsd:documentation>

      @Repeatable(TableGenerators.class)
      @Target({TYPE, METHOD, FIELD, PACKAGE}) @Retention(RUNTIME)
      public @interface TableGenerator {
        String name() default "";
        String table() default "";
        String catalog() default "";
        String schema() default "";
        String pkColumnName() default "";
        String valueColumnName() default "";
        String pkColumnValue() default "";
        int initialValue() default 0;
        int allocationSize() default 50;
        UniqueConstraint[] uniqueConstraints() default {};
        Indexes[] indexes() default {};
        String options() default "";
      }

    </xsd:documentation>
  </xsd:annotation>
  <xsd:sequence>
    <xsd:element name="description" type="xsd:string" minOccurs="0"/>
    <xsd:element name="unique-constraint" type="orm:unique-constraint"
      minOccurs="0" maxOccurs="unbounded"/>
    <xsd:element name="index" type="orm:index"
      minOccurs="0" maxOccurs="unbounded"/>
  </xsd:sequence>

```

```

        <xsd:element name="check-constraint" type="orm:check-constraint"
            minOccurs="0" maxOccurs="unbounded"/>
    </xsd:sequence>
    <xsd:attribute name="name" type="xsd:string"/>
    <xsd:attribute name="table" type="xsd:string"/>
    <xsd:attribute name="catalog" type="xsd:string"/>
    <xsd:attribute name="schema" type="xsd:string"/>
    <xsd:attribute name="pk-column-name" type="xsd:string"/>
    <xsd:attribute name="value-column-name" type="xsd:string"/>
    <xsd:attribute name="pk-column-value" type="xsd:string"/>
    <xsd:attribute name="initial-value" type="xsd:int"/>
    <xsd:attribute name="allocation-size" type="xsd:int"/>
    <xsd:attribute name="options" type="xsd:string"/>
</xsd:complexType>

<!-- ***** -->

<xsd:simpleType name="temporal">
    <xsd:annotation>
        <xsd:documentation>

            @Target({METHOD, FIELD}) @Retention(RUNTIME)
            public @interface Temporal {
                TemporalType value();
            }

        </xsd:documentation>
    </xsd:annotation>
    <xsd:restriction base="orm:temporal-type"/>
</xsd:simpleType>

<!-- ***** -->

<xsd:simpleType name="temporal-type">
    <xsd:annotation>
        <xsd:documentation>

            @Deprecated(since = "3.2")
            public enum TemporalType {
                DATE, // java.sql.Date
                TIME, // java.sql.Time
                TIMESTAMP // java.sql.Timestamp
            }

        </xsd:documentation>
    </xsd:annotation>
    <xsd:restriction base="xsd:token">
        <xsd:enumeration value="DATE"/>
        <xsd:enumeration value="TIME"/>
        <xsd:enumeration value="TIMESTAMP"/>
    </xsd:restriction>
</xsd:simpleType>

<!-- ***** -->

<xsd:complexType name="transient">
    <xsd:annotation>
        <xsd:documentation>

            @Target({METHOD, FIELD}) @Retention(RUNTIME)
            public @interface Transient {}

        </xsd:documentation>
    </xsd:annotation>
    <xsd:attribute name="name" type="xsd:string" use="required"/>
</xsd:complexType>

```

```

<!-- ***** -->
<xsd:complexType name="unique-constraint">
  <xsd:annotation>
    <xsd:documentation>

      @Target({}) @Retention(RUNTIME)
      public @interface UniqueConstraint {
        String name() default "";
        String[] columnNames();
        String options() default "";
      }

    </xsd:documentation>
  </xsd:annotation>
  <xsd:sequence>
    <xsd:element name="column-name" type="xsd:string"
      maxOccurs="unbounded"/>
  </xsd:sequence>
  <xsd:attribute name="name" type="xsd:string"/>
  <xsd:attribute name="options" type="xsd:string"/>
</xsd:complexType>

<!-- ***** -->
<xsd:complexType name="version">
  <xsd:annotation>
    <xsd:documentation>

      @Target({METHOD, FIELD}) @Retention(RUNTIME)
      public @interface Version {}

    </xsd:documentation>
  </xsd:annotation>
  <xsd:sequence>
    <xsd:element name="column" type="orm:column" minOccurs="0"/>
    <xsd:element name="temporal" type="orm:temporal" minOccurs="0"/>
  </xsd:sequence>
  <xsd:attribute name="name" type="xsd:string" use="required"/>
  <xsd:attribute name="access" type="orm:access-type"/>
</xsd:complexType>

</xsd:schema>

```

Related Documents

- [1] Jakarta Persistence, v. 2.2. <https://jakarta.ee/specifications/persistence/2.2/>.
- [2] SQL 2003, Part 2, Foundation (SQL/Foundation). ISO/IEC 9075-2:2003.
- [3] JDBC 4.3 Specification. <http://jcp.org/en/jsr/detail?id=221>.
- [4] Enterprise JavaBeans, v. 2.1.
- [5] Jakarta Bean Validation, v. 3.0. <https://jakarta.ee/specifications/bean-validation/3.0/>.
- [6] Jakarta EE Platform, v. 9.0. <https://jakarta.ee/specifications/platform/9/>.
- [7] Jakarta Contexts and Dependency Injection, v 3.0. <https://jakarta.ee/specifications/cdi/3.0/>.

Appendix A: Revision History

This appendix lists the significant changes that have been made during the development of the Jakarta Persistence specification.

A.1. Jakarta Persistence 3.2

Added support for Java record types as embeddable classes

Added support for `java.time.Instant` and `java.time.Year` and clarified JDBC mappings for basic types

Added `union`, `intersect`, `except`, `cast`, `left`, `right`, and `replace` for Jakarta Persistence QL and criteria queries

Added `||` string concatenation operator and `id` and `version` functions to Jakarta Persistence QL

Added `CriteriaSelect` to the Criteria API

Added `extract()` to `CriteriaBuilder`

Added `subquery(EntityType)` to `CommonAbstractCriteria`

Added support for specifying null precedence when ordering Jakarta Persistence QL and criteria queries

Added `getSingleResultOrNull()` to `Query`, `TypedQuery`, `StoredProcedureQuery`

Added `entities()`, `classes()` and `columns()` to `NamedNativeQuery`

Added `lockMode()` to `EntityResult` with the default being `OPTIMISTIC`

Added `getVersion()`, `isLoading()`, `load()`, `isInstance()` and `getClass()` methods to `PersistenceUnitUtil`

Added overload of `entity()` accepting an entity name to `Metamodel`

Added `javax.annotation.processing.Generated` to the list of defined annotations on `StaticMetamodel`

Added joins on `EntityTypes`

Added constants for managed types, named queries, named graphs and named result set mappings to generated `StaticMetamodel`

Added `LocalDateTime` and `Instant` to supported `Version` types

Added `where()`, `having()`, `and()`, `or()`, `array()`, `tuple()` overloads accepting `List` to `CriteriaQuery` and `CriteriaBuilder`

Added `equalTo()` and `notEqualTo()` to `Expression`

Added `concat()` overload accepting list of expressions to `CriteriaBuilder`

Added `Graph` interface as parent of `EntityGraph` and `Subgraph` and moved common operations there

Added `addAttributeNode()`, `removeAttributeNode()`, `addTreatedSubgraph()`, `addElementSubgraph()`, `addTreatedElementSubgraph()`, `addMapKeySubgraph()`, and `addTreatedMapKeySubgraph()` methods to `Graph`

Added `find()`, `refresh()`, `lock()` overloads to `EntityManager` taking newly introduced `FindOptions`, `RefreshOptions`, and `LockOptions` respectively

Added `setCacheStoreMode()`, and `setCacheRetrieveMode()` methods to `EntityManager` and `Query`

Added `getReference` overload to `EntityManager`

Added `runWithConnection()` and `callWithConnection()` to `EntityManager`

Added `runInTransaction()` and `callInTransaction()` to `EntityManagerFactory`

Added `getName()` to `EntityManagerFactory`

Added `setTimeout(Integer)` and `getTimeout()` to `EntityTransaction`

Added programmatic API to obtain `EntityManagerFactory` using `PersistenceConfiguration`

Added constants for properties defined by the specification to the `PersistenceConfiguration`

Added `SchemaManager` API

Added options member to elements which result in DDL generation

Added `EnumeratedValue` allowing custom mapping of fields of Java enums

Added `comment` and `check` members to `@Table` and `@Column` annotations, along with `@CheckConstraint`

Added `secondPrecision` to `@Column` annotation and clarified semantics of `@Column` members

Added factory-level access to named queries and named entity graphs, along with `TypedQueryReference`

Added integration points for dependency injection

Allowed scalar expressions in the `ORDER BY` clause in Jakarta Persistence QL

Made the `name` member of `TableGenerator` and `SequenceGenerator` optional and allow usage of these annotations at the java package level

Made identification variables and the `SELECT` clause in Jakarta Persistence QL optional

Clarified the primary key types supported for each `GenerationType`

Clarified availability of `SEQUENCE`, `TABLE` and `UUID` generated IDs on `PrePersist`

Clarified semantics of numeric literals and numeric type promotions, and added support for `bi` and `bd` suffixes

Clarified semantics of `Convert/Converter` annotations

Clarified rules around distinction of entity names and identification variables and case-sensitivity in Jakarta Persistence QL queries

Clarified the semantics of `Bindable.ENTITY_TYPE` in javadoc

Clarified the semantics of collection-valued query parameters

Entity and embeddable classes may now be static inner classes

Primary key classes are no longer required to be public and serializable

Pulled `getParameters()` up from `CriteriaQuery` to `CommonAbstractCriteria`

Updated persistence and object/relational mapping schemas

Fixed wildcard types in `addSubgraph` and `addAttributeNode` in `Graph`

Fixed lower type bounds to the `Path.get` entity argument `X`

Fixed example code in the javadoc of `AttributeOverrides`

Fixed `maxOccurs` of the version element in ORM schema to allow at most one element

Partially fixed raw types warnings through the API

Improved AsciiDoc formatting and fixed typos through the specification document

A.1.1. Deprecations

Deprecated usage of `Calendar`, `Date`, `Time`, `Timestamp`, `Temporal`, `MapKeyTemporal` and `TemporalType` in new applications in favour of `java.time` API

Deprecated use of `Byte[]` and `Character[]` arrays types for basic attributes, in favor of primitive array types

Deprecated `multiselect` methods in `CriteriaQuery`. The preference is to use `array` or `tuple` method defined in `CriteriaBuilder`

A.1.2. Deprecations for removal

Deprecated `addSubclassSubgraph()` in `EntityGraph` for removal; `addTreatedSubgraph()` method should be used as direct replacement

Deprecated `addSubgraph(Attribute, Class)` and `addKeySubgraph()` in `Graph/EntityGraph/SubGraph` for removal; `addTreatedSubgraph(Attribute, Class)` and `addMapKeySubgraph()` methods should be used as direct replacements

Deprecated `jakarta.persistence.spi.PersistenceUnitTransactionType` for removal; `jakarta.persistence.PersistenceUnitTransactionType` methods should be used as direct replacement

Deprecated default public no-arg constructor in `jakarta.persistence.Persistence` and `PERSISTENCE_PROVIDER` and `providers` fields in this class for removal with no replacement. This class is not designed for extensibility

A.2. Jakarta Persistence 3.1

`EntityManagerFactory` and `EntityManager` interfaces extend `java.lang.AutoCloseable` interface

Fixed `ClassTransformer.transform` to throw Persistence API specific exception

Added support for `java.util.UUID` and `GenerationType.UUID`

Added `CEILING`, `EXP`, `FLOOR`, `LN`, `POWER`, `ROUND`, and `SIGN` numeric functions to Jakarta Persistence QL and `ceiling()`, `exp()`, `floor()`, `ln()`, `power()`, `round()`, and `sign()` to Criteria API

Added `LOCAL DATE`, `LOCAL DATETIME`, and `LOCAL TIME` functions to Jakarta Persistence QL and corresponding `localDate()`, `localDateTime()`, and `localTime()` to Criteria API

Added `EXTRACT` function to Jakarta Persistence QL

Added support for Expressions as conditions in Criteria CASE expressions

Clarified mixing types of query input parameters

Added missing definition of `single_valued_embeddable_object_field` in Jakarta Persistence QL BNF

Clarified definition of the `Basic` type

Clarified the order of parameters in the `LOCATE` function

Clarified `SqlResultSetMapping` with multiple `EntityResults` and conflicting aliases

A.3. Jakarta Persistence 3.0

Created document from Java Persistence 2.2 Final Release specification.

The document was converted to AsciiDoc format.

Packages of all API classes were changed to `jakarta.persistence`. These changes are reflected in the specification document.

Schema namespaces were changed from <http://xmlns.jcp.org/xml/ns/persistence> and <http://xmlns.jcp.org/xml/ns/persistence/orm> to <https://jakarta.ee/xml/ns/persistence> and <https://jakarta.ee/xml/ns/persistence/orm>

References to schema versions lower than 2.2 were removed.

A.4. Java Persistence 2.2 (Maintenance Release Draft)

Created document from Java Persistence 2.1 Final Release specification.

The following annotations have been marked `@Repeatable`:

- `AssociationOverride`
- `AttributeOverride`
- `Convert`
- `JoinColumn`
- `MapKeyJoinColumn`
- `NamedEntityGraph`
- `NamedNativeQuery`
- `NamedQuery`
- `NamedStoredProcedureQuery`
- `PersistenceContext`
- `PersistenceUnit`
- `PrimaryKeyJoinColumn`
- `SecondaryTable`
- `SqlResultSetMapping`
- `SequenceGenerator`
- `TableGenerator`

Added `SequenceGenerators` and `TableGenerators` annotations.

Added support for CDI injection into `AttributeConverter` classes.

Added support for the mapping of the following `java.time` types:

- `java.time.LocalDate`
- `java.time.LocalDateTime`
- `java.time.LocalTime`
- `java.time.OffsetTime`
- `java.time.OffsetDateTime`

Added default `Stream getResultStream()` method to `Query` interface.

Added default `Stream<X> getResultStream()` method to `TypedQuery` interface.

Replaced reference to JAR file specification in persistence provider bootstrapping section with more general reference to Java SE service provider requirements.

Updated `persistence.xml` and `orm.xml` schemas to 2.2 versions.

Updated Related Documents.

Appendix B: Persistence API Interfaces

The following APIs are defined in the package `jakarta.persistence`.

B.1. EntityManager

```
package jakarta.persistence;

import java.util.Map;
import java.util.List;

import jakarta.persistence.criteria.CriteriaSelect;
import jakarta.persistence.metamodel.Metamodel;
import jakarta.persistence.criteria.CriteriaBuilder;
import jakarta.persistence.criteria.CriteriaQuery;
import jakarta.persistence.criteria.CriteriaUpdate;
import jakarta.persistence.criteria.CriteriaDelete;

/**
 * Interface used to interact with the persistence context.
 *
 * <p>An instance of {@code EntityManager} must be obtained from
 * an {@link EntityManagerFactory}, and is only able to manage
 * persistence of entities belonging to the associated persistence
 * unit.
 *
 * <p>An application-managed {@code EntityManager} may be created
 * via a call to {@link EntityManagerFactory#createEntityManager()}.
 * The {@code EntityManager} must be explicitly closed via a call
 * to {@link #close()}, to allow resources to be cleaned up by the
 * persistence provider. This approach places almost complete
 * responsibility for cleanup and exception management on the client,
 * and is thus considered quite error-prone. It is much safer to use
 * the methods {@link EntityManagerFactory#runInTransaction} and
 * {@link EntityManagerFactory#callInTransaction}.
 * {@snippet :
 * entityManagerFactory.runInTransaction(entityManager -> {
 *     // do work in a persistence context
 *     ...
 * });
 * }
 *
 * <p>In the Jakarta EE environment, a container-managed
 * {@link EntityManager} may be obtained by dependency injection,
 * using {@link PersistenceContext}.
 * {@snippet :
 * // inject the container-managed entity manager
 * @PersistenceContext(unitName="orderMgt")
 * EntityManager entityManager;
 * }
 *
 * <p>If the persistence unit has
 * {@linkplain PersistenceUnitTransactionType#RESOURCE_LOCAL
 * resource local} transaction management, transactions must
 * be managed using the {@link EntityTransaction} obtained by
 * calling {@link #getTransaction()}.
 *
 * <p>A complete idiom for custom application management of
 * the {@link EntityManager} and its associated resource-local
 * {@link EntityTransaction} is as follows:
 * {@snippet :
 * EntityManager entityManager = entityManagerFactory.createEntityManager();
 * EntityTransaction transaction = entityManager.getTransaction();
 * try {
```

```

*     transaction.begin();
*     // do work
*     ...
*     transaction.commit();
* }
* catch (Exception e) {
*     if (transaction.isActive()) transaction.rollback();
*     throw e;
* }
* finally {
*     entityManager.close();
* }
* }
*
* <p>Each EntityManager instance is associated with a
* distinct persistence context. A persistence context
* is a set of entity instances in which for any given persistent
* entity identity (defined by an entity type and primary key)
* there is at most one entity instance. The entity instances
* associated with a persistence context are considered managed
* objects, with a well-defined lifecycle under the control of
* the persistence provider.
*
* <p>Any entity instance can be characterized as being in one of
* the following lifecycle states:
* <ul>
* <li>A new entity has no persistent identity, and is
* not yet associated with any persistence context.
* <li>A managed entity is an instance with a persistent
* identity that is currently associated with a persistence
* context.
* <li>A detached entity is an instance with a persistent
* identity that is not (or no longer) associated with any
* active persistence context.
* <li>A removed entity is an instance with a persistent
* identity, and associated with a persistence context, that
* is scheduled for removal from the database upon transaction
* commit.
* </ul>
*
* <p>The EntityManager API is used to perform operations
* that affect the state of the persistence context, or that modify
* the lifecycle state of individual entity instances. The client
* may persist and remove instances,
* find(Class, Object) entities by their primary
* key, and execute createQuery(String) queries which
* range over entity types. An entity may be disassociated from
* the persistence context by calling detach, and a
* persistence context may be completely cleared, detaching all
* its entities, by calling clear().
*
* <p>The client may also make changes to the state of an entity
* instance by mutating the entity directly, or it may request
* that the state of a detached instance be merge
* merged}, replacing the state of a managed instance with the
* same persistent identity. Note that there is no explicit
* "update" operation; since an entity is a managed object,
* modifications to its persistent fields and properties are
* automatically detected, as long as it is associated with an
* active persistence context.
*
* <p>Modifications to the state of entities associated with a
* persistence context are not immediately synchronized with the
* database. Synchronization happens during a process called
* flush. The timing of the flush process depends on the
* FlushModeType flush mode, which may be set
* explicitly by calling setFlushMode(FlushModeType).

```

```

* <ul>
* <li>For {@link FlushModeType#COMMIT}, the persistence context
*   is flushed before the transaction commits.
* <li>For {@link FlushModeType#AUTO}, which is the default, the
*   persistence context must also be flushed before execution
*   of any query whose result set would be affected by
*   unflushed modifications to entities associated with the
*   persistence context.
* </ul>
* The client may force an immediate flush to occur by calling
* {@link #flush()}.
*
* <p>At any given moment, a persistence context might hold an
* optimistic or pessimistic <em>lock</em> on an entity instance.
* The full range of possible lock types is enumerated by
* {@link LockModeType}. Some operations of this interface,
* including the methods {@link #lock(Object, LockModeType)},
* {@link #refresh(Object, LockModeType)}, and
* {@link #find(Class, Object, LockModeType)}, accept an explicit
* {@link LockModeType}, allowing the client to request a specific
* type of lock.
*
* <p>Interaction of the persistence context (or first-level cache)
* with the second-level cache, if any, may be controlled by
* calling {@link #setCacheRetrieveMode(CacheRetrieveMode)} and
* {@link #setCacheStoreMode(CacheStoreMode)}.
*
* <p>Some operations accept one or more built-in and vendor-specific
* options:
* <ul>
* <li>{@link #find(Class, Object, FindOption...)} and
*   {@link #find(EntityGraph, Object, FindOption...)} accept
*   {@link FindOption}s,
* <li>{@link #refresh(Object, RefreshOption...)} accepts
*   {@link RefreshOption}s, and
* <li>{@link #lock(Object, LockModeType, LockOption...)} accepts
*   {@link LockOption}s.
* </ul>
*
* @see Query
* @see TypedQuery
* @see CriteriaQuery
* @see PersistenceContext
* @see StoredProcedureQuery
* @see EntityManagerFactory
*
* @since 1.0
*/
public interface EntityManager extends AutoCloseable {

    /**
     * Make a new entity instance managed and persistent, resulting in
     * its insertion in the database when the persistence context is
     * synchronized with the database, or make a removed entity managed,
     * undoing the effect of a previous call to {@link #remove(Object)}.
     * This operation cascades to every entity related by an association
     * marked {@link CascadeType#PERSIST cascade=PERSIST}. If the given
     * entity instance is already managed, that is, if it already belongs
     * to this persistence context, and has not been marked for removal,
     * it is itself ignored, but the operation still cascades.
     * @param entity a new, managed, or removed entity instance
     * @throws EntityExistsException if the given entity is detached
     * (if the entity is detached, the {@code EntityExistsException}
     * may be thrown when the persist operation is invoked, or the
     * {@code EntityExistsException} or another {@code PersistenceException}
     * may be thrown at flush or commit time)
     * @throws IllegalArgumentException if the given instance is not an

```

```

*     entity
* @throws TransactionRequiredException if there is no transaction
*     when invoked on a container-managed entity manager that
*     is of type {@link PersistenceContextType#TRANSACTION}
*/
void persist(Object entity);

/**
 * Merge the state of the given new or detached entity instance
 * into the current persistence context, resulting in, respectively,
 * an insert or possible update when the persistence context is
 * synchronized with the database. Return a managed instance with
 * the same persistent state as the given entity instance, but a
 * distinct Java object identity. If the given entity is detached,
 * the returned entity has the same persistent identity. This
 * operation cascades to every entity related by an association
 * marked {@link CascadeType#MERGE cascade=MERGE}. If the given
 * entity instance is managed, that is, if it belongs to this
 * persistence context, and has not been marked for removal, it is
 * itself ignored, but the operation still cascades, and it is
 * returned directly.
 * @param entity a new, managed, or detached entity instance
 * @return the managed instance that the state was merged to
 * @throws IllegalArgumentException if the instance is not an entity
 *         or is a removed entity
 * @throws TransactionRequiredException if there is no transaction
 *         when invoked on a container-managed entity manager of
 *         that is of type {@link PersistenceContextType#TRANSACTION}
 */
<T> T merge(T entity);

/**
 * Mark a managed entity instance as removed, resulting in its deletion
 * from the database when the persistence context is synchronized with
 * the database. This operation cascades to every entity related by an
 * association marked {@link CascadeType#REMOVE cascade=REMOVE}. If the
 * given entity instance is already removed, it is ignored. If the
 * given entity is new, it is itself ignored, but the operation still
 * cascades.
 * @param entity a managed, new, or removed entity instance
 * @throws IllegalArgumentException if the instance is not an entity
 *         or is a detached entity
 * @throws TransactionRequiredException if invoked on a
 *         container-managed entity manager of type
 *         {@link PersistenceContextType#TRANSACTION} and there is
 *         no transaction
 */
void remove(Object entity);

/**
 * Find by primary key.
 * Search for an entity of the specified class and primary key.
 * If the entity instance is contained in the persistence context,
 * it is returned from there.
 * @param entityClass entity class
 * @param primaryKey primary key
 * @return the found entity instance or null if the entity does
 *         not exist
 * @throws IllegalArgumentException if the first argument does
 *         not denote an entity type or if the second argument is
 *         not a valid type for that entity's primary key or is
 *         null
 */
<T> T find(Class<T> entityClass, Object primaryKey);

/**
 * Find by primary key, using the specified properties.

```

```

* Search for an entity of the specified class and primary key.
* If the entity instance is contained in the persistence
* context, it is returned from there.
* If a vendor-specific property or hint is not recognized,
* it is silently ignored.
* @param entityClass entity class
* @param primaryKey primary key
* @param properties standard and vendor-specific properties
* and hints
* @return the found entity instance or null if the entity does
* not exist
* @throws IllegalArgumentException if the first argument does
* not denote an entity type or if the second argument
* is not a valid type for that entity's primary key or
* is null
* @since 2.0
*/
<T> T find(Class<T> entityClass, Object primaryKey,
           Map<String, Object> properties);

/**
* Find by primary key and obtain the given lock type for the
* resulting entity. Search for an entity of the specified class and
* primary key, and lock it with respect to the specified lock type.
* If the entity instance is contained in the persistence context,
* it is returned from there, and the effect of this method is the
* same as if the {@link #lock} method had been called on the entity.
* <p> If the entity is found within the persistence context and
* the lock mode type is pessimistic and the entity has a version
* attribute, the persistence provider must perform optimistic
* version checks when obtaining the database lock. If these checks
* fail, the {@link OptimisticLockException} is thrown.
* <p>If the lock mode type is pessimistic and the entity instance
* is found but cannot be locked:
* <ul>
* <li>the {@link PessimisticLockException} is thrown if the
* database locking failure causes transaction-level rollback
* <li>the {@link LockTimeoutException} is thrown if the database
* locking failure causes only statement-level rollback
* </ul>
* @param entityClass entity class
* @param primaryKey primary key
* @param lockMode lock mode
* @return the found entity instance or null if the entity does
* not exist
* @throws IllegalArgumentException if the first argument does
* not denote an entity type or the second argument is
* not a valid type for that entity's primary key or
* is null
* @throws TransactionRequiredException if there is no
* transaction and a lock mode other than {@code NONE} is
* specified or if invoked on an entity manager which has
* not been joined to the current transaction and a lock
* mode other than {@code NONE} is specified
* @throws OptimisticLockException if the optimistic version
* check fails
* @throws PessimisticLockException if pessimistic locking
* fails and the transaction is rolled back
* @throws LockTimeoutException if pessimistic locking fails and
* only the statement is rolled back
* @throws PersistenceException if an unsupported lock call is made
* @since 2.0
*/
<T> T find(Class<T> entityClass, Object primaryKey,
           LockModeType lockMode);

/**

```



```

* Find by primary key and lock the entity, using the specified
* properties. Search for an entity of the specified class and
* primary key, and lock it with respect to the specified lock type.
* If the entity instance is contained in the persistence context,
* it is returned from there.
* <p>If the entity is found within the persistence context and
* the lock mode type is pessimistic and the entity has a version
* attribute, the persistence provider must perform optimistic
* version checks when obtaining the database lock. If these checks
* fail, the {@link OptimisticLockException} is thrown.
* <p>If the lock mode type is pessimistic and the entity instance
* is found but cannot be locked:
* <ul>
* <li>the {@link PessimisticLockException} is thrown if the
*     database locking failure causes transaction-level rollback
* <li>the {@link LockTimeoutException} is thrown if the database
*     locking failure causes only statement-level rollback
* </ul>
* <p>If a vendor-specific property or hint is not recognized,
* it is silently ignored.
* <p>Portable applications should not rely on the standard
* timeout hint. Depending on the database in use and the locking
* mechanisms used by the provider, the hint may or may not be
* observed.
* @param entityClass  entity class
* @param primaryKey  primary key
* @param lockMode    lock mode
* @param properties  standard and vendor-specific properties
*                   and hints
* @return the found entity instance or null if the entity does
*         not exist
* @throws IllegalArgumentException if the first argument does
*         not denote an entity type or the second argument is
*         not a valid type for that entity's primary key or
*         is null
* @throws TransactionRequiredException if there is no
*         transaction and a lock mode other than {@code NONE} is
*         specified or if invoked on an entity manager which has
*         not been joined to the current transaction and a lock
*         mode other than {@code NONE} is specified
* @throws OptimisticLockException if the optimistic version check
*         fails
* @throws PessimisticLockException if pessimistic locking fails
*         and the transaction is rolled back
* @throws LockTimeoutException if pessimistic locking fails and
*         only the statement is rolled back
* @throws PersistenceException if an unsupported lock call is made
* @since 2.0
*/
<T> T find(Class<T> entityClass, Object primaryKey,
           LockModeType lockMode,
           Map<String, Object> properties);

/**
* Find an instance of the given entity class by primary key,
* using the specified {@linkplain FindOption options}.
* Search for an entity with the specified class and primary key.
* If the given options include a {@link LockModeType}, lock it
* with respect to the specified lock type.
* If the entity instance is contained in the persistence context,
* it is returned from there.
* <p>If the entity is found within the persistence context and
* the lock mode type is pessimistic and the entity has a version
* attribute, the persistence provider must perform optimistic
* version checks when obtaining the database lock. If these checks
* fail, the {@code OptimisticLockException} is thrown.
* <p>If the lock mode type is pessimistic and the entity instance

```

```

* is found but cannot be locked:
* <ul>
* <li>the {@code PessimisticLockException} is thrown if the
*     database locking failure causes transaction-level
*     rollback
* </li>the {@code LockTimeoutException} is thrown if the database
*     locking failure causes only statement-level rollback
* </ul>
* <p>If a vendor-specific {@linkplain FindOption option} is not
* recognized, it is silently ignored.
* <p>Portable applications should not rely on the standard
* {@linkplain Timeout timeout option}. Depending on the database
* in use and the locking mechanisms used by the provider, this
* option may or may not be observed.
* @param entityClass  entity class
* @param primaryKey  primary key
* @param options      standard and vendor-specific options
* @return the found entity instance or null if the entity does
*         not exist
* @throws IllegalArgumentException if there are contradictory
*         options, if the first argument does not denote an entity
*         type belonging to the persistence unit, or if the second
*         argument is not a valid non-null instance of the entity
*         primary key type
* @throws TransactionRequiredException if there is no transaction
*         and a lock mode other than {@code NONE} is
*         specified or if invoked on an entity manager which has
*         not been joined to the current transaction and a lock
*         mode other than {@code NONE} is specified
* @throws OptimisticLockException if the optimistic version check
*         fails
* @throws PessimisticLockException if pessimistic locking fails
*         and the transaction is rolled back
* @throws LockTimeoutException if pessimistic locking fails and
*         only the statement is rolled back
* @throws PersistenceException if an unsupported lock call is made
* @since 3.2
*/
<T> T find(Class<T> entityClass, Object primaryKey,
           FindOption... options);

/**
* Find an instance of the root entity of the given {@link EntityGraph}
* by primary key, using the specified {@linkplain FindOption options},
* and interpreting the {@code EntityGraph} as a load graph.
* Search for an entity with the specified type and primary key.
* If the given options include a {@link LockModeType}, lock it
* with respect to the specified lock type.
* If the entity instance is contained in the persistence context,
* it is returned from there.
* <p> If the entity is found within the persistence context and
* the lock mode type is pessimistic and the entity has a version
* attribute, the persistence provider must perform optimistic
* version checks when obtaining the database lock. If these checks
* fail, the {@code OptimisticLockException} is thrown.
* <p>If the lock mode type is pessimistic and the entity instance
* is found but cannot be locked:
* <ul>
* <li>the {@link PessimisticLockException} is thrown if the
*     database locking failure causes transaction-level rollback
* </li>the {@link LockTimeoutException} is thrown if the database
*     locking failure causes only statement-level rollback
* </ul>
* <p>If a vendor-specific {@linkplain FindOption option} is not
* recognized, it is silently ignored.
* <p>Portable applications should not rely on the standard
* {@linkplain Timeout timeout option}. Depending on the database

```

```

* in use and the locking mechanisms used by the provider, this
* option may or may not be observed.
* @param entityGraph entity graph interpreted as a load graph
* @param primaryKey primary key
* @param options standard and vendor-specific options
* @return the found entity instance or null if the entity does
*         not exist
* @throws IllegalArgumentException if there are contradictory
*         options, if the first argument does not denote an entity
*         type belonging to the persistence unit, or if the second
*         argument is not a valid non-null instance of the entity
*         primary key type
* @throws TransactionRequiredException if there is no transaction
*         and a lock mode other than {@code NONE} is
*         specified or if invoked on an entity manager which has
*         not been joined to the current transaction and a lock
*         mode other than {@code NONE} is specified
* @throws OptimisticLockException if the optimistic version check
*         fails
* @throws PessimisticLockException if pessimistic locking fails
*         and the transaction is rolled back
* @throws LockTimeoutException if pessimistic locking fails and
*         only the statement is rolled back
* @throws PersistenceException if an unsupported lock call is made
* @since 3.2
*/
<T> T find(EntityGraph<T> entityGraph, Object primaryKey,
           FindOption... options);

/**
 * Obtain a reference to an instance of the given entity class
 * with the given primary key, whose state may be lazily fetched.
 * <p>If the requested instance does not exist in the database,
 * the {@link EntityNotFoundException} is thrown when the
 * instance state is first accessed.
 * (The persistence provider runtime is permitted but not
 * required to throw the {@code EntityNotFoundException} when
 * {@code getReference()} is called.)
 * <p>This operation allows the application to create an
 * association to an entity without loading its state from the
 * database.
 * <p>The application should not expect the instance state to
 * be available upon detachment, unless it was accessed by the
 * application while the entity manager was open.
 * @param entityClass entity class
 * @param primaryKey primary key
 * @return a reference to the entity instance
 * @throws IllegalArgumentException if the first argument does
 *         not denote an entity type or the second argument is
 *         not a valid type for that entity's primary key or
 *         is null
 * @throws EntityNotFoundException if the entity state cannot
 *         be accessed
 */
<T> T getReference(Class<T> entityClass, Object primaryKey);

/**
 * Obtain a reference to an instance of the entity class of the
 * given object, with the same primary key as the given object,
 * whose state may be lazily fetched. The given object may be
 * persistent or detached, but may be neither new nor removed.
 * <p>If the requested instance does not exist in the database,
 * the {@link EntityNotFoundException} is thrown when the
 * instance state is first accessed.
 * (The persistence provider runtime is permitted but not
 * required to throw the {@code EntityNotFoundException} when
 * {@code getReference()} is called.)

```

```

* <p>This operation allows the application to create an
* association to an entity without loading its state from the
* database.
* <p>The application should not expect the instance state to
* be available upon detachment, unless it was accessed by the
* application while the entity manager was open.
* @param entity a persistent or detached entity instance
* @return a reference to the entity instance
* @throws IllegalArgumentException if the given object is not
*         an entity, or if it is neither persistent nor detached
* @throws EntityNotFoundException if the entity state cannot be
*         accessed
* @since 3.2
*/
<T> T getReference(T entity);

/**
 * Synchronize changes held in the persistence context to the
 * underlying database.
 * @throws TransactionRequiredException if there is
 *         no transaction or if the entity manager has not been
 *         joined to the current transaction
 * @throws PersistenceException if the flush fails
 */
void flush();

/**
 * Set the {@linkplain FlushModeType flush mode} that applies to
 * all objects contained in the persistence context.
 * @param flushMode flush mode
 */
void setFlushMode(FlushModeType flushMode);

/**
 * Get the {@linkplain FlushModeType flush mode} that applies to
 * all objects contained in the persistence context.
 * @return the current {@link FlushModeType}
 */
FlushModeType getFlushMode();

/**
 * Lock an entity instance belonging to the persistence context,
 * obtaining the specified {@linkplain LockModeType lock mode}.
 * <p>If a pessimistic lock mode type is specified and the entity
 * contains a version attribute, the persistence provider must
 * also perform optimistic version checks when obtaining the
 * database lock. If these checks fail, the
 * {@link OptimisticLockException} is thrown.
 * <p>If the lock mode type is pessimistic and the entity instance
 * is found but cannot be locked:
 * <ul>
 * <li>the {@link PessimisticLockException} is thrown if the
 *         database locking failure causes transaction-level rollback
 * <li>the {@link LockTimeoutException} is thrown if the database
 *         locking failure causes only statement-level rollback
 * </ul>
 * @param entity a managed entity instance
 * @param lockMode lock mode
 * @throws IllegalArgumentException if the instance is not an
 *         entity or is a detached entity
 * @throws TransactionRequiredException if there is no
 *         transaction or if invoked on an entity manager which
 *         has not been joined to the current transaction
 * @throws EntityNotFoundException if the entity does not exist
 *         in the database when pessimistic locking is
 *         performed
 * @throws OptimisticLockException if the optimistic version check

```

```

*         fails
* @throws PessimisticLockException if pessimistic locking fails
*         and the transaction is rolled back
* @throws LockTimeoutException if pessimistic locking fails and
*         only the statement is rolled back
* @throws PersistenceException if an unsupported lock call is made
*/
void lock(Object entity, LockModeType lockMode);

/**
 * Lock an entity instance belonging to the persistence context,
 * obtaining the specified {@linkplain LockModeType lock mode},
 * using the specified properties.
 * <p>If a pessimistic lock mode type is specified and the entity
 * contains a version attribute, the persistence provider must
 * also perform optimistic version checks when obtaining the
 * database lock. If these checks fail, the
 * {@link OptimisticLockException} is thrown.
 * <p>If the lock mode type is pessimistic and the entity instance
 * is found but cannot be locked:
 * <ul>
 * <li>the {@link PessimisticLockException} is thrown if the
 *     database locking failure causes transaction-level rollback
 * <li>the {@link LockTimeoutException} is thrown if the database
 *     locking failure causes only statement-level rollback
 * </ul>
 * <p>If a vendor-specific property or hint is not recognized,
 * it is silently ignored.
 * <p>Portable applications should not rely on the standard
 * timeout hint. Depending on the database in use and the locking
 * mechanisms used by the provider, the hint may or may not be
 * observed.
 * @param entity a managed entity instance
 * @param lockMode lock mode
 * @param properties standard and vendor-specific properties
 *         and hints
 * @throws IllegalArgumentException if the instance is not an
 *         entity or is a detached entity
 * @throws TransactionRequiredException if there is no
 *         transaction or if invoked on an entity manager which
 *         has not been joined to the current transaction
 * @throws EntityNotFoundException if the entity does not exist
 *         in the database when pessimistic locking is performed
 * @throws OptimisticLockException if the optimistic version check
 *         fails
 * @throws PessimisticLockException if pessimistic locking fails
 *         and the transaction is rolled back
 * @throws LockTimeoutException if pessimistic locking fails and
 *         only the statement is rolled back
 * @throws PersistenceException if an unsupported lock call is made
 * @since 2.0
 */
void lock(Object entity, LockModeType lockMode,
          Map<String, Object> properties);

/**
 * Lock an entity instance belonging to the persistence context,
 * obtaining the specified {@linkplain LockModeType lock mode},
 * using the specified {@linkplain LockOption options}.
 * <p>If a pessimistic lock mode type is specified and the entity
 * contains a version attribute, the persistence provider must
 * also perform optimistic version checks when obtaining the
 * database lock. If these checks fail, the
 * {@link OptimisticLockException} is thrown.
 * <p>If the lock mode type is pessimistic and the entity instance
 * is found but cannot be locked:
 * <ul>

```

```

* <li>the {@link PessimisticLockException} is thrown if the
*     database locking failure causes transaction-level rollback
* </li>the {@link LockTimeoutException} is thrown if the database
*     locking failure causes only statement-level rollback
* </ul>
* <p>If a vendor-specific {@link LockOption} is not recognized,
* it is silently ignored.
* <p>Portable applications should not rely on the standard
* {@link Plain Timeout timeout option}. Depending on the database
* in use and the locking mechanisms used by the provider, the
* option may or may not be observed.
* @param entity a managed entity instance
* @param lockMode lock mode
* @param options standard and vendor-specific options
* @throws IllegalArgumentException if the instance is not an
*     entity or is a detached entity
* @throws TransactionRequiredException if there is no
*     transaction or if invoked on an entity manager which
*     has not been joined to the current transaction
* @throws EntityNotFoundException if the entity does not exist
*     in the database when pessimistic locking is
*     performed
* @throws OptimisticLockException if the optimistic version
*     check fails
* @throws PessimisticLockException if pessimistic locking fails
*     and the transaction is rolled back
* @throws LockTimeoutException if pessimistic locking fails and
*     only the statement is rolled back
* @throws PersistenceException if an unsupported lock call is made
* @since 3.2
*/

```

```

void lock(Object entity, LockModeType lockMode,
         LockOption... options);

```

```

/**
* Refresh the state of the given managed entity instance from
* the database, overwriting unflushed changes made to the entity,
* if any. This operation cascades to every entity related by an
* association marked {@link CascadeType#REFRESH cascade=REFRESH}.
* @param entity a managed entity instance
* @throws IllegalArgumentException if the instance is not
*     an entity or the entity is not managed
* @throws TransactionRequiredException if there is no
*     transaction when invoked on a container-managed
*     entity manager of type
*     {@link PersistenceContextType#TRANSACTION}
* @throws EntityNotFoundException if the entity no longer
*     exists in the database
*/

```

```

void refresh(Object entity);

```

```

/**
* Refresh the state of the given managed entity instance from
* the database, using the specified properties, and overwriting
* unflushed changes made to the entity, if any. This operation
* cascades to every entity related by an association marked
* {@link CascadeType#REFRESH cascade=REFRESH}.
* <p>If a vendor-specific property or hint is not recognized,
* it is silently ignored.
* @param entity a managed entity instance
* @param properties standard and vendor-specific properties
*     and hints
* @throws IllegalArgumentException if the instance is not
*     an entity or the entity is not managed
* @throws TransactionRequiredException if there is no
*     transaction when invoked on a container-managed
*     entity manager of type

```

```

*         {@link PersistenceContextType#TRANSACTION}
* @throws EntityNotFoundException if the entity no longer
*         exists in the database
* @since 2.0
*/
void refresh(Object entity,
             Map<String, Object> properties);

/**
 * Refresh the state of the given managed entity instance from
 * the database, overwriting unflushed changes made to the entity,
 * if any, and obtain the given {@linkplain LockModeType lock mode}.
 * This operation cascades to every entity related by an association
 * marked {@link CascadeType#REFRESH cascade=REFRESH}.
 * <p>If the lock mode type is pessimistic and the entity instance
 * is found but cannot be locked:
 * <ul>
 * <li>the {@link PessimisticLockException} is thrown if the
 *     database locking failure causes transaction-level rollback
 * <li>the {@link LockTimeoutException} is thrown if the database
 *     locking failure causes only statement-level rollback.
 * </ul>
 * @param entity a managed entity instance
 * @param lockMode lock mode
 * @throws IllegalArgumentException if the instance is not an entity
 *         or if the entity is not managed
 * @throws TransactionRequiredException if invoked on a
 *         container-managed entity manager of type
 *         {@link PersistenceContextType#TRANSACTION} when there is
 *         no transaction; if invoked on an extended entity manager
 *         when there is no transaction and a lock mode other than
 *         {@link LockModeType#NONE} was specified; or if invoked
 *         on an extended entity manager that has not been joined
 *         to the current transaction and any lock mode other than
 *         {@code NONE} was specified
 * @throws EntityNotFoundException if the entity no longer exists
 *         in the database
 * @throws PessimisticLockException if pessimistic locking fails
 *         and the transaction is rolled back
 * @throws LockTimeoutException if pessimistic locking fails and
 *         only the statement is rolled back
 * @throws PersistenceException if an unsupported lock call is made
 * @since 2.0
 */
void refresh(Object entity, LockModeType lockMode);

/**
 * Refresh the state of the given managed entity instance from
 * the database, overwriting unflushed changes made to the entity,
 * if any, and obtain the given {@linkplain LockModeType lock mode},
 * using the specified properties. This operation cascades to every
 * entity related by an association marked {@link CascadeType#REFRESH
 * cascade=REFRESH}.
 * <p>If the lock mode type is pessimistic and the entity instance
 * is found but cannot be locked:
 * <ul>
 * <li>the {@link PessimisticLockException} is thrown if the
 *     database locking failure causes transaction-level rollback
 * <li>the {@link LockTimeoutException} is thrown if the database
 *     locking failure causes only statement-level rollback.
 * </ul>
 * <p>If a vendor-specific property or hint is not recognized,
 * it is silently ignored.
 * <p>Portable applications should not rely on the standard
 * timeout hint. Depending on the database in use and the locking
 * mechanisms used by the provider, the hint may or may not be
 * observed.

```

```

* @param entity a managed entity instance
* @param lockMode lock mode
* @param properties standard and vendor-specific properties
* and hints
* @throws IllegalArgumentException if the instance is not an
* entity or if the entity is not managed
* @throws TransactionRequiredException if invoked on a
* container-managed entity manager of type
* {@link PersistenceContextType#TRANSACTION} when there is
* no transaction; if invoked on an extended entity manager
* when there is no transaction and a lock mode other than
* {@link LockModeType#NONE} was specified; or if invoked
* on an extended entity manager that has not been joined
* to the current transaction and any lock mode other than
* {@code NONE} was specified
* @throws EntityNotFoundException if the entity no longer exists
* in the database
* @throws PessimisticLockException if pessimistic locking fails
* and the transaction is rolled back
* @throws LockTimeoutException if pessimistic locking fails and
* only the statement is rolled back
* @throws PersistenceException if an unsupported lock call is made
* @since 2.0
*/

```

```

void refresh(Object entity, LockModeType lockMode,
             Map<String, Object> properties);

```

```

/**
 * Refresh the state of the given managed entity instance from the
 * database, using the specified {@linkplain RefreshOption options},
 * overwriting changes made to the entity, if any. If the supplied
 * options include a {@link LockModeType}, lock the given entity,
 * obtaining the given lock mode. This operation cascades to every
 * entity related by an association marked {@link CascadeType#REFRESH
 * cascade=REFRESH}.
 * <p>If the lock mode type is pessimistic and the entity instance is
 * found but cannot be locked:
 * <ul>
 * <li>the {@link PessimisticLockException} is thrown if the
 * database locking failure causes transaction-level rollback
 * <li>the {@link LockTimeoutException} is thrown if the database
 * locking failure causes only statement-level rollback.
 * </ul>
 * <p>If a vendor-specific {@link RefreshOption} is not recognized,
 * it is silently ignored.
 * <p>Portable applications should not rely on the standard
 * {@linkplain Timeout} option. Depending on the database in
 * use and the locking mechanisms used by the provider, the hint may
 * or may not be observed.
 * @param entity a managed entity instance
 * @param options standard and vendor-specific options
 * @throws IllegalArgumentException if the instance is not an entity
 * or if the entity is not managed
 * @throws TransactionRequiredException if invoked on a
 * container-managed entity manager of type
 * {@link PersistenceContextType#TRANSACTION} when there is
 * no transaction; if invoked on an extended entity manager
 * when there is no transaction and a lock mode other than
 * {@link LockModeType#NONE} was specified; or if invoked
 * on an extended entity manager that has not been joined
 * to the current transaction and any lock mode other than
 * {@code NONE} was specified
 * @throws EntityNotFoundException if the entity no longer exists in
 * the database
 * @throws PessimisticLockException if pessimistic locking fails and
 * the transaction is rolled back
 * @throws LockTimeoutException if pessimistic locking fails and only

```



```

*         the statement is rolled back
* @throws PersistenceException if an unsupported lock call is made
* @since 3.2
*/
void refresh(Object entity,
             RefreshOption... options);

/**
 * Clear the persistence context, causing all managed entities to
 * become detached. Changes made to entities that have not already
 * been flushed to the database will never be made persistent.
 */
void clear();

/**
 * Evict the given managed or removed entity from the persistence
 * context, causing the entity to become immediately detached.
 * Unflushed changes made to the entity, if any, including deletion
 * of the entity, will never be synchronized to the database.
 * Managed entities which reference the given entity continue to
 * reference it. This operation cascades to every entity related by
 * an association marked {@link CascadeType#DETACH cascade=DETACH}.
 * If the given entity instance is new or detached, that is, if it
 * is not associated with this persistence context, it is ignored.
 * @param entity a managed or removed entity instance
 * @throws IllegalArgumentException if the instance is not an
 *         entity
 * @since 2.0
 */
void detach(Object entity);

/**
 * Determine if the given object is a managed entity instance
 * belonging to the current persistence context.
 * @param entity entity instance
 * @return boolean value indicating if entity belongs to the
 *         persistence context
 * @throws IllegalArgumentException if not an entity
 */
boolean contains(Object entity);

/**
 * Get the current {@linkplain LockModeType lock mode} held by
 * this persistence context on the given managed entity instance.
 * @param entity a managed entity instance
 * @return the lock mode currently held
 * @throws TransactionRequiredException if there is no active
 *         transaction or if the entity manager has not been
 *         joined to the current transaction
 * @throws IllegalArgumentException if a transaction is active
 *         but the given instance is not a managed entity
 * @since 2.0
 */
LockModeType getLockMode(Object entity);

/**
 * Set the default {@linkplain CacheRetrieveMode cache retrieval
 * mode} for this persistence context.
 * @param cacheRetrieveMode cache retrieval mode
 * @since 3.2
 */
void setCacheRetrieveMode(CacheRetrieveMode cacheRetrieveMode);

/**
 * Set the default {@linkplain CacheStoreMode cache storage mode}
 * for this persistence context.
 * @param cacheStoreMode cache storage mode

```

```

* @since 3.2
*/
void setCacheStoreMode(CacheStoreMode cacheStoreMode);

/**
 * The cache retrieval mode for this persistence context.
 * @since 3.2
 */
CacheRetrieveMode getCacheRetrieveMode();

/**
 * The cache storage mode for this persistence context.
 * @since 3.2
 */
CacheStoreMode getCacheStoreMode();

/**
 * Set an entity manager property or hint.
 * If a vendor-specific property or hint is not recognized, it is
 * silently ignored.
 * @param propertyName name of the property or hint
 * @param value value for the property or hint
 * @throws IllegalArgumentException if the property or hint name
 *         is recognized by the implementation, but the second
 *         argument is not valid value
 * @since 2.0
 */
void setProperty(String propertyName, Object value);

/**
 * The properties and hints and their associated values which are
 * in effect for this entity manager. Modifying the contents of
 * the returned map does not change the configuration in effect.
 * @return a map of properties and hints currently in effect
 * @since 2.0
 */
Map<String, Object> getProperties();

/**
 * Create an instance of {@link Query} for executing a
 * Jakarta Persistence query language statement.
 * @param qlString a Jakarta Persistence query string
 * @return the new query instance
 * @throws IllegalArgumentException if the query string is
 *         found to be invalid
 */
Query createQuery(String qlString);

/**
 * Create an instance of {@link TypedQuery} for executing a
 * criteria query.
 * @param criteriaQuery a criteria query object
 * @return the new query instance
 * @throws IllegalArgumentException if the criteria query is
 *         found to be invalid
 * @since 2.0
 */
<T> TypedQuery<T> createQuery(CriteriaQuery<T> criteriaQuery);

/**
 * Create an instance of {@link TypedQuery} for executing a
 * criteria query, which may be a union or intersection of
 * top-level queries.
 * @param selectQuery a criteria query object
 * @return the new query instance
 * @throws IllegalArgumentException if the criteria query is
 *         found to be invalid

```

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    * @since 3.2
    */
    <T> TypedQuery<T> createQuery(CriteriaSelect<T> selectQuery);

    /**
     * Create an instance of {@link Query} for executing a criteria
     * update query.
     * @param updateQuery a criteria update query object
     * @return the new query instance
     * @throws IllegalArgumentException if the update query is
     *         found to be invalid
     * @since 2.1
     */
    Query createQuery(CriteriaUpdate<?> updateQuery);

    /**
     * Create an instance of {@link Query} for executing a criteria
     * delete query.
     * @param deleteQuery a criteria delete query object
     * @return the new query instance
     * @throws IllegalArgumentException if the delete query is
     *         found to be invalid
     * @since 2.1
     */
    Query createQuery(CriteriaDelete<?> deleteQuery);

    /**
     * Create an instance of {@link TypedQuery} for executing a
     * Jakarta Persistence query language statement.
     * The select list of the query must contain only a single
     * item, which must be assignable to the type specified by
     * the {@code resultClass} argument.
     * @param qlString a Jakarta Persistence query string
     * @param resultClass the type of the query result
     * @return the new query instance
     * @throws IllegalArgumentException if the query string is
     *         found to be invalid or if the query result is
     *         found to not be assignable to the specified type
     * @since 2.0
     */
    <T> TypedQuery<T> createQuery(String qlString, Class<T> resultClass);

    /**
     * Create an instance of {@link Query} for executing a named
     * query written in the Jakarta Persistence query language or
     * in native SQL.
     * @param name the name of a query defined in metadata
     * @return the new query instance
     * @throws IllegalArgumentException if a query has not been
     *         defined with the given name or if the query string is
     *         found to be invalid
     * @see NamedQuery
     * @see NamedNativeQuery
     */
    Query createNamedQuery(String name);

    /**
     * Create an instance of {@link TypedQuery} for executing a
     * Jakarta Persistence query language named query.
     * The select list of the query must contain only a single
     * item, which must be assignable to the type specified by
     * the {@code resultClass} argument.
     * @param name the name of a query defined in metadata
     * @param resultClass the type of the query result
     * @return the new query instance
     * @throws IllegalArgumentException if a query has not been
     *         defined with the given name or if the query string is

```

```

*         found to be invalid or if the query result is found to
*         not be assignable to the specified type
* @since 2.0
*/
<T> TypedQuery<T> createNamedQuery(String name, Class<T> resultClass);

/**
 * Create an instance of {@link TypedQuery} for executing a
 * named query written in the Jakarta Persistence query
 * language or in native SQL.
 * @param reference a reference to the query defined in metadata
 * @return the new query instance
 * @throws IllegalArgumentException if a query has not been
 *         defined, or if the query string is found to be
 *         invalid, or if the query result is found to not be
 *         assignable to the specified type
 * @see EntityManagerFactory#getNamedQueries(Class)
 * @see NamedQuery
 * @see NamedNativeQuery
 */
<T> TypedQuery<T> createQuery(TypedQueryReference<T> reference);

/**
 * Create an instance of {@link Query} for executing a native
 * SQL statement, e.g., for update or delete.
 *
 * <p>If the query is not an update or delete query, query
 * execution will result in each row of the SQL result being
 * returned as a result of type {@code Object[]} (or a result
 * of type {@code Object} if there is only one column in the
 * select list.) Column values are returned in the order of
 * their occurrence in the select list and default JDBC type
 * mappings are applied.
 * @param sqlString a native SQL query string
 * @return the new query instance
 */
Query createNativeQuery(String sqlString);

/**
 * Create an instance of {@link Query} for executing a native
 * SQL query.
 *
 * <p><em>In the next release of this API, the return type of this
 * method will change to {@code TypedQuery<T>}.</em>
 * @param sqlString a native SQL query string
 * @param resultClass the type of the query result
 * @return the new query instance
 */
<T> Query createNativeQuery(String sqlString, Class<T> resultClass);

/**
 * Create an instance of {@link Query} for executing
 * a native SQL query.
 * @param sqlString a native SQL query string
 * @param resultSetMapping the name of the result set mapping
 * @return the new query instance
 */
Query createNativeQuery(String sqlString, String resultSetMapping);

/**
 * Create an instance of {@link StoredProcedureQuery} for executing
 * a stored procedure in the database.
 * <p>Parameters must be registered before the stored procedure can
 * be executed.
 * <p>If the stored procedure returns one or more result sets, any
 * result set is returned as a list of type {@code Object[]}.
 * @param name name assigned to the stored procedure query in

```

```

*      metadata
* @return the new stored procedure query instance
* @throws IllegalArgumentException if no query has been defined
*      with the given name
* @since 2.1
*/
StoredProcedureQuery createNamedStoredProcedureQuery(String name);

/**
 * Create an instance of {@link StoredProcedureQuery} for executing a
 * stored procedure in the database.
 * <p>Parameters must be registered before the stored procedure can
 * be executed.
 * <p>If the stored procedure returns one or more result sets, any
 * result set is returned as a list of type {@code Object[]}.
 * @param procedureName name of the stored procedure in the database
 * @return the new stored procedure query instance
 * @throws IllegalArgumentException if a stored procedure of the
 *      given name does not exist (or if query execution will
 *      fail)
 * @since 2.1
 */
StoredProcedureQuery createStoredProcedureQuery(String procedureName);

/**
 * Create an instance of {@link StoredProcedureQuery} for executing
 * a stored procedure in the database.
 * <p>Parameters must be registered before the stored procedure can
 * be executed.
 * <p>The {@code resultClass} arguments must be specified in the
 * order in which the result sets is returned by the stored procedure
 * invocation.
 * @param procedureName name of the stored procedure in the database
 * @param resultClasses classes to which the result sets
 *      produced by the stored procedure are to be mapped
 * @return the new stored procedure query instance
 * @throws IllegalArgumentException if a stored procedure of the
 *      given name does not exist (or if query execution will
 *      fail)
 * @since 2.1
 */
StoredProcedureQuery createStoredProcedureQuery(
    String procedureName, Class<?>... resultClasses);

/**
 * Create an instance of {@link StoredProcedureQuery} for executing
 * a stored procedure in the database.
 * <p>Parameters must be registered before the stored procedure can
 * be executed.
 * <p>The {@code resultSetMapping} arguments must be specified in
 * the order in which the result sets is returned by the stored
 * procedure invocation.
 * @param procedureName name of the stored procedure in the
 *      database
 * @param resultSetMappings the names of the result set mappings
 *      to be used in mapping result sets
 *      returned by the stored procedure
 * @return the new stored procedure query instance
 * @throws IllegalArgumentException if a stored procedure or
 *      result set mapping of the given name does not exist
 *      (or the query execution will fail)
 */
StoredProcedureQuery createStoredProcedureQuery(
    String procedureName, String... resultSetMappings);

/**
 * Indicate to the entity manager that a JTA transaction is

```

```

* active and join the persistence context to it.
* <p>This method should be called on a JTA application
* managed entity manager that was created outside the scope
* of the active transaction or on an entity manager of type
* {@link SynchronizationType#UNSYNCHRONIZED} to associate
* it with the current JTA transaction.
* @throws TransactionRequiredException if there is no active
*     transaction
*/
void joinTransaction();

/**
* Determine whether the entity manager is joined to the
* current transaction. Returns false if the entity manager
* is not joined to the current transaction or if no
* transaction is active.
* @return boolean
* @since 2.1
*/
boolean isJoinedToTransaction();

/**
* Return an object of the specified type to allow access to
* a provider-specific API. If the provider implementation
* of {@code EntityManager} does not support the given type,
* the {@link PersistenceException} is thrown.
* @param cls the class of the object to be returned.
*     This is usually either the underlying class
*     implementing {@code EntityManager} or an
*     interface it implements.
* @return an instance of the specified class
* @throws PersistenceException if the provider does not
*     support the given type
* @since 2.0
*/
<T> T unwrap(Class<T> cls);

/**
* Return the underlying provider object for the
* {@link EntityManager}, if available. The result of this
* method is implementation-specific.
* <p>The {@code unwrap} method is to be preferred for new
* applications.
* @return the underlying provider object
*/
Object getDelegate();

/**
* Close an application-managed entity manager.
* <p>After invocation of {@code close()}, every method of
* the {@code EntityManager} instance and of any instance
* of {@link Query}, {@link TypedQuery}, or
* {@link StoredProcedureQuery} obtained from it throws
* the {@link IllegalStateException}, except for
* {@link #getProperties()}, {@link #getTransaction()},
* and {@link #isOpen()} (which returns false).
* <p>If this method is called when the entity manager is
* joined to an active transaction, the persistence context
* remains managed until the transaction completes.
* @throws IllegalStateException if the entity manager is
*     container-managed
*/
void close();

/**
* Determine whether the entity manager is open.
* @return true until the entity manager has been closed

```

```

*/
boolean isOpen();

/**
 * Return the resource-level {@link EntityTransaction} object.
 * The {@code EntityTransaction} instance may be used serially
 * to begin and commit multiple transactions.
 * @return EntityTransaction instance
 * @throws IllegalStateException if invoked on a JTA entity
 *         manager
 */
EntityTransaction getTransaction();

/**
 * The {@linkplain EntityManagerFactory} entity manager factory}
 * which created this entity manager.
 * @return the {@link EntityManagerFactory}
 * @throws IllegalStateException if the entity manager has
 *         been closed
 * @since 2.0
 */
EntityManagerFactory getEntityManagerFactory();

/**
 * Obtain an instance of {@link CriteriaBuilder} which may be
 * used to construct {@link CriteriaQuery} objects.
 * @return an instance of {@link CriteriaBuilder}
 * @throws IllegalStateException if the entity manager has
 *         been closed
 * @see EntityManagerFactory#getCriteriaBuilder()
 * @since 2.0
 */
CriteriaBuilder getCriteriaBuilder();

/**
 * Obtain an instance of the {@link Metamodel} interface which
 * provides access to metamodel objects describing the managed
 * types belonging to the persistence unit.
 * @return an instance of {@link Metamodel}
 * @throws IllegalStateException if the entity manager has
 *         been closed
 * @since 2.0
 */
Metamodel getMetamodel();

/**
 * Create a new mutable {@link EntityGraph}, allowing dynamic
 * definition of an entity graph.
 * @param rootType class of entity graph
 * @return entity graph
 * @since 2.1
 */
<T> EntityGraph<T> createEntityGraph(Class<T> rootType);

/**
 * Obtain a mutable copy of a named {@link EntityGraph}, or
 * return null if there is no entity graph with the given
 * name.
 * @param graphName name of an entity graph
 * @return entity graph
 * @since 2.1
 */
EntityGraph<?> createEntityGraph(String graphName);

/**
 * Obtain a named {@link EntityGraph}. The returned instance
 * of {@code EntityGraph} should be considered immutable.

```

```

    * @param graphName name of an existing entity graph
    * @return named entity graph
    * @throws IllegalArgumentException if there is no entity
    *         of graph with the given name
    * @since 2.1
    */
    EntityGraph<?> getEntityGraph(String graphName);

    /**
     * Return all named {@link EntityGraph}s that are defined for
     * the given entity class type.
     * @param entityClass entity class
     * @return list of all entity graphs defined for the entity
     * @throws IllegalArgumentException if the class is not an entity
     * @since 2.1
     */
    <T> List<EntityGraph<? super T>> getEntityGraphs(Class<T> entityClass);

    /**
     * Execute the given action using the database connection underlying this
     * {@code EntityManager}. Usually, the connection is a JDBC connection, but a
     * provider might support some other native connection type, and is not required
     * to support {@code java.sql.Connection}. If this {@code EntityManager} is
     * associated with a transaction, the action is executed in the context of the
     * transaction. The given action should close any resources it creates, but should
     * not close the connection itself, nor commit or roll back the transaction. If
     * the given action throws an exception, the persistence provider must mark the
     * transaction for rollback.
     * @param action the action
     * @param <C> the connection type, usually {@code java.sql.Connection}
     * @throws PersistenceException wrapping the checked {@link Exception} thrown by
     *         {@link ConnectionConsumer#accept}, if any
     * @since 3.2
     */
    <C> void runWithConnection(ConnectionConsumer<C> action);

    /**
     * Call the given function and return its result using the database connection
     * underlying this {@code EntityManager}. Usually, the connection is a JDBC
     * connection, but a provider might support some other native connection type,
     * and is not required to support {@code java.sql.Connection}. If this
     * {@code EntityManager} is associated with a transaction, the function is
     * executed in the context of the transaction. The given function should close
     * any resources it creates, but should not close the connection itself, nor
     * commit or roll back the transaction. If the given action throws an exception,
     * the persistence provider must mark the transaction for rollback.
     * @param function the function
     * @param <C> the connection type, usually {@code java.sql.Connection}
     * @param <T> the type of result returned by the function
     * @return the value returned by {@link ConnectionFunction#apply}.
     * @throws PersistenceException wrapping the checked {@link Exception} thrown by
     *         {@link ConnectionFunction#apply}, if any
     * @since 3.2
     */
    <C,T> T callWithConnection(ConnectionFunction<C, T> function);
}

```

B.2. EntityTransaction

```

package jakarta.persistence;

/**
 * Interface used to control transactions on resource-local entity
 * managers. The {@link EntityManager#getTransaction} method returns

```



```

* the {@code EntityTransaction} interface.
*
* @since 1.0
*/
public interface EntityTransaction {

    /**
     * Start a resource transaction.
     * @throws IllegalStateException if {@link #isActive()} is true
     */
    void begin();

    /**
     * Commit the current resource transaction, writing any unflushed
     * changes to the database.
     * @throws IllegalStateException if {@link #isActive()} is false
     * @throws RollbackException if the commit fails
     */
    void commit();

    /**
     * Roll back the current resource transaction.
     * @throws IllegalStateException if {@link #isActive()} is false
     * @throws PersistenceException if an unexpected error
     *     condition is encountered
     */
    void rollback();

    /**
     * Mark the current resource transaction so that the only possible
     * outcome of the transaction is for the transaction
     * to be rolled back.
     * @throws IllegalStateException if {@link #isActive()} is false
     */
    void setRollbackOnly();

    /**
     * Determine whether the current resource transaction has been
     * marked for rollback.
     * @return boolean indicating whether the transaction has been
     *     marked for rollback
     * @throws IllegalStateException if {@link #isActive()} is false
     */
    boolean getRollbackOnly();

    /**
     * Indicate whether a resource transaction is in progress.
     * @return boolean indicating whether transaction is in progress
     * @throws PersistenceException if an unexpected error
     *     condition is encountered
     */
    boolean isActive();

    /**
     * Set the transaction timeout, in seconds. This is a hint.
     * @param timeout the timeout, in seconds, or null to indicate
     *     that the database server should set the timeout
     * @since 3.2
     */
    void setTimeout(Integer timeout);

    /**
     * The transaction timeout.
     * @since 3.2
     */
    Integer getTimeout();
}

```

```
}
```

B.3. EntityManagerFactory

```
package jakarta.persistence;

import java.util.Map;
import java.util.function.Consumer;
import java.util.function.Function;

import jakarta.persistence.metamodel.Metamodel;
import jakarta.persistence.criteria.CriteriaBuilder;

/**
 * Interface used to interact with the persistence unit, and to
 * create new instances of {@link EntityManager}.
 *
 * <p>A persistence unit defines the set of all classes that are
 * related or grouped by the application, and which must be
 * colocated in their mapping to a single database. If two entity
 * types participate in an association, then they must belong to
 * the same persistence unit.
 *
 * <p>A persistence unit may be defined by a {@code persistence.xml}
 * file, or it may be defined at runtime via the
 * {@link PersistenceConfiguration} API.
 *
 * <p>Every persistence unit has a <em>transaction type</em>,
 * either {@link PersistenceUnitTransactionType#JTA JTA}, or
 * {@link PersistenceUnitTransactionType#RESOURCE_LOCAL RESOURCE_LOCAL}.
 * Resource-local transactions are managed programmatically via the
 * {@link EntityTransaction} interface.
 *
 * <p>An {@link EntityManagerFactory} with a lifecycle managed by
 * the application may be created using the static operations of
 * the {@link Persistence} class:
 * <ul>
 * <li>if the persistence unit is defined in {@code persistence.xml},
 *     an entity manager factory may be created by calling
 *     {@link Persistence#createEntityManagerFactory(String)} or
 *     {@link Persistence#createEntityManagerFactory(String,Map)},
 *     or
 * <li>if the persistence unit was defined using
 *     {@link PersistenceConfiguration}, an entity manager factory
 *     may be created by calling
 *     {@link Persistence#createEntityManagerFactory(PersistenceConfiguration)}.
 * </ul>
 *
 * <p>Usually, there is exactly one {@code EntityManagerFactory} for
 * each persistence unit:
 * {@snippet :
 * // create a factory at initialization time
 * static final EntityManagerFactory entityManagerFactory =
 *     Persistence.createEntityManagerFactory("orderMgt");
 * }
 *
 * <p>Alternatively, in the Jakarta EE environment, a
 * container-managed {@code EntityManagerFactory} may be obtained
 * by dependency injection, using {@link PersistenceUnit}.
 * {@snippet :
 * // inject the container-managed factory
 * @PersistenceUnit(unitName="orderMgt")
 * EntityManagerFactory entityManagerFactory;
 * }
 *
 *

```

```

* <p>An application-managed {@code EntityManager} may be created
* via a call to {@link #createEntityManager()}. However, this
* approach places complete responsibility for cleanup and exception
* management on the client, and is thus considered error-prone. It
* is much safer to use the methods {@link #runInTransaction} and
* {@link #callInTransaction} to obtain {@code EntityManager}s.
* Alternatively, in the Jakarta EE environment, a container-managed
* {@link EntityManager} may be obtained by dependency injection,
* using {@link PersistenceContext}, and the application need not
* interact with the {@code EntityManagerFactory} directly.
*
* <p>The {@code EntityManagerFactory} provides access to certain
* other useful APIs:
* <ul>
* <li>an instance of {@link Metamodel} exposing a model of the
*     managed types associated with the persistence unit may be
*     obtained by calling {@link #getMetamodel()},
* <li>an instance of {@link SchemaManager}, allowing programmatic
*     control over schema generation and validation, may be
*     obtained by calling {@link #getSchemaManager()},
* <li>an instance of {@link Cache}, allowing direct programmatic
*     control over the second-level cache, may be obtained by
*     calling {@link #getCache()},
* <li>the {@link CriteriaBuilder}, used to define criteria queries,
*     may be obtained by calling {@link #getCriteriaBuilder()},
*     and
* <li>the {@link PersistenceUnitUtil} may be obtained by calling
*     {@link #getPersistenceUnitUtil()}.
* </ul>
*
* <p>When the application has finished using the entity manager
* factory, or when the application terminates, the application
* should {@linkplain #close} the entity manager factory. If
* necessary, a {@link java.lang.ref.Cleaner} may be used:
* {@snippet :
* // factory should be destroyed before program terminates
* Cleaner.create().register(entityManagerFactory, entityManagerFactory::close);
* }
* Once an {@code EntityManagerFactory} has been closed, all its
* entity managers are considered to be in the closed state.
*
* @see EntityManager
*
* @since 1.0
*/

```

```

public interface EntityManagerFactory extends AutoCloseable {

    /**
     * Create a new application-managed {@link EntityManager}. This
     * method returns a new {@code EntityManager} instance each time
     * it is invoked.
     * <p>The {@link EntityManager#isOpen} method will return true
     * on the returned instance.
     * @return entity manager instance
     * @throws IllegalStateException if the entity manager factory
     * has been closed
     */
    EntityManager createEntityManager();

    /**
     * Create a new application-managed {@link EntityManager} with
     * the given {@link Map} specifying property settings. This
     * method returns a new {@code EntityManager} instance each time
     * it is invoked.
     * <p>The {@link EntityManager#isOpen} method will return true
     * on the returned instance.
     * @param map properties for entity manager
     */

```

```

* @return entity manager instance
* @throws IllegalStateException if the entity manager factory
* has been closed
*/
EntityManager createEntityManager(Map<?, ?> map);

/**
 * Create a new JTA application-managed {@link EntityManager} with
 * the specified synchronization type. This method returns a new
 * {@code EntityManager} instance each time it is invoked.
 * <p>The {@link EntityManager#isOpen} method will return true on
 * the returned instance.
 * @param synchronizationType how and when the entity manager should
 * be synchronized with the current JTA
 * transaction
 * @return entity manager instance
 * @throws IllegalStateException if the entity manager factory has
 * been configured for resource-local entity managers or is closed
 *
 * @since 2.1
 */
EntityManager createEntityManager(SynchronizationType synchronizationType);

/**
 * Create a new JTA application-managed {@link EntityManager} with
 * the specified synchronization type and map of properties. This
 * method returns a new {@code EntityManager} instance each time it
 * is invoked.
 * <p>The {@link EntityManager#isOpen} method will return true on the
 * returned instance.
 * @param synchronizationType how and when the entity manager should
 * be synchronized with the current JTA
 * transaction
 * @param map properties for entity manager
 * @return entity manager instance
 * @throws IllegalStateException if the entity manager factory has
 * been configured for resource-local entity managers or is closed
 *
 * @since 2.1
 */
EntityManager createEntityManager(SynchronizationType synchronizationType, Map<?, ?> map);

/**
 * Return an instance of {@link CriteriaBuilder} which may be used
 * to construct {@link jakarta.persistence.criteria.CriteriaQuery}
 * objects.
 * @return an instance of {@link CriteriaBuilder}
 * @throws IllegalStateException if the entity manager factory has
 * been closed
 *
 * @see EntityManager#getCriteriaBuilder()
 *
 * @since 2.0
 */
CriteriaBuilder getCriteriaBuilder();

/**
 * Return an instance of the {@link Metamodel} interface for access
 * to the metamodel of the persistence unit.
 * @return an instance of {@link Metamodel}
 * @throws IllegalStateException if the entity manager factory
 * has been closed
 *
 * @since 2.0
 */
Metamodel getMetamodel();

```

```

/**
 * Indicates whether the factory is open. Returns true until the
 * factory has been closed.
 * @return boolean indicating whether the factory is open
 */
boolean isOpen();

/**
 * Close the factory, releasing any resources that it holds.
 * After a factory instance has been closed, all methods invoked
 * on it will throw the {@link IllegalStateException}, except
 * for {@link #isOpen}, which will return false. Once an
 * {@code EntityManagerFactory} has been closed, all its
 * entity managers are considered to be in the closed state.
 * @throws IllegalStateException if the entity manager factory
 * has been closed
 */
void close();

/**
 * The name of the persistence unit.
 *
 * @since 3.2
 */
String getName();

/**
 * Get the properties and associated values that are in effect
 * for the entity manager factory. Changing the contents of the
 * map does not change the configuration in effect.
 * @return properties
 * @throws IllegalStateException if the entity manager factory
 * has been closed
 *
 * @since 2.0
 */
Map<String, Object> getProperties();

/**
 * Access the cache that is associated with the entity manager
 * factory (the "second level cache").
 * @return an instance of {@link Cache}, or null if there is no
 * second-level cache in use
 * @throws IllegalStateException if the entity manager factory
 * has been closed
 *
 * @since 2.0
 */
Cache getCache();

/**
 * Return interface providing access to utility methods for the
 * persistence unit.
 * @return an instance of {@link PersistenceUnitUtil}
 * @throws IllegalStateException if the entity manager factory
 * has been closed
 *
 * @since 2.0
 */
PersistenceUnitUtil getPersistenceUnitUtil();

/**
 * The type of transaction management used by this persistence
 * unit, either resource-local transaction management, or JTA.
 *
 * @since 3.2
 */

```

```

PersistenceUnitTransactionType getTransactionType();

/**
 * Return interface providing access to schema management
 * operations for the persistence unit.
 * @return an instance of {@link SchemaManager}
 * @throws IllegalStateException if the entity manager factory
 * has been closed
 *
 * @since 3.2
 */
SchemaManager getSchemaManager();

/**
 * Define the query, typed query, or stored procedure query as
 * a named query such that future query objects can be created
 * from it using the {@link EntityManager#createNamedQuery} or
 * {@link EntityManager#createNamedQuery} methods.
 * <p>Any configuration of the query object (except for actual
 * parameter binding) in effect when the named query is added
 * is retained as part of the named query definition. This
 * includes configuration information such as max results, hints,
 * flush mode, lock mode, result set mapping information, and
 * information about stored procedure parameters.
 * <p>When the query is executed, information that can be set by
 * means of the query APIs can be overridden. Information that is
 * overridden does not affect the named query as registered with
 * the entity manager factory, and thus does not affect subsequent
 * query objects created from it by calling {@code createNamedQuery}
 * or {@code createNamedQuery}.
 * <p>If a named query of the same name has been previously defined,
 * either statically via metadata or via this method, that query
 * definition is replaced.
 *
 * @param name name for the query
 * @param query a {@link Query}, {@link TypedQuery},
 *             or {@link StoredProcedureQuery}
 *
 * @since 2.1
 */
void addNamedQuery(String name, Query query);

/**
 * Return an object of the specified type to allow access to
 * a provider-specific API. If the provider implementation of
 * {@code EntityManagerFactory} does not support the given
 * type, the {@link PersistenceException} is thrown.
 * @param cls the class of the object to be returned.
 *           This is usually either the underlying class
 *           implementing {@code EntityManagerFactory} or an
 *           interface it implements.
 * @return an instance of the specified class
 * @throws PersistenceException if the provider does not support
 * the given type
 * @since 2.1
 */
<T> T unwrap(Class<T> cls);

/**
 * Add a named copy of the given {@link EntityGraph} to this
 * {@code EntityManagerFactory}. If an entity graph with the
 * given name already exists, it is replaced.
 * @param graphName name for the entity graph
 * @param entityGraph entity graph
 * @since 2.1
 */
<T> void addNamedEntityGraph(String graphName, EntityGraph<T> entityGraph);

```

```

/**
 * A map keyed by {@linkplain NamedQuery#name query name}, containing
 * {@linkplain TypedQueryReference references} to every named query whose
 * result type is assignable to the given Java type.
 * @param resultType any Java type, including {@code Object.class}
 * meaning all queries
 * @return a map keyed by query name
 * @param <R> the specified upper bound on the query result types
 *
 * @since 3.2
 */
<R> Map<String, TypedQueryReference<R>> getNamedQueries(Class<R> resultType);

/**
 * A map keyed by {@linkplain NamedEntityGraph#name graph name}, containing
 * every named {@linkplain EntityGraph entity graph} whose entity type is
 * assignable to the given Java type.
 * @param entityType any Java type, including {@code Object.class}
 * meaning all entity graphs
 * @return a map keyed by graph name
 * @param <E> the specified upper bound on the entity graph types
 *
 * @since 3.2
 */
<E> Map<String, EntityGraph<? extends E>> getNamedEntityGraphs(Class<E> entityType);

/**
 * Create a new application-managed {@link EntityManager} with an active
 * transaction, and execute the given function, passing the {@code EntityManager}
 * to the function.
 * <p>
 * If the transaction type of the persistence unit is JTA, and there is a JTA
 * transaction already associated with the caller, then the {@code EntityManager}
 * is associated with this current transaction. If the given function throws an
 * exception, the JTA transaction is marked for rollback, and the exception is
 * rethrown.
 * <p>
 * Otherwise, if the transaction type of the persistence unit is resource-local,
 * or if there is no JTA transaction already associated with the caller, then
 * the {@code EntityManager} is associated with a new transaction. If the given
 * function returns without throwing an exception, this transaction is committed.
 * If the function does throw an exception, the transaction is rolled back, and
 * the exception is rethrown.
 * <p>
 * Finally, the {@code EntityManager} is closed before this method returns
 * control to the client.
 *
 * @param work a function to be executed in the scope of the transaction
 *
 * @since 3.2
 */
void runInTransaction(Consumer<EntityManager> work);

/**
 * Create a new application-managed {@link EntityManager} with an active
 * transaction, and call the given function, passing the {@code EntityManager}
 * to the function.
 * <p>
 * If the transaction type of the persistence unit is JTA, and there is a JTA
 * transaction already associated with the caller, then the {@code EntityManager}
 * is associated with this current transaction. If the given function returns
 * without throwing an exception, the result of the function is returned. If the
 * given function throws an exception, the JTA transaction is marked for rollback,
 * and the exception is rethrown.
 * <p>
 * Otherwise, if the transaction type of the persistence unit is resource-local,
 * or if there is no JTA transaction already associated with the caller, then

```

```

* the {@code EntityManager} is associated with a new transaction. If the given
* function returns without throwing an exception, this transaction is committed
* and the result of the function is returned. If the function does throw an
* exception, the transaction is rolled back, and the exception is rethrown.
* <p>
* Finally, the {@code EntityManager} is closed before this method returns
* control to the client.
*
* @param work a function to be called in the scope of the transaction
* @return the value returned by the given function
*
* @since 3.2
*/
<R> R callInTransaction(Function<EntityManager, R> work);
}

```

B.4. LockModeType

```

/**
* Enumerates the kinds of optimistic or pessimistic lock which may
* be obtained on an entity instance.
*
* <p>A specific lock mode may be requested by passing an explicit
* {@code LockModeType} as an argument to:
* <ul>
* <li>one of the methods of {@link EntityManager} which obtains
* locks ({@link EntityManager#lock lock()},
* {@link EntityManager#find find()}, or
* {@link EntityManager#refresh refresh()}), or
* <li>to {@link Query#setLockMode(LockModeType)} or
* {@link TypedQuery#setLockMode(LockModeType)}.
* </ul>
* <p>Lock modes other than {@link #NONE} prevent dirty reads and
* non-repeatable reads of locked entity data within the current
* transaction.
*
* <p>An optimistic lock is requested by specifying the lock mode
* type {@link #OPTIMISTIC} or {@link #OPTIMISTIC_FORCE_INCREMENT}.
* The lock mode types {@link #READ} and {@link #WRITE} are synonyms
* for {@code OPTIMISTIC} and {@code OPTIMISTIC_FORCE_INCREMENT}
* respectively. The latter are preferred for new applications.
*
* <p>The persistence implementation is not required to accept
* requests for optimistic locks on non-versioned entities. When
* a provider does not support such a lock request, it must throw
* {@link PersistenceException}.
*
* <p>An immediate pessimistic database-level lock is requested by
* specifying one of the lock mode types {@link #PESSIMISTIC_READ},
* {@link #PESSIMISTIC_WRITE}, or {@link #PESSIMISTIC_FORCE_INCREMENT}.
* <ul>
* <li>A lock with type {@code PESSIMISTIC_WRITE} can be obtained on
* an entity instance to force serialization among transactions
* attempting to update the entity data.
* <li>A lock with type {@code PESSIMISTIC_READ} can be used to query
* data using repeatable-read semantics without the need to reread
* the data at the end of the transaction to obtain a lock, and
* without blocking other transactions reading the data.
* <li>A lock with type {@code PESSIMISTIC_WRITE} can be used when
* querying data and there is a high likelihood of deadlock or
* update failure among concurrent updating transactions.
* </ul>
*
* <p>The persistence implementation must accept requests for locks
* of type {@code PESSIMISTIC_READ} and {@code PESSIMISTIC_WRITE} on

```



```

* both versioned and non-versioned entities.
* <ul>
* <li>When the lock cannot be obtained, and the database locking
*   failure results in transaction-level rollback, the provider
*   must throw {@link PessimisticLockException} and ensure that
*   the JTA transaction or {@code EntityTransaction} has been
*   marked for rollback.
* <li>When the lock cannot be obtained, and the database locking
*   failure results in only statement-level rollback, the provider
*   must throw the {@link LockTimeoutException} (and must not mark
*   the transaction for rollback).</li>
* </ul>
* <p>The persistence implementation is not required to accept
* requests for locks of type {@code PESSIMISTIC_FORCE_INCREMENT} on
* non-versioned entities. When a provider does not support such a
* lock request, it must throw {@link PersistenceException}.
*
* @since 1.0
*
*/
public enum LockModeType implements FindOption, RefreshOption {
    /**
     * Synonymous with {@link #OPTIMISTIC}.
     * <p>
     * {@code OPTIMISTIC} is preferred for new applications.
     *
     */
    READ,

    /**
     * Synonymous with {@link #OPTIMISTIC_FORCE_INCREMENT}.
     * <p>
     * {@code OPTIMISTIC_FORCE_INCREMENT} is preferred for
     * new applications.
     *
     */
    WRITE,

    /**
     * An optimistic lock.
     *
     * <p>If transaction T1 calls for a lock of type
     * {@code OPTIMISTIC} on a versioned object, the entity manager
     * must ensure that neither of the following phenomena can occur:
     * <ul>
     * <li>P1 <b>Dirty read</b>: Transaction T1 modifies a row.
     *   Another transaction T2 then reads that row and obtains the
     *   modified value, before T1 has committed or rolled back.
     *   Transaction T2 eventually commits successfully; it does not
     *   matter whether T1 commits or rolls back and whether it does
     *   so before or after T2 commits.
     * </li>
     * <li>P2 <b>Non-repeatable read</b>: Transaction T1 reads a row.
     *   Another transaction T2 then modifies or deletes that row,
     *   before T1 has committed. Both transactions eventually commit
     *   successfully.
     * </li>
     * </ul>
     *
     * <p>The persistence implementation is not required to accept
     * requests for {@code OPTIMISTIC} locks on non-versioned entities.
     *
     * @since 2.0
     */
    OPTIMISTIC,

    /**

```

```

* Optimistic lock, with version update, which prevents the
* following phenomena:
*
* <p>If transaction T1 calls for a lock of type
* {@code OPTIMISTIC_FORCE_INCREMENT} on a versioned object,
* the entity manager must ensure that neither of the following
* phenomena can occur:
* <ul>
* <li>P1 <b>Dirty read</b>: Transaction T1 modifies a row.
*   Another transaction T2 then reads that row and obtains the
*   modified value, before T1 has committed or rolled back.
*   Transaction T2 eventually commits successfully; it does not
*   matter whether T1 commits or rolls back and whether it does
*   so before or after T2 commits.
* </li>
* <li>P2 <b>Non-repeatable read</b>: Transaction T1 reads a row.
*   Another transaction T2 then modifies or deletes that row,
*   before T1 has committed. Both transactions eventually commit
*   successfully.
* </li>
* </ul>
*
* <p>In addition, obtaining a lock of type
* {@code OPTIMISTIC_FORCE_INCREMENT} on a versioned entity will
* also force an update (increment) to the {@linkplain Version
* version column}.
*
* <p>The persistence implementation is not required to accept
* requests for {@code OPTIMISTIC_FORCE_INCREMENT} locks on
* non-versioned entities.
*
* @since 2.0
*/

```

OPTIMISTIC_FORCE_INCREMENT,

/**

```

* Pessimistic read lock.
*
* <p>If transaction T1 calls for a lock of type
* {@code PESSIMISTIC_READ} on an object, the entity manager must
* ensure that neither of the following phenomena can occur:
* <ul>
* <li>P1 <b>Dirty read</b>: Transaction T1 modifies a row.
*   Another transaction T2 then reads that row and obtains the
*   modified value, before T1 has committed or rolled back.
* </li>
* <li>P2 <b>Non-repeatable read</b>: Transaction T1 reads a row.
*   Another transaction T2 then modifies or deletes that row,
*   before T1 has committed or rolled back.
* </li>
* </ul>
*
* @since 2.0
*/

```

PESSIMISTIC_READ,

/**

```

* Pessimistic write lock.
*
* <p>If transaction T1 calls for a lock of type
* {@code PESSIMISTIC_WRITE} on an object, the entity manager must
* ensure that neither of the following phenomena can occur:
* <ul>
* <li>P1 <b>Dirty read</b>: Transaction T1 modifies a row.
*   Another transaction T2 then reads that row and obtains the
*   modified value, before T1 has committed or rolled back.
* </li>
* <li>P2 <b>Non-repeatable read</b>: Transaction T1 reads a row.

```

```

* Another transaction T2 then modifies or deletes that row,
* before T1 has committed or rolled back.
* </ul>
*
* @since 2.0
*/
PESSIMISTIC_WRITE,

/**
 * Pessimistic write lock, with version update.
 *
 * <p>If transaction T1 calls for a lock of type
 * {@code PESSIMISTIC_FORCE_INCREMENT} on an object, the entity
 * manager must ensure that neither of the following phenomena
 * can occur:
 * <ul>
 * <li>P1 <b>Dirty read</b>: Transaction T1 modifies a row.
 * Another transaction T2 then reads that row and obtains the
 * modified value, before T1 has committed or rolled back.
 * </li>
 * <li>P2 <b>Non-repeatable read</b>: Transaction T1 reads a row.
 * Another transaction T2 then modifies or deletes that row,
 * before T1 has committed or rolled back.
 * </ul>
 *
 * <p>In addition, obtaining a lock of type
 * {@code PESSIMISTIC_FORCE_INCREMENT} on a versioned entity will
 * also force an update (increment) to the {@linkplain Version
 * version column}.
 *
 * <p>The persistence implementation is not required to accept
 * requests for {@code PESSIMISTIC_FORCE_INCREMENT} locks on
 * non-versioned entities.
 *
 * @since 2.0
 */
PESSIMISTIC_FORCE_INCREMENT,

/**
 * No lock.
 *
 * @since 2.0
 */
NONE
}

```

B.5. Cache

```

/**
 * Interface used to interact with the second-level cache.
 * If no second-level cache is in use, the methods of this
 * interface have no effect, except for {@link #contains},
 * which returns false.
 *
 * @since 2.0
 */
public interface Cache {

    /**
     * Whether the cache contains data for the given entity.
     * @param cls entity class
     * @param primaryKey primary key
     * @return boolean indicating whether the entity is in the cache
     */
    boolean contains(Class<?> cls, Object primaryKey);
}

```

```

/**
 * Remove the data for the given entity from the cache.
 * @param cls entity class
 * @param primaryKey primary key
 */
void evict(Class<?> cls, Object primaryKey);

/**
 * Remove the data for entities of the specified class
 * (and its subclasses) from the cache.
 * @param cls entity class
 */
void evict(Class<?> cls);

/**
 * Clear the cache.
 */
void evictAll();

/**
 * Return an object of the specified type to allow access to
 * the provider-specific API. If the provider's implementation
 * of the {@code Cache} interface does not support the specified
 * class, the {@link PersistenceException} is thrown.
 * @param cls the class of the object to be returned.
 *           This is usually either the underlying class
 *           implementing {@code Cache}, or an interface it
 *           implements.
 * @return an instance of the specified type
 * @throws PersistenceException if the provider does not support
 *         the given type
 * @since 2.1
 */
<T> T unwrap(Class<T> cls);
}

```

B.6. Query

```

package jakarta.persistence;

import java.util.Calendar;
import java.util.Date;
import java.util.List;
import java.util.Set;
import java.util.Map;
import java.util.stream.Stream;

/**
 * Interface used to control query execution.
 *
 * @see TypedQuery
 * @see StoredProcedureQuery
 * @see Parameter
 *
 * @since 1.0
 */
public interface Query {

    /**
     * Execute a SELECT query and return the query results as an untyped
     * {@link List}.
     * @return a list of the results, or an empty list if there are
     *         no results
     * @throws IllegalStateException if called for a Jakarta
     */

```

```

* Persistence query language UPDATE or DELETE statement
* @throws QueryTimeoutException if the query execution exceeds
* the query timeout value set and only the statement is
* rolled back
* @throws TransactionRequiredException if a lock mode other than
* {@code NONE} has been set and there is no transaction
* or the persistence context has not been joined to the
* transaction
* @throws PessimisticLockException if pessimistic locking
* fails and the transaction is rolled back
* @throws LockTimeoutException if pessimistic locking
* fails and only the statement is rolled back
* @throws PersistenceException if the query execution exceeds
* the query timeout value set and the transaction
* is rolled back
*/
@SuppressWarnings({"rawtypes"})
List getResultList();

/**
 * Execute a SELECT query and return the query results as an untyped
 * {@link java.util.stream.Stream}.
 *
 * <p>By default, this method delegates to {@code getResultList().stream()},
 * however persistence provider may choose to override this method
 * to provide additional capabilities.
 *
 * @return a stream of the results, or an empty stream if there
 * are no results
 * @throws IllegalStateException if called for a Jakarta
 * Persistence query language UPDATE or DELETE statement
 * @throws QueryTimeoutException if the query execution exceeds
 * the query timeout value set and only the statement is
 * rolled back
 * @throws TransactionRequiredException if a lock mode other than
 * {@code NONE} has been set and there is no transaction
 * or the persistence context has not been joined to the
 * transaction
 * @throws PessimisticLockException if pessimistic locking
 * fails and the transaction is rolled back
 * @throws LockTimeoutException if pessimistic locking
 * fails and only the statement is rolled back
 * @throws PersistenceException if the query execution exceeds
 * the query timeout value set and the transaction
 * is rolled back
 * @see Stream
 * @see #getResultList()
 * @since 2.2
 */
@SuppressWarnings({"rawtypes"})
default Stream getResultStream() {
    return getResultList().stream();
}

/**
 * Execute a SELECT query that returns a single untyped result.
 * @return the result
 * @throws NoResultException if there is no result
 * @throws NonUniqueResultException if more than one result
 * @throws IllegalStateException if called for a Jakarta
 * Persistence query language UPDATE or DELETE statement
 * @throws QueryTimeoutException if the query execution exceeds
 * the query timeout value set and only the statement is
 * rolled back
 * @throws TransactionRequiredException if a lock mode other than
 * {@code NONE} has been set and there is no transaction
 * or the persistence context has not been joined to the

```

```

*         transaction
* @throws PessimisticLockException if pessimistic locking
*         fails and the transaction is rolled back
* @throws LockTimeoutException if pessimistic locking
*         fails and only the statement is rolled back
* @throws PersistenceException if the query execution exceeds
*         the query timeout value set and the transaction
*         is rolled back
*/
Object getSingleResult();

/**
* Execute a SELECT query that returns a single untyped result.
* @return the result, or null if there is no result
* @throws NonUniqueResultException if more than one result
* @throws IllegalStateException if called for a Jakarta
*         Persistence query language UPDATE or DELETE statement
* @throws QueryTimeoutException if the query execution exceeds
*         the query timeout value set and only the statement is
*         rolled back
* @throws TransactionRequiredException if a lock mode other than
*         {@code NONE} has been set and there is no transaction
*         or the persistence context has not been joined to the
*         transaction
* @throws PessimisticLockException if pessimistic locking
*         fails and the transaction is rolled back
* @throws LockTimeoutException if pessimistic locking
*         fails and only the statement is rolled back
* @throws PersistenceException if the query execution exceeds
*         the query timeout value set and the transaction
*         is rolled back
*
* @since 3.2
*/
Object getSingleResultOrNull();

/**
* Execute an update or delete statement.
* @return the number of entities updated or deleted
* @throws IllegalStateException if called for a Jakarta
*         Persistence query language SELECT statement or for
*         a criteria query
* @throws TransactionRequiredException if there is
*         no transaction or the persistence context has not
*         been joined to the transaction
* @throws QueryTimeoutException if the statement execution
*         exceeds the query timeout value set and only
*         the statement is rolled back
* @throws PersistenceException if the query execution exceeds
*         the query timeout value set and the transaction
*         is rolled back
*/
int executeUpdate();

/**
* Set the maximum number of results to retrieve.
* @param maxResult maximum number of results to retrieve
* @return the same query instance
* @throws IllegalArgumentException if the argument is negative
*/
Query setMaxResults(int maxResult);

/**
* The maximum number of results the query object was set to retrieve.
* Returns {@link Integer#MAX_VALUE} if {@link #setMaxResults} was not
* applied to the query object.
* @return maximum number of results

```

```

* @since 2.0
*/
int getMaxResults();

/**
 * Set the position of the first result to retrieve.
 * @param startPosition position of the first result, numbered from 0
 * @return the same query instance
 * @throws IllegalArgumentException if the argument is negative
 */
Query setFirstResult(int startPosition);

/**
 * The position of the first result the query object was set to
 * retrieve. Returns {@code 0} if {@code setFirstResult} was not
 * applied to the query object.
 * @return position of the first result
 * @since 2.0
 */
int getFirstResult();

/**
 * Set a query property or hint. The hints elements may be used
 * to specify query properties and hints. Properties defined by
 * this specification must be observed by the provider.
 * Vendor-specific hints that are not recognized by a provider
 * must be silently ignored. Portable applications should not
 * rely on the standard timeout hint. Depending on the database
 * in use and the locking mechanisms used by the provider,
 * this hint may or may not be observed.
 * @param hintName name of the property or hint
 * @param value value for the property or hint
 * @return the same query instance
 * @throws IllegalArgumentException if the second argument is not
 *         valid for the implementation
 */
Query setHint(String hintName, Object value);

/**
 * Get the properties and hints and associated values that are in
 * effect for the query instance.
 * @return query properties and hints
 * @since 2.0
 */
Map<String, Object> getHints();

/**
 * Bind the value of a {@code Parameter} object.
 * @param param parameter object
 * @param value parameter value
 * @return the same query instance
 * @throws IllegalArgumentException if the parameter
 *         does not correspond to a parameter of the
 *         query
 * @since 2.0
 */
<T> Query setParameter(Parameter<T> param, T value);

/**
 * Bind an instance of {@link java.util.Calendar} to a {@link Parameter} object.
 * @param param parameter object
 * @param value parameter value
 * @param temporalType temporal type
 * @return the same query instance
 * @throws IllegalArgumentException if the parameter does not
 *         correspond to a parameter of the query
 * @since 2.0

```

```

* @deprecated Newly-written code should use the date/time types
*     defined in {@link java.time}.
*/
@Deprecated(since = "3.2")
Query setParameter(Parameter<Calendar> param, Calendar value,
    TemporalType temporalType);

/**
 * Bind an instance of {@link java.util.Date} to a {@link Parameter} object.
 * @param param parameter object
 * @param value parameter value
 * @param temporalType temporal type
 * @return the same query instance
 * @throws IllegalArgumentException if the parameter does not
 *     correspond to a parameter of the query
 * @since 2.0
 * @deprecated Newly-written code should use the date/time types
 *     defined in {@link java.time}.
 */
@Deprecated(since = "3.2")
Query setParameter(Parameter<Date> param, Date value,
    TemporalType temporalType);

/**
 * Bind an argument value to a named parameter.
 * @param name parameter name
 * @param value parameter value
 * @return the same query instance
 * @throws IllegalArgumentException if the parameter name does
 *     not correspond to a parameter of the query or if
 *     the argument is of incorrect type
 */
Query setParameter(String name, Object value);

/**
 * Bind an instance of {@link java.util.Calendar} to a named parameter.
 * @param name parameter name
 * @param value parameter value
 * @param temporalType temporal type
 * @return the same query instance
 * @throws IllegalArgumentException if the parameter name does
 *     not correspond to a parameter of the query or if
 *     the value argument is of incorrect type
 * @deprecated Newly-written code should use the date/time types
 *     defined in {@link java.time}.
 */
@Deprecated(since = "3.2")
Query setParameter(String name, Calendar value,
    TemporalType temporalType);

/**
 * Bind an instance of {@link java.util.Date} to a named parameter.
 * @param name parameter name
 * @param value parameter value
 * @param temporalType temporal type
 * @return the same query instance
 * @throws IllegalArgumentException if the parameter name does
 *     not correspond to a parameter of the query or if
 *     the value argument is of incorrect type
 * @deprecated Newly-written code should use the date/time types
 *     defined in {@link java.time}.
 */
@Deprecated(since = "3.2")
Query setParameter(String name, Date value,
    TemporalType temporalType);

/**

```



```

* Bind an argument value to a positional parameter.
* @param position position
* @param value parameter value
* @return the same query instance
* @throws IllegalArgumentException if position does not
*         correspond to a positional parameter of the
*         query or if the argument is of incorrect type
*/
Query setParameter(int position, Object value);

/**
* Bind an instance of {@link java.util.Calendar} to a positional
* parameter.
* @param position position
* @param value parameter value
* @param temporalType temporal type
* @return the same query instance
* @throws IllegalArgumentException if position does not
*         correspond to a positional parameter of the query or
*         if the value argument is of incorrect type
* @deprecated Newly-written code should use the date/time types
*         defined in {@link java.time}.
*/
@Deprecated(since = "3.2")
Query setParameter(int position, Calendar value,
                  TemporalType temporalType);

/**
* Bind an instance of {@link java.util.Date} to a positional
* parameter.
* @param position position
* @param value parameter value
* @param temporalType temporal type
* @return the same query instance
* @throws IllegalArgumentException if position does not
*         correspond to a positional parameter of the query or
*         if the value argument is of incorrect type
* @deprecated Newly-written code should use the date/time types
*         defined in {@link java.time}.
*/
@Deprecated(since = "3.2")
Query setParameter(int position, Date value,
                  TemporalType temporalType);

/**
* Get the parameter objects corresponding to the declared
* parameters of the query.
* Returns empty set if the query has no parameters.
* This method is not required to be supported for native
* queries.
* @return set of the parameter objects
* @throws IllegalStateException if invoked on a native
*         query when the implementation does not support
*         this use
* @since 2.0
*/
Set<Parameter<?>> getParameters();

/**
* Get the parameter object corresponding to the declared
* parameter of the given name.
* This method is not required to be supported for native
* queries.
* @param name parameter name
* @return parameter object
* @throws IllegalArgumentException if the parameter of the
*         specified name does not exist

```

```

* @throws IllegalStateException if invoked on a native
*     query when the implementation does not support
*     this use
* @since 2.0
*/
Parameter<?> getParameter(String name);

/**
 * Get the parameter object corresponding to the declared
 * parameter of the given name and type.
 * This method is required to be supported for criteria queries
 * only.
 * @param name parameter name
 * @param type type
 * @return parameter object
 * @throws IllegalArgumentException if the parameter of the
 *     specified name does not exist or is not assignable
 *     to the type
 * @throws IllegalStateException if invoked on a native
 *     query or Jakarta Persistence query language query when
 *     the implementation does not support this use
 * @since 2.0
 */
<T> Parameter<T> getParameter(String name, Class<T> type);

/**
 * Get the parameter object corresponding to the declared
 * positional parameter with the given position.
 * This method is not required to be supported for native
 * queries.
 * @param position position
 * @return parameter object
 * @throws IllegalArgumentException if the parameter with the
 *     specified position does not exist
 * @throws IllegalStateException if invoked on a native
 *     query when the implementation does not support
 *     this use
 * @since 2.0
 */
Parameter<?> getParameter(int position);

/**
 * Get the parameter object corresponding to the declared
 * positional parameter with the given position and type.
 * This method is not required to be supported by the provider.
 * @param position position
 * @param type type
 * @return parameter object
 * @throws IllegalArgumentException if the parameter with the
 *     specified position does not exist or is not assignable
 *     to the type
 * @throws IllegalStateException if invoked on a native
 *     query or Jakarta Persistence query language query when
 *     the implementation does not support this use
 * @since 2.0
 */
<T> Parameter<T> getParameter(int position, Class<T> type);

/**
 * Return a boolean indicating whether a value has been bound
 * to the parameter.
 * @param param parameter object
 * @return boolean indicating whether parameter has been bound
 * @since 2.0
 */
boolean isBound(Parameter<?> param);

```

```

/**
 * Return the input value bound to the parameter.
 * (Note that OUT parameters are unbound.)
 * @param param parameter object
 * @return parameter value
 * @throws IllegalArgumentException if the parameter is not
 *         a parameter of the query
 * @throws IllegalStateException if the parameter has not
 *         been bound
 * @since 2.0
 */

```

```

<T> T getParameterValue(Parameter<T> param);

```

```

/**
 * Return the input value bound to the named parameter.
 * (Note that OUT parameters are unbound.)
 * @param name parameter name
 * @return parameter value
 * @throws IllegalStateException if the parameter has not
 *         been bound
 * @throws IllegalArgumentException if the parameter of the
 *         specified name does not exist
 * @since 2.0
 */

```

```

Object getParameterValue(String name);

```

```

/**
 * Return the input value bound to the positional parameter.
 * (Note that OUT parameters are unbound.)
 * @param position position
 * @return parameter value
 * @throws IllegalStateException if the parameter has not
 *         been bound
 * @throws IllegalArgumentException if the parameter with the
 *         specified position does not exist
 * @since 2.0
 */

```

```

Object getParameterValue(int position);

```

```

/**
 * Set the flush mode type to be used for the query execution.
 * The flush mode type applies to the query regardless of the
 * flush mode type in use for the entity manager.
 * @param flushMode flush mode
 * @return the same query instance
 */

```

```

Query setFlushMode(FlushModeType flushMode);

```

```

/**
 * Get the flush mode in effect for the query execution.
 * If a flush mode has not been set for the query object,
 * returns the flush mode in effect for the entity manager.
 * @return flush mode
 * @since 2.0
 */

```

```

FlushModeType getFlushMode();

```

```

/**
 * Set the lock mode type to be used for the query execution.
 * @param lockMode lock mode
 * @return the same query instance
 * @throws IllegalStateException if the query is found not to
 *         be a Jakarta Persistence query language SELECT query
 *         or a {@link jakarta.persistence.criteria.CriteriaQuery}
 *         query
 * @since 2.0
 */

```

```

Query setLockMode(LockModeType lockMode);

/**
 * Get the current lock mode for the query. Returns null if a
 * lock mode has not been set on the query object.
 * @return lock mode
 * @throws IllegalStateException if the query is found not to
 *         be a Jakarta Persistence query language SELECT query
 *         or a {@link jakarta.persistence.criteria.CriteriaQuery}
 *         query
 * @since 2.0
 */
LockModeType getLockMode();

/**
 * Set the cache retrieval mode that is in effect during query
 * execution. This cache retrieval mode overrides the cache
 * retrieve mode in use by the entity manager.
 * @param cacheRetrieveMode cache retrieval mode
 * @return the same query instance
 * @since 3.2
 */
Query setCacheRetrieveMode(CacheRetrieveMode cacheRetrieveMode);

/**
 * Set the cache storage mode that is in effect during query
 * execution. This cache storage mode overrides the cache
 * storage mode in use by the entity manager.
 * @param cacheStoreMode cache storage mode
 * @return the same query instance
 * @since 3.2
 */
Query setCacheStoreMode(CacheStoreMode cacheStoreMode);

/**
 * The cache retrieval mode that will be in effect during query
 * execution.
 * @since 3.2
 */
CacheRetrieveMode getCacheRetrieveMode();

/**
 * The cache storage mode that will be in effect during query
 * execution.
 * @since 3.2
 */
CacheStoreMode getCacheStoreMode();

/**
 * Set the query timeout, in milliseconds. This is a hint,
 * and is an alternative to {@linkplain #setHint setting
 * the hint} {@code jakarta.persistence.query.timeout}.
 * @param timeout the timeout, in milliseconds, or null to
 *         indicate no timeout
 * @return the same query instance
 * @since 3.2
 */
Query setTimeout(Integer timeout);

/**
 * The query timeout.
 * @since 3.2
 */
Integer getTimeout();

/**
 * Return an object of the specified type to allow access to

```

```

    * a provider-specific API. If the provider implementation of
    * {@code Query} does not support the given type, the
    * {@link PersistenceException} is thrown.
    * @param cls the type of the object to be returned.
    *           This is usually either the underlying class
    *           implementing {@code Query} or an interface it
    *           implements.
    * @return an instance of the specified class
    * @throws PersistenceException if the provider does not support
    *         the given type
    * @since 2.0
    */
    <T> T unwrap(Class<T> cls);
}

```

B.7. TypedQuery

```

package jakarta.persistence;

import java.util.List;
import java.util.Date;
import java.util.Calendar;
import java.util.stream.Stream;

/**
 * Interface used to control the execution of typed queries.
 *
 * @param <X> query result type
 *
 * @see Query
 * @see Parameter
 *
 * @since 2.0
 */
public interface TypedQuery<X> extends Query {

    /**
     * Execute a SELECT query and return the query results as a typed
     * {@link List List<X>}.
     * @return a list of the results, each of type {@link X}, or an
     *         empty list if there are no results
     * @throws IllegalStateException if called for a Jakarta
     *         Persistence query language UPDATE or DELETE statement
     * @throws QueryTimeoutException if the query execution exceeds
     *         the query timeout value set and only the statement is
     *         rolled back
     * @throws TransactionRequiredException if a lock mode other than
     *         {@code NONE} has been set and there is no transaction
     *         or the persistence context has not been joined to the
     *         transaction
     * @throws PessimisticLockException if pessimistic locking
     *         fails and the transaction is rolled back
     * @throws LockTimeoutException if pessimistic locking
     *         fails and only the statement is rolled back
     * @throws PersistenceException if the query execution exceeds
     *         the query timeout value set and the transaction
     *         is rolled back
     */
    List<X> getResultList();

    /**
     * Execute a SELECT query and return the query result as a typed
     * {@link java.util.stream.Stream Stream<X>}.
     *
     * <p>By default, this method delegates to {@link List#stream()}

```

```

* getResultList().stream()}, however, persistence provider may
* choose to override this method to provide additional capabilities.
*
* @return a stream of the results, each of type {@link X}, or an
*         empty stream if there are no results
* @throws IllegalStateException if called for a Jakarta
*         Persistence query language UPDATE or DELETE statement
* @throws QueryTimeoutException if the query execution exceeds
*         the query timeout value set and only the statement is
*         rolled back
* @throws TransactionRequiredException if a lock mode other than
*         {@code NONE} has been set and there is no transaction
*         or the persistence context has not been joined to the
*         transaction
* @throws PessimisticLockException if pessimistic locking
*         fails and the transaction is rolled back
* @throws LockTimeoutException if pessimistic locking
*         fails and only the statement is rolled back
* @throws PersistenceException if the query execution exceeds
*         the query timeout value set and the transaction
*         is rolled back
* @see Stream
* @see #getResultList()
* @since 2.2
*/
default Stream<X> getResultStream() {
    return getResultList().stream();
}

/**
* Execute a SELECT query that returns a single result.
* @return the result, of type {@link X}
* @throws NoResultException if there is no result
* @throws NonUniqueResultException if more than one result
* @throws IllegalStateException if called for a Jakarta
*         Persistence query language UPDATE or DELETE statement
* @throws QueryTimeoutException if the query execution exceeds
*         the query timeout value set and only the statement is
*         rolled back
* @throws TransactionRequiredException if a lock mode other than
*         {@code NONE} has been set and there is no transaction
*         or the persistence context has not been joined to the
*         transaction
* @throws PessimisticLockException if pessimistic locking
*         fails and the transaction is rolled back
* @throws LockTimeoutException if pessimistic locking
*         fails and only the statement is rolled back
* @throws PersistenceException if the query execution exceeds
*         the query timeout value set and the transaction
*         is rolled back
*/
X getSingleResult();

/**
* Execute a SELECT query that returns a single untyped result.
* @return the result, of type {@link X}, or null if there is no
*         result
* @throws NonUniqueResultException if more than one result
* @throws IllegalStateException if called for a Jakarta
*         Persistence query language UPDATE or DELETE statement
* @throws QueryTimeoutException if the query execution exceeds
*         the query timeout value set and only the statement is
*         rolled back
* @throws TransactionRequiredException if a lock mode other than
*         {@code NONE} has been set and there is no transaction
*         or the persistence context has not been joined to the
*         transaction

```

```

* @throws PessimisticLockException if pessimistic locking
*       fails and the transaction is rolled back
* @throws LockTimeoutException if pessimistic locking
*       fails and only the statement is rolled back
* @throws PersistenceException if the query execution exceeds
*       the query timeout value set and the transaction
*       is rolled back
*
* @since 3.2
*/
X getSingleResultOrNull();

/**
 * Set the maximum number of results to retrieve.
 * @param maxResult maximum number of results to retrieve
 * @return the same query instance
 * @throws IllegalArgumentException if the argument is negative
 */
TypedQuery<X> setMaxResults(int maxResult);

/**
 * Set the position of the first result to retrieve.
 * @param startPosition position of the first result,
 *       numbered from 0
 * @return the same query instance
 * @throws IllegalArgumentException if the argument is negative
 */
TypedQuery<X> setFirstResult(int startPosition);

/**
 * Set a query property or hint. The hints elements may be used
 * to specify query properties and hints. Properties defined by
 * this specification must be observed by the provider.
 * Vendor-specific hints that are not recognized by a provider
 * must be silently ignored. Portable applications should not
 * rely on the standard timeout hint. Depending on the database
 * in use and the locking mechanisms used by the provider,
 * this hint may or may not be observed.
 * @param hintName name of property or hint
 * @param value value for the property or hint
 * @return the same query instance
 * @throws IllegalArgumentException if the second argument is not
 *       valid for the implementation
 */
TypedQuery<X> setHint(String hintName, Object value);

/**
 * Bind the value of a {@code Parameter} object.
 * @param param parameter object
 * @param value parameter value
 * @return the same query instance
 * @throws IllegalArgumentException if the parameter
 *       does not correspond to a parameter of the
 *       query
 */
<T> TypedQuery<X> setParameter(Parameter<T> param, T value);

/**
 * Bind an instance of {@link java.util.Calendar} to a {@link Parameter} object.
 * @param param parameter object
 * @param value parameter value
 * @param temporalType temporal type
 * @return the same query instance
 * @throws IllegalArgumentException if the parameter does not
 *       correspond to a parameter of the query
 * @deprecated Newly-written code should use the date/time types
 *       defined in {@link java.time}.

```

```

*/
@Deprecated(since = "3.2")
TypedQuery<X> setParameter(Parameter<Calendar> param,
                          Calendar value,
                          TemporalType temporalType);

/**
 * Bind an instance of {@link java.util.Date} to a {@link Parameter} object.
 * @param param parameter object
 * @param value parameter value
 * @param temporalType temporal type
 * @return the same query instance
 * @throws IllegalArgumentException if the parameter does not
 *         correspond to a parameter of the query
 * @deprecated Newly-written code should use the date/time types
 *         defined in {@link java.time}.
 */
@Deprecated(since = "3.2")
TypedQuery<X> setParameter(Parameter<Date> param, Date value,
                          TemporalType temporalType);

/**
 * Bind an argument value to a named parameter.
 * @param name parameter name
 * @param value parameter value
 * @return the same query instance
 * @throws IllegalArgumentException if the parameter name does
 *         not correspond to a parameter of the query or if
 *         the argument is of incorrect type
 */
TypedQuery<X> setParameter(String name, Object value);

/**
 * Bind an instance of {@link java.util.Calendar} to a named parameter.
 * @param name parameter name
 * @param value parameter value
 * @param temporalType temporal type
 * @return the same query instance
 * @throws IllegalArgumentException if the parameter name does
 *         not correspond to a parameter of the query or if
 *         the value argument is of incorrect type
 * @deprecated Newly-written code should use the date/time types
 *         defined in {@link java.time}.
 */
@Deprecated(since = "3.2")
TypedQuery<X> setParameter(String name, Calendar value,
                          TemporalType temporalType);

/**
 * Bind an instance of {@link java.util.Date} to a named parameter.
 * @param name parameter name
 * @param value parameter value
 * @param temporalType temporal type
 * @return the same query instance
 * @throws IllegalArgumentException if the parameter name does
 *         not correspond to a parameter of the query or if
 *         the value argument is of incorrect type
 * @deprecated Newly-written code should use the date/time types
 *         defined in {@link java.time}.
 */
@Deprecated(since = "3.2")
TypedQuery<X> setParameter(String name, Date value,
                          TemporalType temporalType);

/**
 * Bind an argument value to a positional parameter.
 * @param position position

```



```

* @param value parameter value
* @return the same query instance
* @throws IllegalArgumentException if position does not
*         correspond to a positional parameter of the
*         query or if the argument is of incorrect type
*/
TypedQuery<X> setParameter(int position, Object value);

/**
 * Bind an instance of {@link java.util.Calendar} to a positional
 * parameter.
 * @param position position
 * @param value parameter value
 * @param temporalType temporal type
 * @return the same query instance
 * @throws IllegalArgumentException if position does not
 *         correspond to a positional parameter of the query
 *         or if the value argument is of incorrect type
 * @deprecated Newly-written code should use the date/time types
 *         defined in {@link java.time}.
 */
@Deprecated(since = "3.2")
TypedQuery<X> setParameter(int position, Calendar value,
                           TemporalType temporalType);

/**
 * Bind an instance of {@link java.util.Date} to a positional
 * parameter.
 * @param position position
 * @param value parameter value
 * @param temporalType temporal type
 * @return the same query instance
 * @throws IllegalArgumentException if position does not
 *         correspond to a positional parameter of the query
 *         or if the value argument is of incorrect type
 * @deprecated Newly-written code should use the date/time types
 *         defined in {@link java.time}.
 */
@Deprecated(since = "3.2")
TypedQuery<X> setParameter(int position, Date value,
                           TemporalType temporalType);

/**
 * Set the flush mode type to be used for the query execution.
 * The flush mode type applies to the query regardless of the
 * flush mode type in use for the entity manager.
 * @param flushMode flush mode
 * @return the same query instance
 */
TypedQuery<X> setFlushMode(FlushModeType flushMode);

/**
 * Set the lock mode type to be used for the query execution.
 * @param lockMode lock mode
 * @return the same query instance
 * @throws IllegalStateException if the query is found not to
 *         be a Jakarta Persistence query language SELECT query
 *         or a {@link jakarta.persistence.criteria.CriteriaQuery}
 *         query
 */
TypedQuery<X> setLockMode(LockModeType lockMode);

/**
 * Set the cache retrieval mode that is in effect during
 * query execution. This cache retrieval mode overrides the
 * cache retrieve mode in use by the entity manager.
 * @param cacheRetrieveMode cache retrieval mode

```

```

    * @return the same query instance
    * @since 3.2
    */
    TypedQuery<X> setCacheRetrieveMode(CacheRetrieveMode cacheRetrieveMode);

    /**
     * Set the cache storage mode that is in effect during
     * query execution. This cache storage mode overrides the
     * cache storage mode in use by the entity manager.
     * @param cacheStoreMode cache storage mode
     * @return the same query instance
     * @since 3.2
     */
    TypedQuery<X> setCacheStoreMode(CacheStoreMode cacheStoreMode);

    /**
     * Set the query timeout, in milliseconds. This is a hint,
     * and is an alternative to {@linkplain #setHint setting
     * the hint} {@code jakarta.persistence.query.timeout}.
     * @param timeout the timeout, in milliseconds, or null to
     *             indicate no timeout
     * @return the same query instance
     * @since 3.2
     */
    TypedQuery<X> setTimeout(Integer timeout);
}

```

B.8. StoredProcedureQuery

```

import java.util.Calendar;
import java.util.Date;
import java.util.List;

/**
 * Interface used to control stored procedure query execution.
 *
 * <p>
 * Stored procedure query execution may be controlled in accordance with
 * the following:
 * <ul>
 * <li>The {@link #setParameter} methods are used to set the values of
 * all required {@code IN} and {@code INOUT} parameters. It is not
 * required to set the values of stored procedure parameters for which
 * default values have been defined by the stored procedure.</li>
 * <li>When {@link #getResultList} and {@link #getSingleResult} are
 * called on a {@code StoredProcedureQuery} object, the provider calls
 * {@link #execute} on an unexecuted stored procedure query before
 * processing {@code getResultList} or {@code getSingleResult}.</li>
 * <li>When {@link #executeUpdate} is called on a
 * {@code StoredProcedureQuery} object, the provider will call
 * {@link #execute} on an unexecuted stored procedure query, followed
 * by {@link #getUpdateCount}. The results of {@code executeUpdate} will
 * be those of {@code getUpdateCount}.</li>
 * <li>The {@link #execute} method supports both the simple case where
 * scalar results are passed back only via {@code INOUT} and {@code OUT}
 * parameters as well as the most general case (multiple result sets
 * and/or update counts, possibly also in combination with output
 * parameter values).</li>
 * <li>The {@code execute} method returns true if the first result is
 * a result set, and false if it is an update count or there are no
 * results other than through {@code INOUT} and {@code OUT} parameters,
 * if any.</li>
 * <li>If the {@code execute} method returns true, the pending result
 * set can be obtained by calling {@link #getResultList} or
 * {@link #getSingleResult}.</li>

```

```

* <li> The {@link #hasMoreResults} method can then be used to test for
* further results.</li>
* <li> If {@code execute} or {@code hasMoreResults} returns false, the
* {@link #getUpdateCount} method can be called to obtain the pending
* result if it is an update count. The {@code getUpdateCount} method
* will return either the update count (zero or greater) or -1 if there
* is no update count (i.e., either the next result is a result set or
* there is no next update count).</li>
* <li> For portability, results that correspond to JDBC result sets
* and update counts need to be processed before the values of any
* {@code INOUT} or {@code OUT} parameters are extracted.</li>
* <li> After results returned through {@link #getResultList} and
* {@link #getUpdateCount} have been exhausted, results returned through
* {@code INOUT} and {@code OUT} parameters can be retrieved.</li>
* <li> The {@link #getOutputParameterValue} methods are used to
* retrieve the values passed back from the procedure through
* {@code INOUT} and {@code OUT} parameters.</li>
* <li> When using {@code REF_CURSOR} parameters for result sets the
* update counts should be exhausted before calling {@link #getResultList}
* to retrieve the result set. Alternatively, the {@code REF_CURSOR}
* result set can be retrieved through {@link #getOutputParameterValue}.
* Result set mappings are applied to results corresponding to
* {@code REF_CURSOR} parameters in the order the {@code REF_CURSOR}
* parameters were registered with the query.</li>
* <li> In the simplest case, where results are returned only via
* {@code INOUT} and {@code OUT} parameters, {@code execute} can be
* followed immediately by calls to {@link #getOutputParameterValue}.
* </li>
* </ul>
*
* @see Query
* @see Parameter
*
* @since 2.1
*/

```

```

public interface StoredProcedureQuery extends Query {

    /**
     * Set a query property or hint. The hints elements may be used
     * to specify query properties and hints. Properties defined by
     * this specification must be observed by the provider.
     * Vendor-specific hints that are not recognized by a provider
     * must be silently ignored. Portable applications should not
     * rely on the standard timeout hint. Depending on the database
     * in use, this hint may or may not be observed.
     * @param hintName name of the property or hint
     * @param value value for the property or hint
     * @return the same query instance
     * @throws IllegalArgumentException if the second argument is not
     *         valid for the implementation
     */
    StoredProcedureQuery setHint(String hintName, Object value);

    /**
     * Bind the value of a {@code Parameter} object.
     * @param param parameter object
     * @param value parameter value
     * @return the same query instance
     * @throws IllegalArgumentException if the parameter does not
     *         correspond to a parameter of the query
     */
    <T> StoredProcedureQuery setParameter(Parameter<T> param,
                                           T value);

    /**
     * Bind an instance of {@link java.util.Calendar} to a {@link Parameter} object.
     * @param param parameter object
     */

```

```

* @param value parameter value
* @param temporalType temporal type
* @return the same query instance
* @throws IllegalArgumentException if the parameter does not
*         correspond to a parameter of the query
* @deprecated Newly-written code should use the date/time types
*         defined in {@link java.time}.
*/
@Deprecated(since = "3.2")
StoredProcedureQuery setParameter(Parameter<Calendar> param,
                                Calendar value,
                                TemporalType temporalType);

/**
 * Bind an instance of {@link java.util.Date} to a {@link Parameter} object.
 * @param param parameter object
 * @param value parameter value
 * @param temporalType temporal type
 * @return the same query instance
 * @throws IllegalArgumentException if the parameter does not
 *         correspond to a parameter of the query
 * @deprecated Newly-written code should use the date/time types
 *         defined in {@link java.time}.
 */
@Deprecated(since = "3.2")
StoredProcedureQuery setParameter(Parameter<Date> param,
                                Date value,
                                TemporalType temporalType);

/**
 * Bind an argument value to a named parameter.
 * @param name parameter name
 * @param value parameter value
 * @return the same query instance
 * @throws IllegalArgumentException if the parameter name does
 *         not correspond to a parameter of the query or if the
 *         argument is of incorrect type
 */
StoredProcedureQuery setParameter(String name, Object value);

/**
 * Bind an instance of {@code java.util.Calendar} to a named parameter.
 * @param name parameter name
 * @param value parameter value
 * @param temporalType temporal type
 * @return the same query instance
 * @throws IllegalArgumentException if the parameter name does
 *         not correspond to a parameter of the query or if the
 *         value argument is of incorrect type
 * @deprecated Newly-written code should use the date/time types
 *         defined in {@link java.time}.
 */
@Deprecated(since = "3.2")
StoredProcedureQuery setParameter(String name,
                                Calendar value,
                                TemporalType temporalType);

/**
 * Bind an instance of {@code java.util.Date} to a named parameter.
 * @param name parameter name
 * @param value parameter value
 * @param temporalType temporal type
 * @return the same query instance
 * @throws IllegalArgumentException if the parameter name does
 *         not correspond to a parameter of the query or if the
 *         value argument is of incorrect type
 * @deprecated Newly-written code should use the date/time types

```

```

*         defined in {@link java.time}.
*/
@Deprecated(since = "3.2")
StoredProcedureQuery setParameter(String name,
                                Date value,
                                TemporalType temporalType);

/**
 * Bind an argument value to a positional parameter.
 * @param position position
 * @param value parameter value
 * @return the same query instance
 * @throws IllegalArgumentException if position does not
 *         correspond to a positional parameter of the query
 *         or if the argument is of incorrect type
 */
StoredProcedureQuery setParameter(int position, Object value);

/**
 * Bind an instance of {@code java.util.Calendar} to a positional
 * parameter.
 * @param position position
 * @param value parameter value
 * @param temporalType temporal type
 * @return the same query instance
 * @throws IllegalArgumentException if position does not
 *         correspond to a positional parameter of the query or
 *         if the value argument is of incorrect type
 * @deprecated Newly-written code should use the date/time types
 *         defined in {@link java.time}.
 */
@Deprecated(since = "3.2")
StoredProcedureQuery setParameter(int position,
                                Calendar value,
                                TemporalType temporalType);

/**
 * Bind an instance of {@code java.util.Date} to a positional parameter.
 * @param position position
 * @param value parameter value
 * @param temporalType temporal type
 * @return the same query instance
 * @throws IllegalArgumentException if position does not
 *         correspond to a positional parameter of the query or
 *         if the value argument is of incorrect type
 * @deprecated Newly-written code should use the date/time types
 *         defined in {@link java.time}.
 */
@Deprecated(since = "3.2")
StoredProcedureQuery setParameter(int position,
                                Date value,
                                TemporalType temporalType);

/**
 * Set the flush mode type to be used for the query execution.
 * The flush mode type applies to the query regardless of the
 * flush mode type in use for the entity manager.
 * @param flushMode flush mode
 * @return the same query instance
 */
StoredProcedureQuery setFlushMode(FlushModeType flushMode);

/**
 * Set the cache retrieval mode that is in effect during
 * query execution. This cache retrieval mode overrides the
 * cache retrieve mode in use by the entity manager.
 * @param cacheRetrieveMode cache retrieval mode

```

```

    * @return the same query instance
    * @since 3.2
    */
StoredProcedureQuery setCacheRetrieveMode(CacheRetrieveMode cacheRetrieveMode);

/**
 * Set the cache storage mode that is in effect during
 * query execution. This cache storage mode overrides the
 * cache storage mode in use by the entity manager.
 * @param cacheStoreMode cache storage mode
 * @return the same query instance
 * @since 3.2
 */
StoredProcedureQuery setCacheStoreMode(CacheStoreMode cacheStoreMode);

/**
 * Set the query timeout, in milliseconds. This is a hint,
 * and is an alternative to {@linkplain #setHint setting
 * the hint} {@code jakarta.persistence.query.timeout}.
 * @param timeout the timeout, in milliseconds, or null to
 *                 indicate no timeout
 * @return the same query instance
 * @since 3.2
 */
StoredProcedureQuery setTimeout(Integer timeout);

/**
 * Register a positional parameter.
 * All parameters must be registered.
 * @param position parameter position
 * @param type type of the parameter
 * @param mode parameter mode
 * @return the same query instance
 */
StoredProcedureQuery registerStoredProcedureParameter(
    int position,
    Class<?> type,
    ParameterMode mode);

/**
 * Register a named parameter.
 * @param parameterName name of the parameter as registered or
 *                       specified in metadata
 * @param type type of the parameter
 * @param mode parameter mode
 * @return the same query instance
 */
StoredProcedureQuery registerStoredProcedureParameter(
    String parameterName,
    Class<?> type,
    ParameterMode mode);

/**
 * Retrieve a value passed back from the procedure
 * through an INOUT or OUT parameter.
 * For portability, all results corresponding to result sets
 * and update counts must be retrieved before the values of
 * output parameters.
 * @param position parameter position
 * @return the result that is passed back through the parameter
 * @throws IllegalArgumentException if the position does
 *         not correspond to a parameter of the query or is
 *         not an INOUT or OUT parameter
 */
Object getOutputParameterValue(int position);

/**

```

```

* Retrieve a value passed back from the procedure
* through an INOUT or OUT parameter.
* For portability, all results corresponding to result sets
* and update counts must be retrieved before the values of
* output parameters.
* @param parameterName name of the parameter as registered or
*     specified in metadata
* @return the result that is passed back through the parameter
* @throws IllegalArgumentException if the parameter name does
*     not correspond to a parameter of the query or is
*     not an INOUT or OUT parameter
*/

```

```
Object getOutputParameterValue(String parameterName);
```

```

/**
* Return true if the first result corresponds to a result set,
* and false if it is an update count or if there are no results
* other than through INOUT and OUT parameters, if any.
* @return true if first result corresponds to result set
* @throws QueryTimeoutException if the query execution exceeds
*     the query timeout value set and only the statement is
*     rolled back
* @throws PersistenceException if the query execution exceeds
*     the query timeout value set and the transaction
*     is rolled back
*/

```

```
boolean execute();
```

```

/**
* Return the update count of -1 if there is no pending result or
* if the first result is not an update count. The provider will
* call {@code execute} on the query if needed.
* @return the update count or -1 if there is no pending result
* or if the next result is not an update count.
* @throws TransactionRequiredException if there is
*     no transaction or the persistence context has not
*     been joined to the transaction
* @throws QueryTimeoutException if the statement execution
*     exceeds the query timeout value set and only
*     the statement is rolled back
* @throws PersistenceException if the query execution exceeds
*     the query timeout value set and the transaction
*     is rolled back
*/

```

```
int executeUpdate();
```

```

/**
* Retrieve the list of results from the next result set.
* The provider will call {@code execute} on the query
* if needed.
* A {@code REF_CURSOR} result set, if any, is retrieved
* in the order the {@code REF_CURSOR} parameter was
* registered with the query.
* @return a list of the results or null if the next item is not
* a result set
* @throws QueryTimeoutException if the query execution exceeds
*     the query timeout value set and only the statement is
*     rolled back
* @throws PersistenceException if the query execution exceeds
*     the query timeout value set and the transaction
*     is rolled back
*/

```

```
List getResultList();
```

```

/**
* Retrieve a single result from the next result set.
* The provider will call {@code execute} on the query

```

```

* if needed.
* A {@code REF_CURSOR} result set, if any, is retrieved
* in the order the {@code REF_CURSOR} parameter was
* registered with the query.
* @return the result or null if the next item is not a result set
* @throws NoResultException if there is no result in the next
*         result set
* @throws NonUniqueResultException if more than one result
* @throws QueryTimeoutException if the query execution exceeds
*         the query timeout value set and only the statement is
*         rolled back
* @throws PersistenceException if the query execution exceeds
*         the query timeout value set and the transaction
*         is rolled back
*/

```

```
Object getSingleResult();
```

```

/**
* Retrieve a single result from the next result set.
* The provider will call {@code execute} on the query
* if needed.
* A {@code REF_CURSOR} result set, if any, is retrieved
* in the order the {@code REF_CURSOR} parameter was
* registered with the query.
* @return the result or null if the next item is not a result set
*         or if there is no result in the next result set
* @throws NonUniqueResultException if more than one result
* @throws QueryTimeoutException if the query execution exceeds
*         the query timeout value set and only the statement is
*         rolled back
* @throws PersistenceException if the query execution exceeds
*         the query timeout value set and the transaction
*         is rolled back
*/

```

```
Object getSingleResultOrNull();
```

```

/**
* Return true if the next result corresponds to a result set,
* and false if it is an update count or if there are no results
* other than through INOUT and OUT parameters, if any.
* @return true if next result corresponds to result set
* @throws QueryTimeoutException if the query execution exceeds
*         the query timeout value set and only the statement is
*         rolled back
* @throws PersistenceException if the query execution exceeds
*         the query timeout value set and the transaction
*         is rolled back
*/

```

```
boolean hasMoreResults();
```

```

/**
* Return the update count or -1 if there is no pending result
* or if the next result is not an update count.
* @return update count or -1 if there is no pending result or if
*         the next result is not an update count
* @throws QueryTimeoutException if the query execution exceeds
*         the query timeout value set and only the statement is
*         rolled back
* @throws PersistenceException if the query execution exceeds
*         the query timeout value set and the transaction
*         is rolled back
*/

```

```
int getUpdateCount();
```

```
}
```


B.9. Tuple

```
import java.util.List;

/**
 * Interface for extracting the elements of a query result tuple.
 *
 * @see TupleElement
 *
 * @since 2.0
 */
public interface Tuple {

    /**
     * Get the value of the specified tuple element.
     * @param tupleElement tuple element
     * @return value of tuple element
     * @throws IllegalArgumentException if tuple element
     *         does not correspond to an element in the
     *         query result tuple
     */
    <X> X get(TupleElement<X> tupleElement);

    /**
     * Get the value of the tuple element to which the
     * specified alias has been assigned.
     * @param alias alias assigned to tuple element
     * @param type of the tuple element
     * @return value of the tuple element
     * @throws IllegalArgumentException if alias
     *         does not correspond to an element in the
     *         query result tuple or element cannot be
     *         assigned to the specified type
     */
    <X> X get(String alias, Class<X> type);

    /**
     * Get the value of the tuple element to which the
     * specified alias has been assigned.
     * @param alias alias assigned to tuple element
     * @return value of the tuple element
     * @throws IllegalArgumentException if alias
     *         does not correspond to an element in the
     *         query result tuple
     */
    Object get(String alias);

    /**
     * Get the value of the element at the specified
     * position in the result tuple. The first position
     * is 0.
     * @param i position in result tuple
     * @param type type of the tuple element
     * @return value of the tuple element
     * @throws IllegalArgumentException if i exceeds
     *         length of result tuple or element cannot
     *         be assigned to the specified type
     */
    <X> X get(int i, Class<X> type);

    /**
     * Get the value of the element at the specified
     * position in the result tuple. The first position
     * is 0.
     * @param i position in result tuple
     * @return value of the tuple element
     */
}
```

```

    * @throws IllegalArgumentException if i exceeds
    *     length of result tuple
    */
    Object get(int i);

    /**
     * Return the values of the result tuple elements as
     * an array.
     * @return tuple element values
     */
    Object[] toArray();

    /**
     * Return the tuple elements.
     * @return tuple elements
     */
    List<TupleElement<?>> getElements();
}

```

B.10. TupleElement

```

/**
 * The {@code TupleElement} interface defines an element that is
 * returned in a query result tuple.
 *
 * @param <X> the type of the element
 *
 * @see Tuple
 *
 * @since 2.0
 */
public interface TupleElement<X> {

    /**
     * Return the Java type of the tuple element.
     * @return the Java type of the tuple element
     */
    Class<? extends X> getJavaType();

    /**
     * Return the alias assigned to the tuple element or null,
     * if no alias has been assigned.
     * @return alias
     */
    String getAlias();
}

```

B.11. Parameter

```

/**
 * Type for query parameter objects.
 *
 * @param <T> the type of the parameter
 *
 * @see Query
 * @see TypedQuery
 *
 * @since 2.0
 */
public interface Parameter<T> {

    /**
     * Return the parameter name, or null if the parameter is

```

```

    * not a named parameter or no name has been assigned.
    * @return parameter name
    */
    String getName();

    /**
     * Return the parameter position, or null if the parameter
     * is not a positional parameter.
     * @return position of parameter
     */
    Integer getPosition();

    /**
     * Return the Java type of the parameter. Values bound to
     * the parameter must be assignable to this type.
     * This method is required to be supported for criteria
     * queries only. Applications that use this method for
     * Jakarta Persistence query language queries and native
     * queries will not be portable.
     * @return the Java type of the parameter
     * @throws IllegalStateException if invoked on a parameter
     *         obtained from a query language query or native
     *         query when the implementation does not support
     *         this usage
     */
    Class<T> getParameterType();
}

```

B.12. Graph

```

import jakarta.persistence.metamodel.Attribute;
import jakarta.persistence.metamodel.MapAttribute;
import jakarta.persistence.metamodel.PluralAttribute;

import java.util.List;

/**
 * Declares operations common to {@link EntityGraph} and {@link Subgraph}.
 *
 * @see EntityGraph
 * @see Subgraph
 *
 * @since 3.2
 */
public interface Graph<T> {

    /**
     * Get an existing attribute node for the attribute with the given
     * name, or add a new attribute node if there is no existing node.
     *
     * @param attributeName name of the attribute
     * @return the attribute node
     * @throws IllegalArgumentException if the attribute is not an
     *         attribute of this entity.
     * @throws IllegalStateException if the EntityGraph has been
     *         statically defined
     *
     * @since 3.2
     */
    <Y> AttributeNode<Y> addAttributeNode(String attributeName);

    /**
     * Get an existing attribute node for the given attribute, or add
     * a new attribute node if there is no existing node.
     *
     *
     */
}

```

```

* @param attribute attribute
* @return the attribute node
* @throws IllegalStateException if the EntityGraph has been
*       statically defined
*
* @since 3.2
*/
<Y> AttributeNode<Y> addAttributeNode(Attribute<? super T, Y> attribute);

/**
 * Determine if there is an existing attribute node for the attribute
 * with the given name.
 *
 * @param attributeName name of the attribute
 * @return true if there is an existing attribute node
 * @throws IllegalArgumentException if the attribute is not an
 *       attribute of this entity.
 *
 * @since 3.2
 */
boolean hasAttributeNode(String attributeName);

/**
 * Determine if there is an existing attribute node for the given
 * attribute.
 *
 * @param attribute attribute
 * @return true if there is an existing attribute node
 *
 * @since 3.2
 */
boolean hasAttributeNode(Attribute<? super T, ?> attribute);

/**
 * Get an existing attribute node for the attribute with the given
 * name.
 *
 * @param attributeName name of the attribute
 * @return the attribute node
 * @throws IllegalArgumentException if the attribute is not an
 *       attribute of this entity.
 * @throws java.util.NoSuchElementException if there is no existing
 *       node for the attribute
 *
 * @since 3.2
 */
<Y> AttributeNode<Y> getAttributeNode(String attributeName);

/**
 * Get an existing attribute node for the given attribute.
 *
 * @param attribute attribute
 * @return the attribute node
 * @throws java.util.NoSuchElementException if there is no existing
 *       node for the attribute
 *
 * @since 3.2
 */
<Y> AttributeNode<Y> getAttributeNode(Attribute<? super T, Y> attribute);

/**
 * Remove an attribute node from the entity graph.
 * When this graph is interpreted as a load graph, this operation
 * suppresses inclusion of an attribute mapped for eager fetching.
 * The effect of this call may be overridden by subsequent
 * invocations of {@link #addAttributeNode} or {@link #addSubgraph}.
 * If there is no existing node for the given attribute name, this

```

```

* operation has no effect.
*
* @param attributeName name of the attribute
*
* @since 3.2
*/
void removeAttributeNode(String attributeName);

/**
 * Remove an attribute node from the entity graph.
 * When this graph is interpreted as a load graph, this operation
 * suppresses inclusion of an attribute mapped for eager fetching.
 * The effect of this call may be overridden by subsequent
 * invocations of {@link #addAttributeNode} or {@link #addSubgraph}.
 * If there is no existing node for the given attribute, this
 * operation has no effect.
 *
 * @param attribute attribute
 *
 * @since 3.2
 */
void removeAttributeNode(Attribute<? super T, ?> attribute);

/**
 * Remove all attribute nodes of the given attribute types.
 * When this graph is interpreted as a load graph, this operation
 * suppresses inclusion of attributes mapped for eager fetching.
 * The effect of this call may be overridden by subsequent
 * invocations of {@link #addAttributeNode} or {@link #addSubgraph}.
 *
 * @since 3.2
 */
void removeAttributeNodes(Attribute.PersistentAttributeType nodeTypes);

/**
 * Add one or more attribute nodes to the entity graph.
 * If there is already an existing node for one of the given
 * attribute names, that particular argument is ignored and
 * has no effect.
 *
 * @param attributeName name of the attribute
 * @throws IllegalArgumentException if the attribute is not an
 *         attribute of this managed type.
 * @throws IllegalStateException if the EntityGraph has been
 *         statically defined
 */
void addAttributeNodes(String... attributeName);

/**
 * Add one or more attribute nodes to the entity graph.
 * If there is already an existing node for one of the given
 * attributes, that particular argument is ignored and has no
 * effect.
 *
 * @param attribute attribute
 * @throws IllegalStateException if this EntityGraph has been
 *         statically defined
 */
void addAttributeNodes(Attribute<? super T, ?>... attribute);

/**
 * Add a node to the graph that corresponds to a managed
 * type. This allows for construction of multi-node entity graphs
 * that include related managed types.
 *
 * @param attribute attribute
 * @return subgraph for the attribute

```

```

* @throws IllegalArgumentException if the attribute's target
*     type is not a managed type
* @throws IllegalStateException if the EntityGraph has been
*     statically defined
*/
<X> Subgraph<X> addSubgraph(Attribute<? super T, X> attribute);

/**
 * Add a node to the graph that corresponds to a managed
 * type with inheritance. This allows for multiple subclass
 * subgraphs to be defined for this node of the entity
 * graph. Subclass subgraphs will automatically include the
 * specified attributes of superclass subgraphs.
 *
 * @param attribute attribute
 * @param type entity subclass
 * @return subgraph for the attribute
 * @throws IllegalArgumentException if the attribute's target
 *     type is not a managed type
 * @throws IllegalStateException if the EntityGraph has been
 *     statically defined
 *
 * @since 3.2
 */
<Y> Subgraph<Y> addTreatedSubgraph(Attribute<? super T, ? super Y> attribute, Class<Y> type);

/**
 * Add a node to the graph that corresponds to a managed type
 * with inheritance. This allows for multiple subclass
 * subgraphs to be defined for this node of the entity graph.
 * Subclass subgraphs will automatically include the specified
 * attributes of superclass subgraphs
 *
 * @param attribute attribute
 * @param type entity subclass
 * @return subgraph for the attribute
 * @throws IllegalArgumentException if the attribute's target
 *     type is not a managed type
 * @throws IllegalStateException if this EntityGraph has been
 *     statically defined
 * @deprecated use {@link #addTreatedSubgraph(Attribute, Class)}
 */
@Deprecated(since = "3.2", forRemoval = true)
<X> Subgraph<? extends X> addSubgraph(Attribute<? super T, X> attribute, Class<? extends X> type);

/**
 * Add a node to the graph that corresponds to a managed type.
 * This allows for construction of multi-node entity graphs
 * that include related managed types.
 *
 * @param attributeName name of the attribute
 * @return subgraph for the attribute
 * @throws IllegalArgumentException if the attribute is not an
 *     attribute of this managed type.
 * @throws IllegalArgumentException if the attribute's target
 *     type is not a managed type
 * @throws IllegalStateException if this EntityGraph has been
 *     statically defined
 */
<X> Subgraph<X> addSubgraph(String attributeName);

/**
 * Add a node to the graph that corresponds to a managed
 * type with inheritance. This allows for multiple subclass
 * subgraphs to be defined for this node of the entity
 * graph. Subclass subgraphs will automatically include the
 * specified attributes of superclass subgraphs

```

```

*
* @param attributeName name of the attribute
* @param type entity subclass
* @return subgraph for the attribute
* @throws IllegalArgumentException if the attribute is not
*         an attribute of this managed type.
* @throws IllegalArgumentException if the attribute's target
*         type is not a managed type
* @throws IllegalStateException if this EntityGraph has been
*         statically defined
*/
<X> Subgraph<X> addSubgraph(String attributeName, Class<X> type);

/**
 * Add a node to the graph that corresponds to a collection element
 * that is a managed type. This allows for construction of
 * multi-node entity graphs that include related managed types.
 *
 * @param attribute attribute
 * @return subgraph for the element attribute
 * @throws IllegalArgumentException if the attribute's target type
 *         is not an entity
 * @throws IllegalStateException if this EntityGraph has been
 *         statically defined
 *
 * @since 3.2
 */
<E> Subgraph<E> addElementSubgraph(PluralAttribute<? super T, ?, E> attribute);

/**
 * Add a node to the graph that corresponds to a collection element
 * that is a managed type. This allows for construction of
 * multi-node entity graphs that include related managed types.
 *
 * @param attribute attribute
 * @return subgraph for the element attribute
 * @throws IllegalArgumentException if the attribute's target type
 *         is not an entity
 * @throws IllegalStateException if this EntityGraph has been
 *         statically defined
 *
 * @since 3.2
 */
<E> Subgraph<E> addTreatedElementSubgraph(PluralAttribute<? super T, ?, ? super E> attribute, Class<E> type);

/**
 * Add a node to the graph that corresponds to a collection element
 * that is a managed type. This allows for construction of
 * multi-node entity graphs that include related managed types.
 *
 * @param attributeName name of the attribute
 * @return subgraph for the element attribute
 * @throws IllegalArgumentException if the attribute is not an
 *         attribute of this entity.
 * @throws IllegalArgumentException if the attribute's target
 *         type is not a managed type
 * @throws IllegalStateException if this EntityGraph has been
 *         statically defined
 */
<X> Subgraph<X> addElementSubgraph(String attributeName);

/**
 * Add a node to the graph that corresponds to a collection element
 * that is a managed type. This allows for construction of
 * multi-node entity graphs that include related managed types.
 *
 * @param attributeName name of the attribute

```

```

* @param type entity subclass
* @return subgraph for the element attribute
* @throws IllegalArgumentException if the attribute is not an
*       attribute of this entity.
* @throws IllegalArgumentException if the attribute's target
*       type is not a managed type
* @throws IllegalStateException if this EntityGraph has been
*       statically defined
*/
<X> Subgraph<X> addElementSubgraph(String attributeName, Class<X> type);

/**
 * Add a node to the graph that corresponds to a map key
 * that is a managed type. This allows for construction of
 * multi-node entity graphs that include related managed types.
 *
 * @param attribute attribute
 * @return subgraph for the key attribute
 * @throws IllegalArgumentException if the attribute's target
 *       type is not a managed type entity
 * @throws IllegalStateException if this EntityGraph has been
 *       statically defined
 */
<K> Subgraph<K> addMapKeySubgraph(MapAttribute<? super T, K, ?> attribute);

/**
 * Add a node to the graph that corresponds to a map key
 * that is a managed type with inheritance. This allows for
 * construction of multi-node entity graphs that include related
 * managed types. Subclass subgraphs will automatically include
 * the specified attributes of superclass subgraphs
 *
 * @param attribute attribute
 * @param type entity subclass
 * @return subgraph for the attribute
 * @throws IllegalArgumentException if the attribute's target
 *       type is not a managed type entity
 * @throws IllegalStateException if this EntityGraph has been
 *       statically defined
 */
<K> Subgraph<K> addTreatedMapKeySubgraph(MapAttribute<? super T, ? super K, ?> attribute, Class<K> type);

/**
 * Add a node to the graph that corresponds to a map key
 * that is a managed type. This allows for construction of
 * multi-node entity graphs that include related managed types.
 *
 * @param attribute attribute
 * @return subgraph for the key attribute
 * @throws IllegalArgumentException if the attribute's target
 *       type is not a managed type entity
 * @throws IllegalStateException if this EntityGraph has been
 *       statically defined
 * @deprecated use {@link #addMapKeySubgraph(MapAttribute)}
 */
@Deprecated(since = "3.2", forRemoval = true)
<X> Subgraph<X> addKeySubgraph(Attribute<? super T, X> attribute);

/**
 * Add a node to the graph that corresponds to a map key
 * that is a managed type with inheritance. This allows for
 * construction of multi-node entity graphs that include related
 * managed types. Subclass subgraphs will automatically include
 * the specified attributes of superclass subgraphs
 *
 * @param attribute attribute
 * @param type entity subclass

```



```

* @return subgraph for the attribute
* @throws IllegalArgumentException if the attribute's target
*     type is not a managed type entity
* @throws IllegalStateException if this EntityGraph has been
*     statically defined
* @deprecated use {@link #addTreatedMapKeySubgraph(MapAttribute, Class)}
*/
@Deprecated(since = "3.2", forRemoval = true)
<X> Subgraph<? extends X> addKeySubgraph(Attribute<? super T, X> attribute, Class<? extends X> type);

/**
 * Add a node to the graph that corresponds to a map key
 * that is a managed type. This allows for construction of
 * multi-node entity graphs that include related managed types.
 *
 * @param attributeName name of the attribute
 * @return subgraph for the key attribute
 * @throws IllegalArgumentException if the attribute is not an
 *     attribute of this entity.
 * @throws IllegalArgumentException if the attribute's target
 *     type is not a managed type
 * @throws IllegalStateException if this EntityGraph has been
 *     statically defined
 */
<X> Subgraph<X> addKeySubgraph(String attributeName);

/**
 * Add a node to the graph that corresponds to a map key
 * that is a managed type with inheritance. This allows for
 * construction of multi-node entity graphs that include related
 * managed types. Subclass subgraphs will include the specified
 * attributes of superclass subgraphs
 *
 * @param attributeName name of the attribute
 * @param type entity subclass
 * @return subgraph for the attribute
 * @throws IllegalArgumentException if the attribute is not an
 *     attribute of this entity.
 * @throws IllegalArgumentException if the attribute's target
 *     type is not a managed type
 * @throws IllegalStateException if this EntityGraph has been
 *     statically defined
 */
<X> Subgraph<X> addKeySubgraph(String attributeName, Class<X> type);

/**
 * Return the attribute nodes corresponding to the attributes of
 * this managed type that are included in the graph.
 * @return list of attribute nodes included in the graph or an
 * empty list if none have been defined
 */
List<AttributeNode<?>> getAttributeNodes();
}

```

B.13. EntityGraph

```

/**
 * This type represents the root of an entity graph that will be
 * used as a template to define the attribute nodes and boundaries
 * of a graph of entities and entity relationships. The root must
 * be an entity type.
 *
 * <p>
 * The methods to add subgraphs implicitly create the corresponding
 * attribute nodes as well; such attribute nodes should not be

```

```

* redundantly specified.
*
* @param <T> The type of the root entity.
*
* @see AttributeNode
* @see Subgraph
* @see NamedEntityGraph
*
* @see EntityManager#createEntityGraph(Class)
* @see EntityManager#createEntityGraph(String)
* @see EntityManager#getEntityGraph(String)
* @see EntityManagerFactory#addNamedEntityGraph(String, EntityGraph)
* @see EntityManager#find(EntityGraph, Object, FindOption...)
*
* @since 2.1
*/
public interface EntityGraph<T> extends Graph<T> {

    /**
     * Return the name of a named {@code EntityGraph} (an entity
     * graph defined by means of the {@link NamedEntityGraph}
     * annotation, XML descriptor element, or added by means of the
     * {@link EntityManagerFactory#addNamedEntityGraph} method).
     * Returns null if the {@code EntityGraph} is not a named
     * {@code EntityGraph}.
     */
    String getName();

    /**
     * Add additional attributes to this entity graph that
     * correspond to attributes of subclasses of the entity type of
     * this {@code EntityGraph}. Subclass subgraphs automatically
     * include the specified attributes of superclass subgraphs.
     *
     * @param type entity subclass
     * @return subgraph for the subclass
     * @throws IllegalArgumentException if the type is not an entity type
     * @throws IllegalStateException if the EntityGraph has been
     *         statically defined
     */
    <S extends T> Subgraph<S> addTreatedSubgraph(Class<S> type);

    /**
     * Add additional attributes to this entity graph that
     * correspond to attributes of subclasses of the entity type of
     * this {@code EntityGraph}. Subclass subgraphs automatically
     * include the specified attributes of superclass subgraphs.
     *
     * @param type entity subclass
     * @return subgraph for the subclass
     * @throws IllegalArgumentException if the type is not an entity type
     * @throws IllegalStateException if the EntityGraph has been
     *         statically defined
     * @deprecated use {@link #addTreatedSubgraph(Class)}
     */
    @Deprecated(since = "3.2", forRemoval = true)
    <T> Subgraph<? extends T> addSubclassSubgraph(Class<? extends T> type);
}

```

B.14. Subgraph

```

/**
 * This type represents a subgraph for an attribute node that
 * corresponds to a managed type. Using this class, an entity

```

```

* subgraph can be embedded within an {@link EntityGraph}.
*
* @param <T> The type of the attribute.
*
* @see EntityGraph
* @see AttributeNode
* @see NamedSubgraph
*
* @since 2.1
*/
public interface Subgraph<T> extends Graph<T> {

    /**
     * Return the type for which this subgraph was defined.
     * @return managed type referenced by the subgraph
     */
    Class<T> getClassType();

}

```

B.15. AttributeNode

```

import java.util.Map;

/**
 * Represents an attribute node of an entity graph.
 *
 * @param <T> The type of the attribute.
 *
 * @see EntityGraph
 * @see Subgraph
 * @see NamedAttributeNode
 *
 * @since 2.1
 */
public interface AttributeNode<T> {

    /**
     * Return the name of the attribute corresponding to the
     * attribute node.
     * @return name of the attribute
     */
    String getAttributeName();

    /**
     * Return a map of subgraphs associated with this attribute
     * node.
     * @return a {@link Map} of subgraphs associated with this
     * attribute node or an empty {@code Map} if none have been
     * defined
     */
    Map<Class, Subgraph> getSubgraphs();

    /**
     * Return a map of subgraphs associated with this attribute
     * node's map key.
     * @return a {@link Map} of subgraphs associated with this
     * attribute node's map key or an empty {@code Map} if none
     * have been defined
     */
    Map<Class, Subgraph> getKeySubgraphs();

}

```

B.16. SchemaManager

```
import java.util.Map;

/**
 * Allows programmatic {@linkplain #create schema creation},
 * {@linkplain #validate schema validation},
 * {@linkplain #truncate data cleanup}, and
 * {@linkplain #drop schema cleanup} for entities belonging
 * to a certain persistence unit.
 *
 * <p>Properties are inherited from the {@link EntityManagerFactory},
 * that is, they may be specified via {@code persistence.xml} or
 * {@link Persistence#createEntityManagerFactory(String, Map)}.
 *
 * @see EntityManagerFactory#getSchemaManager()
 *
 * @since 3.2
 */
public interface SchemaManager {
    /**
     * Create database objects mapped by entities belonging to the
     * persistence unit.
     *
     * <p>If a DDL operation fails, the behavior is undefined.
     * A provider may throw an exception, or it may ignore the problem
     * and continue.
     *
     * @param createSchemas if {@code true}, attempt to create schemas,
     * otherwise, assume the schemas already exist
     */
    void create(boolean createSchemas);

    /**
     * Drop database objects mapped by entities belonging to the
     * persistence unit, undoing the effects of the
     * {@linkplain #create(boolean)} previous creation.
     *
     * <p>If a DDL operation fails, the behavior is undefined.
     * A provider may throw an exception, or it may ignore the problem
     * and continue.
     *
     * @param dropSchemas if {@code true}, drop schemas,
     * otherwise, leave them be
     */
    void drop(boolean dropSchemas);

    /**
     * Validate that the database objects mapped by entities belonging
     * to the persistence unit have the expected definitions.
     *
     * <p>The persistence provider is not required to perform
     * any specific validation, so the semantics of this operation are
     * entirely provider-specific.
     *
     * @throws SchemaValidationException if a database object is missing or
     * does not have the expected definition
     */
    void validate() throws SchemaValidationException;

    /**
     * Truncate the database tables mapped by entities belonging to
     * the persistence unit, and then re-import initial data from any
     * configured SQL scripts for data loading.
     *
     * <p>If a SQL operation fails, the behavior is undefined.
     */
}
```

```

    * A provider may throw an exception, or it may ignore the problem
    * and continue.
    */
    void truncate();
}

```

B.17. Persistence

```

package jakarta.persistence;

import java.util.List;
import java.util.Map;
import java.util.Set;
import java.util.HashSet;
import jakarta.persistence.spi.PersistenceProvider;
import jakarta.persistence.spi.PersistenceProviderResolver;
import jakarta.persistence.spi.PersistenceProviderResolverHolder;
import jakarta.persistence.spi.LoadState;

/**
 * Bootstrap class used to obtain an {@link EntityManagerFactory}
 * in Java SE environments. It may also be used to cause schema
 * generation to occur.
 *
 * <p>The {@code Persistence} class is available in a Jakarta EE
 * container environment as well; however, support for the Java SE
 * bootstrapping APIs is not required in container environments.
 *
 * <p>The {@code Persistence} class is used to obtain a {@link
 * PersistenceUtil PersistenceUtil} instance in both Jakarta EE
 * and Java SE environments.
 *
 * @since 1.0
 */
public class Persistence {

    /**
     * Default constructor.
     * @deprecated This class is not intended to be extended nor instantiated,
     * it is going to be marked {@code final} when this constructor becomes hidden.
     */
    @Deprecated(since = "3.2", forRemoval = true)
    public Persistence() {
        //kept for backward compatibility with pre-3.2 versions
    }

    /**
     * Create and return an {@link EntityManagerFactory} for the named
     * persistence unit.
     *
     * @param persistenceUnitName the name of the persistence unit
     * @return the factory that creates {@link EntityManager}s configured
     * according to the specified persistence unit
     */
    public static EntityManagerFactory createEntityManagerFactory(String persistenceUnitName) {
        return createEntityManagerFactory(persistenceUnitName, null);
    }

    /**
     * Create and return an {@link EntityManagerFactory} for the named
     * persistence unit, using the given properties.
     *
     * @param persistenceUnitName the name of the persistence unit
     * @param properties additional properties to use when creating the
     * factory. These properties may include properties

```

```

*         to control schema generation. The values of these
*         properties override any values that may have been
*         configured elsewhere.
* @return the factory that creates {@link EntityManager}s configured
*         according to the specified persistence unit
*/
public static EntityManagerFactory createEntityManagerFactory(String persistenceUnitName, Map<?,?> properties)
{
    EntityManagerFactory emf = null;
    PersistenceProviderResolver resolver = PersistenceProviderResolverHolder.getPersistenceProviderResolver();

    List<PersistenceProvider> providers = resolver.getPersistenceProviders();

    for (PersistenceProvider provider : providers) {
        emf = provider.createEntityManagerFactory(persistenceUnitName, properties);
        if (emf != null) {
            break;
        }
    }
    if (emf == null) {
        throw new PersistenceException("No Persistence provider for EntityManager named " +
persistenceUnitName);
    }
    return emf;
}

/**
* Create and return an {@link EntityManagerFactory} for the named
* persistence unit, using the given properties.
*
* @param configuration configuration of the persistence unit
* @return the factory that creates {@link EntityManager}s configured
*         according to the specified persistence unit
*
* @since 3.2
*/
public static EntityManagerFactory createEntityManagerFactory(PersistenceConfiguration configuration) {

    EntityManagerFactory emf = null;
    PersistenceProviderResolver resolver = PersistenceProviderResolverHolder.getPersistenceProviderResolver();

    List<PersistenceProvider> providers = resolver.getPersistenceProviders();

    for (PersistenceProvider provider : providers) {
        emf = provider.createEntityManagerFactory(configuration);
        if (emf != null) {
            break;
        }
    }
    if (emf == null) {
        throw new PersistenceException("No Persistence provider for EntityManager named " + configuration.name
());
    }
    return emf;
}

/**
* Create database schemas and/or tables and/or create DDL scripts
* as determined by the supplied properties.
* <p>
* Called when schema generation is to occur as a separate phase
* from creation of the entity manager factory.
* <p>
* @param persistenceUnitName the name of the persistence unit
* @param map properties for schema generation; these may also

```

```

*         contain provider-specific properties. The values
*         of these properties override any values that may
*         have been configured elsewhere.
* @throws PersistenceException if insufficient or inconsistent
*         configuration information is provided or if schema
*         generation otherwise fails.
*
* @since 2.1
*/
public static void generateSchema(String persistenceUnitName, Map<?,?> map) {
    PersistenceProviderResolver resolver = PersistenceProviderResolverHolder.getPersistenceProviderResolver();
    List<PersistenceProvider> providers = resolver.getPersistenceProviders();

    for (PersistenceProvider provider : providers) {
        if (provider.generateSchema(persistenceUnitName, map)) {
            return;
        }
    }

    throw new PersistenceException("No Persistence provider to generate schema named " + persistenceUnitName);
}

/**
 * Return the {@link PersistenceUtil} instance
 * @return {@link PersistenceUtil} instance
 * @since 2.0
 */
public static PersistenceUtil getPersistenceUtil() {
    return new PersistenceUtilImpl();
}

/**
 * Implementation of the {@link PersistenceUtil} interface
 * @since 2.0
 */
private static class PersistenceUtilImpl implements PersistenceUtil {
    public boolean isLoading(Object entity, String attributeName) {
        PersistenceProviderResolver resolver = PersistenceProviderResolverHolder.
getPersistenceProviderResolver();

        List<PersistenceProvider> providers = resolver.getPersistenceProviders();

        for (PersistenceProvider provider : providers) {
            LoadState loadstate = provider.getProviderUtil().isLoadingWithoutReference(entity, attributeName);
            if(loadstate == LoadState.LOADED) {
                return true;
            } else if (loadstate == LoadState.NOT_LOADED) {
                return false;
            } // else continue
        }

        //None of the providers could determine the load state try isLoadingWithReference
        for (PersistenceProvider provider : providers) {
            LoadState loadstate = provider.getProviderUtil().isLoadingWithReference(entity, attributeName);
            if(loadstate == LoadState.LOADED) {
                return true;
            } else if (loadstate == LoadState.NOT_LOADED) {
                return false;
            } // else continue
        }

        //None of the providers could determine the load state.
        return true;
    }
}

```

```

    public boolean isLoaded(Object entity) {
        PersistenceProviderResolver resolver = PersistenceProviderResolverHolder.
getPersistenceProviderResolver();

        List<PersistenceProvider> providers = resolver.getPersistenceProviders();

        for (PersistenceProvider provider : providers) {
            LoadState loadstate = provider.getProviderUtil().isLoaded(entity);
            if(loadstate == LoadState.LOADED) {
                return true;
            } else if (loadstate == LoadState.NOT_LOADED) {
                return false;
            } // else continue
        }
        //None of the providers could determine the load state
        return true;
    }
}

/**
 * This final String is deprecated and should be removed and is only here for TCK backward compatibility
 * @since 1.0
 * @deprecated
 *
 * TODO: Either change TCK reference to PERSISTENCE_PROVIDER field to expect
 * "jakarta.persistence.spi.PersistenceProvider" or remove PERSISTENCE_PROVIDER field and also update TCK
signature
 * tests.
 */
@Deprecated(since = "3.2", forRemoval = true)
public static final String PERSISTENCE_PROVIDER = "jakarta.persistence.spi.PersistenceProvider";

/**
 * This instance variable is deprecated and should be removed and is only here for TCK backward compatibility
 * @since 1.0
 * @deprecated
 */
@Deprecated(since = "3.2", forRemoval = true)
protected static final Set<PersistenceProvider> providers = new HashSet<PersistenceProvider>();
}

```

B.18. PersistenceConfiguration

```

import java.util.HashMap;
import java.util.List;
import java.util.Map;
import java.util.Objects;

/**
 * Represents a configuration of a persistence unit, allowing programmatic
 * creation of an {@link EntityManagerFactory}. The configuration options
 * available via this API reflect the similarly-named elements of the
 * {@code persistence.xml} file.
 *
 * <p>This API may not be used to configure a container-managed persistence
 * unit. That is, the configured persistence unit should be considered a
 * Java SE persistence unit, even when this API is used within the Jakarta
 * EE environment.
 *
 * <p>If injection of the {@link EntityManagerFactory} is required, a CDI
 * {@code Producer} may be used to make the {@link EntityManagerFactory}
 * available as a CDI managed bean.
 *
 * {@snippet :
 * @Produces @ApplicationScoped @Documents

```



```

* EntityManagerFactory configure() {
*     return new PersistenceConfiguration()
*         .name("DocumentData")
*         .nonJtaDataSource("java:global/jdbc/DocumentDatabase")
*         .managedClass(Document.class)
*         .createEntityManagerFactory();
* }
* }
*
* <p>Similarly, if injection of an {@link EntityManager} is required,
* a CDI {@code Producer} method/{@code Disposer} method pair may be
* used to make the {@link EntityManager} available as a CDI managed
* bean.
*
* {@snippet :
* @Produces @TransactionScoped @Documents
* EntityManager create(@Documents EntityManagerFactory factory) {
*     return factory.createEntityManager();
* }
*
* void close(@Disposes @Documents EntityManager entityManager) {
*     entityManager.close();
* }
* }
*
* <p>It is intended that persistence providers define subclasses of
* this class with vendor-specific configuration options. A provider
* must support configuration via any instance of this class or of any
* subclass of this class.
*
* @see Persistence#createEntityManagerFactory(PersistenceConfiguration)
*
* @since 3.2
*/

```

```

public class PersistenceConfiguration {

    /**
     * Fully qualified name of the JDBC driver class.
     */
    public static final String JDBC_DRIVER = "jakarta.persistence.jdbc.driver";
    /**
     * JDBC URL.
     */
    public static final String JDBC_URL = "jakarta.persistence.jdbc.url";
    /**
     * Username for JDBC authentication.
     */
    public static final String JDBC_USER = "jakarta.persistence.jdbc.user";
    /**
     * Password for JDBC authentication.
     */
    public static final String JDBC_PASSWORD = "jakarta.persistence.jdbc.password";
    /**
     * An instance of {@code javax.sql.DataSource}.
     */
    public static final String JDBC_DATASOURCE = "jakarta.persistence.dataSource";

    /**
     * Default pessimistic lock timeout hint.
     */
    public static final String LOCK_TIMEOUT = "jakarta.persistence.lock.timeout";
    /**
     * Default query timeout hint.
     */
    public static final String QUERY_TIMEOUT = "jakarta.persistence.query.timeout";

    /**

```

```

* The action to be performed against the database.
*
* <p>Standard actions are: {@code none}, {@code create},
* {@code drop}, {@code drop-and-create}, {@code validate}.
*/
public static final String SCHEMAGEN_DATABASE_ACTION = "jakarta.persistence.schema-generation.database.action";
/**
* The action to be generated as a SQL script.
*
* <p>The script is generated in the location specified by
* {@value #SCHEMAGEN_CREATE_TARGET} or {@value #SCHEMAGEN_DROP_TARGET}.
*
* <p>Standard actions are: {@code none}, {@code create},
* {@code drop}, {@code drop-and-create}.
*/
public static final String SCHEMAGEN_SCRIPTS_ACTION = "jakarta.persistence.schema-generation.scripts.action";
/**
* The source of artifacts to be created.
*
* <p>Standard sources are: {@code metadata}, {@code script},
* {@code metadata-then-script}, {@code script-then-metadata}.
*
* <p>The location of the script source is specified by
* {@value #SCHEMAGEN_CREATE_SCRIPT_SOURCE}.
*/
public static final String SCHEMAGEN_CREATE_SOURCE = "jakarta.persistence.schema-generation.create-source";
/**
* The source of artifacts to be dropped.
*
* <p>Standard sources are: {@code metadata}, {@code script},
* {@code metadata-then-script}, {@code script-then-metadata}.
*
* <p>The location of the script source is specified by
* {@value #SCHEMAGEN_DROP_SCRIPT_SOURCE}.
*/
public static final String SCHEMAGEN_DROP_SOURCE = "jakarta.persistence.schema-generation.drop-source";
/**
* An application-provided SQL script to be executed when the
* schema is created.
*/
public static final String SCHEMAGEN_CREATE_SCRIPT_SOURCE = "jakarta.persistence.schema-generation.create-
script-source";
/**
* An application-provided SQL script to be executed when the
* schema is dropped.
*/
public static final String SCHEMAGEN_DROP_SCRIPT_SOURCE = "jakarta.persistence.schema-generation.drop-script-
source";
/**
* The provider-generated SQL script which creates the schema
* when {@value SCHEMAGEN_SCRIPTS_ACTION} is set.
*/
public static final String SCHEMAGEN_CREATE_TARGET = "jakarta.persistence.schema-generation.create-target";
/**
* The provider-generated SQL script which drops the schema
* when {@value SCHEMAGEN_SCRIPTS_ACTION} is set.
*/
public static final String SCHEMAGEN_DROP_TARGET = "jakarta.persistence.schema-generation.drop-target";
/**
* An instance of {@code jakarta.validation.ValidatorFactory},
*/
public static final String VALIDATION_FACTORY = "jakarta.persistence.validation.factory";
/**
* Target groups for validation at {@link PrePersist}.
*/
public static final String VALIDATION_GROUP_PRE_PERSIST = "jakarta.persistence.validation.group.pre-persist";

```

```

/**
 * Target groups for validation at {@link PreUpdate}.
 */
public static final String VALIDATION_GROUP_PRE_UPDATE = "jakarta.persistence.validation.group.pre-update";
/**
 * Target groups for validation at {@link PreRemove}.
 */
public static final String VALIDATION_GROUP_PRE_REMOVE = "jakarta.persistence.validation.group.pre-remove";

/**
 * String specifying a {@link SharedCacheMode}.
 *
 * <p>Defined for use with
 * {@link Persistence#createEntityManagerFactory(String, Map)}.
 * Clients of this {@code PersistenceConfiguration} class
 * should use {@link #sharedCacheMode(SharedCacheMode)}.
 */
public static final String CACHE_MODE = "jakarta.persistence.sharedCache.mode";

private final String name;

private String provider;
private String jtaDataSource;
private String nonJtaDataSource;

private SharedCacheMode sharedCacheMode = SharedCacheMode.UNSPECIFIED;
private ValidationMode validationMode = ValidationMode.AUTO;
private PersistenceUnitTransactionType transactionType = PersistenceUnitTransactionType.RESOURCE_LOCAL;

private final List<Class<?>> managedClasses = new ArrayList<>();
private final List<String> mappingFileNames = new ArrayList<>();
private final Map<String, Object> properties = new HashMap<>();

/**
 * Create a new empty configuration. An empty configuration does not
 * typically hold enough information for successful invocation of
 * {@link #createEntityManagerFactory()}.
 *
 * @param name the name of the persistence unit, which may be used by
 *             the persistence provider for logging and error reporting
 */
public PersistenceConfiguration(String name) {
    Objects.requireNonNull(name, "Persistence unit name should not be null");
    this.name = name;
}

/**
 * Create a new {@link EntityManagerFactory} based on this configuration.
 * @throws PersistenceException if required configuration is missing or
 *                               if the factory could not be created
 */
public EntityManagerFactory createEntityManagerFactory() {
    return Persistence.createEntityManagerFactory(this);
}

/**
 * The name of the persistence unit, which may be used by the persistence
 * provider for logging and error reporting.
 * @return the name of the persistence unit.
 */
public String name() {
    return name;
}

/**
 * Specify the persistence provider.
 * @param providerClassName the qualified name of the persistence provider class

```

```

    * @return this configuration
    */
    public PersistenceConfiguration provider(String providerClassName) {
        this.provider = providerClassName;
        return this;
    }

    /**
     * The fully-qualified name of a concrete class implementing
     * {@link jakarta.persistence.spi.PersistenceProvider}.
     * @return the qualified name of the persistence provider class.
     */
    public String provider() {
        return provider;
    }

    /**
     * Specify the JNDI name of a JTA {@code javax.sql.DataSource}.
     * @param dataSourceJndiName the JNDI name of a JTA datasource
     * @return this configuration
     */
    public PersistenceConfiguration jtaDataSource(String dataSourceJndiName) {
        this.jtaDataSource = dataSourceJndiName;
        return this;
    }

    /**
     * The JNDI name of a JTA {@code javax.sql.DataSource}.
     * @return the configured JTA datasource, if any, or null
     */
    public String jtaDataSource() {
        return jtaDataSource;
    }

    /**
     * Specify the JNDI name of a non-JTA {@code javax.sql.DataSource}.
     * @param dataSourceJndiName the JNDI name of a non-JTA datasource
     * @return this configuration
     */
    public PersistenceConfiguration nonJtaDataSource(String dataSourceJndiName) {
        this.nonJtaDataSource = dataSourceJndiName;
        return this;
    }

    /**
     * The JNDI name of a non-JTA {@code javax.sql.DataSource}.
     * @return the configured non-JTA datasource, if any, or null
     */
    public String nonJtaDataSource() {
        return nonJtaDataSource;
    }

    /**
     * Add a managed class (an {@link Entity}, {@link Embeddable},
     * {@link MappedSuperclass}, or {@link Converter}) to the
     * configuration.
     * @param managedClass the managed class
     * @return this configuration
     */
    public PersistenceConfiguration managedClass(Class<?> managedClass) {
        managedClasses.add(managedClass);
        return this;
    }

    /**
     * The configured managed classes, that is, a list of classes
     * annotated {@link Entity}, {@link Embeddable},

```

```

* {@link MappedSuperclass}, or {@link Converter}.
* @return all configured managed classes
*/
public List<Class<?>> managedClasses() {
    return managedClasses;
}

/**
 * Add the path of an XML mapping file loaded as a resource to
 * the configuration.
 * @param name the resource path of the mapping file
 * @return this configuration
 */
public PersistenceConfiguration mappingFile(String name) {
    mappingFileNames.add(name);
    return this;
}

/**
 * The configured resource paths of XML mapping files.
 * @return all configured mapping file resource paths
 */
public List<String> mappingFiles() {
    return mappingFileNames;
}

/**
 * Specify the transaction type for the persistence unit.
 * @param transactionType the transaction type
 * @return this configuration
 */
public PersistenceConfiguration transactionType(PersistenceUnitTransactionType transactionType) {
    this.transactionType = transactionType;
    return this;
}

/**
 * The {@link PlainPersistenceUnitTransactionType transaction type}.
 * <ul>
 * <li>If {@link PersistenceUnitTransactionType#JTA}, a JTA data
 * source must be provided via {@link #jtaDataSource()},
 * or by the container.
 * <li>If {@link PersistenceUnitTransactionType#RESOURCE_LOCAL},
 * database connection properties may be specified via
 * {@link #properties()}, or a non-JTA datasource may be
 * provided via {@link #nonJtaDataSource()}.
 * </ul>
 * @return the transaction type
 */
public PersistenceUnitTransactionType transactionType() {
    return transactionType;
}

/**
 * Specify the shared cache mode for the persistence unit.
 * @param sharedCacheMode the shared cache mode
 * @return this configuration
 */
public PersistenceConfiguration sharedCacheMode(SharedCacheMode sharedCacheMode) {
    this.sharedCacheMode = sharedCacheMode;
    return this;
}

/**
 * The shared cache mode. The default behavior is unspecified
 * and {@link PlainSharedCacheMode#UNSPECIFIED provider-specific}.
 * @return the shared cache mode

```

```

    */
    public SharedCacheMode sharedCacheMode() {
        return sharedCacheMode;
    }

    /**
     * Specify the validation mode for the persistence unit.
     * @param validationMode the shared cache mode
     * @return this configuration
     */
    public PersistenceConfiguration validationMode(ValidationMode validationMode) {
        this.validationMode = validationMode;
        return this;
    }

    /**
     * The validation mode, {@link ValidationMode#AUTO} by default.
     * @return the validation mode
     */
    public ValidationMode validationMode() {
        return validationMode;
    }

    /**
     * Set a property of this persistence unit.
     * @param name the property name
     * @param value the property value
     * @return this configuration
     */
    public PersistenceConfiguration property(String name, Object value) {
        properties.put(name, value);
        return this;
    }

    /**
     * Set multiple properties of this persistence unit.
     * @param properties the properties
     * @return this configuration
     */
    public PersistenceConfiguration properties(Map<String,?> properties) {
        this.properties.putAll(properties);
        return this;
    }

    /**
     * Standard and vendor-specific property settings.
     * @return the configured properties
     */
    public Map<String, Object> properties() {
        return properties;
    }
}

```

B.19. PersistenceUtil

```

package jakarta.persistence;

/**
 * Utility interface between the application and the persistence
 * provider(s).
 *
 * <p>The {@code PersistenceUtil} interface instance obtained from
 * the {@link Persistence} class is used to determine the load state
 * of an entity or entity attribute regardless of which persistence
 * provider in the environment created the entity.

```

```

*
* @since 2.0
*/
public interface PersistenceUtil {

    /**
     * Determine the load state of a given persistent attribute.
     * @param entity entity containing the attribute
     * @param attributeName name of attribute whose load state is
     *     to be determined
     * @return false if entity's state has not been loaded or if
     *     the attribute state has not been loaded, else true
     */
    boolean isLoaded(Object entity, String attributeName);

    /**
     * Determine the load state of an entity.
     * This method can be used to determine the load state of an
     * entity passed as a reference. An entity is considered loaded
     * if all attributes for which {@link FetchType#EAGER} has been
     * specified have been loaded.
     * <p>The {@link #isLoaded(Object, String)} method should be
     * used to determine the load state of an attribute. Not doing
     * so might lead to unintended loading of state.
     * @param entity whose load state is to be determined
     * @return false if the entity has not been loaded, else true
     */
    boolean isLoaded(Object entity);
}

```

B.20. PersistenceUnitUtil

```

package jakarta.persistence;

import jakarta.persistence.metamodel.Attribute;

/**
 * Utility interface between the application and the persistence
 * provider managing the persistence unit.
 *
 * <p>The methods of this interface should only be invoked on
 * entity instances obtained from or managed by entity managers
 * for this persistence unit or on new entity instances.
 *
 * @since 2.0
 */
public interface PersistenceUnitUtil extends PersistenceUtil {

    /**
     * Determine the load state of a given persistent attribute
     * of an entity belonging to the persistence unit.
     * @param entity entity instance containing the attribute
     * @param attributeName name of attribute whose load state is
     *     to be determined
     * @return false if entity's state has not been loaded or if
     *     the attribute state has not been loaded, else true
     */
    boolean isLoaded(Object entity, String attributeName);

    /**
     * Determine the load state of a given persistent attribute
     * of an entity belonging to the persistence unit.
     * @param entity entity instance containing the attribute
     * @param attribute attribute whose load state is to be determined
     * @return false if entity's state has not been loaded or if

```

```

*         the attribute state has not been loaded, else true
* @since 3.2
*/
<E> boolean isLoaded(E entity, Attribute<? super E, ?> attribute);

/**
 * Determine the load state of an entity belonging to the
 * persistence unit. This method can be used to determine the
 * load state of an entity passed as a reference. An entity is
 * considered loaded if all attributes for which
 * {@link FetchType#EAGER} has been specified have been loaded.
 * <p> The {@link #isLoaded(Object, String)} method should be
 * used to determine the load state of an attribute. Not doing
 * so might lead to unintended loading of state.
 * @param entity  entity instance whose load state is to be determined
 * @return false if the entity has not been loaded, else true
 */
boolean isLoaded(Object entity);

/**
 * Load the persistent value of a given persistent attribute
 * of an entity belonging to the persistence unit and to an
 * open persistence context.
 * After this method returns, {@link #isLoaded(Object,String)}
 * must return true with the given entity instance and attribute.
 * @param entity  entity instance
 * @param attributeName  the name of the attribute to be loaded
 * @throws IllegalArgumentException if the given object is not an
 * instance of an entity class belonging to the persistence unit
 * @throws PersistenceException if the entity is not associated
 * with an open persistence context or cannot be loaded from the
 * database
 * @since 3.2
 */
void load(Object entity, String attributeName);

/**
 * Load the persistent value of a given persistent attribute
 * of an entity belonging to the persistence unit and to an
 * open persistence context.
 * After this method returns, {@link #isLoaded(Object,Attribute)}
 * must return true with the given entity instance and attribute.
 * @param entity  entity instance to be loaded
 * @param attribute  the attribute to be loaded
 * @throws IllegalArgumentException if the given object is not an
 * instance of an entity class belonging to the persistence unit
 * @throws PersistenceException if the entity is not associated
 * with an open persistence context or cannot be loaded from the
 * database
 * @since 3.2
 */
<E> void load(E entity, Attribute<? super E, ?> attribute);

/**
 * Load the persistent state of an entity belonging to the
 * persistence unit and to an open persistence context.
 * After this method returns, {@link #isLoaded(Object)} must
 * return true with the given entity instance.
 * @param entity  entity instance to be loaded
 * @throws IllegalArgumentException if the given object is not an
 * instance of an entity class belonging to the persistence unit
 * @throws PersistenceException if the entity is not associated
 * with an open persistence context or cannot be loaded from the
 * database
 * @since 3.2
 */
void load(Object entity);

```



```

/**
 * Return true if the given entity belonging to the persistence
 * unit and to an open persistence context is an instance of the
 * given entity class, or false otherwise. This method may, but
 * is not required to, load the given entity by side effect.
 * @param entity entity instance
 * @param entityClass an entity class belonging to the persistence
 * unit
 * @throws IllegalArgumentException if the given object is not an
 * instance of an entity class belonging to the persistence unit
 * or if the given class is not an entity class belonging to the
 * persistence unit
 * @throws PersistenceException if the entity is not associated
 * with an open persistence context or cannot be loaded from the
 * database
 * @since 3.2
 */
boolean isInstance(Object entity, Class<?> entityClass);

/**
 * Return the concrete entity class if the given entity belonging
 * to the persistence unit and to an open persistence context.
 * This method may, but is not required to, load the given entity
 * by side effect.
 * @param entity entity instance
 * @return an entity class belonging to the persistence unit
 * @throws IllegalArgumentException if the given object is not an
 * instance of an entity class belonging to the persistence unit
 * @throws PersistenceException if the entity is not associated
 * with an open persistence context or cannot be loaded from the
 * database
 * @since 3.2
 */
<T> Class<? extends T> getClass(T entity);

/**
 * Return the id of the entity.
 * A generated id is not guaranteed to be available until after
 * the database insert has occurred.
 * Returns null if the entity does not yet have an id.
 * @param entity entity instance
 * @return id of the entity
 * @throws IllegalArgumentException if the object is found not
 * to be an entity
 */
Object getIdentifier(Object entity);

/**
 * Return the version of the entity.
 * A generated version is not guaranteed to be available until after
 * the database insert has occurred.
 * Returns null if the entity does not yet have an id.
 * @param entity entity instance
 * @return id of the entity
 * @throws IllegalArgumentException if the object is found not
 * to be an entity
 * @since 3.2
 */
Object getVersion(Object entity);
}

```

Appendix C: Criteria API Interfaces

The following APIs are defined in the package `jakarta.persistence.criteria`.

C.1. CriteriaBuilder

```
package jakarta.persistence.criteria;

import java.math.BigDecimal;
import java.math.BigInteger;
import java.time.temporal.Temporal;
import java.util.Collection;
import java.util.List;
import java.util.Map;
import java.util.Set;
import jakarta.persistence.Tuple;

/**
 * Used to construct criteria queries, compound selections,
 * expressions, predicates, orderings.
 *
 * <p> Note that {@link Predicate} is used instead of
 * Expression<Boolean> in this API in
 * order to work around the fact that Java generics are not
 * compatible with varargs.
 *
 * @since 2.0
 */
public interface CriteriaBuilder {

    /**
     * Create a {@link CriteriaQuery} object.
     * @return criteria query object
     */
    CriteriaQuery<Object> createQuery();

    /**
     * Create a {@link CriteriaQuery} object with the given
     * result type.
     * @param resultClass type of the query result
     * @return criteria query object
     */
    <T> CriteriaQuery<T> createQuery(Class<T> resultClass);

    /**
     * Create a {@link CriteriaQuery} object that returns a
     * tuple of objects as its result.
     * @return criteria query object
     */
    CriteriaQuery<Tuple> createTupleQuery();

    // methods to construct queries for bulk updates and deletes:

    /**
     * Create a {@link CriteriaUpdate} query object to perform a
     * bulk update operation.
     * @param targetEntity target type for update operation
     * @return the query object
     * @since 2.1
     */
    <T> CriteriaUpdate<T> createCriteriaUpdate(Class<T> targetEntity);

    /**
     * Create a {@link CriteriaDelete} query object to perform a
```

```

* bulk delete operation.
* @param targetEntity target type for delete operation
* @return the query object
* @since 2.1
*/
<T> CriteriaDelete<T> createCriteriaDelete(Class<T> targetEntity);

// selection construction methods:

/**
 * Create a selection item corresponding to a constructor.
 * This method is used to specify a constructor that is
 * applied to the results of the query execution. If the
 * constructor is for an entity class, the resulting entities
 * will be in the new state after the query is executed.
 * @param resultClass class whose instance is to be constructed
 * @param selections arguments to the constructor
 * @return compound selection item
 * @throws IllegalArgumentException if an argument is a
 *         tuple- or array-valued selection item
 */
<Y> CompoundSelection<Y> construct(Class<Y> resultClass, Selection<?>... selections);

/**
 * Create a tuple-valued selection item.
 * @param selections selection items
 * @return tuple-valued compound selection
 * @throws IllegalArgumentException if an argument is a
 *         tuple- or array-valued selection item
 */
CompoundSelection<Tuple> tuple(Selection<?>... selections);

/**
 * Create a tuple-valued selection item.
 * @param selections list of selection items
 * @return tuple-valued compound selection
 * @throws IllegalArgumentException if an argument is a
 *         tuple- or array-valued selection item
 * @since 3.2
 */
CompoundSelection<Tuple> tuple(List<Selection<?>> selections);

/**
 * Create an array-valued selection item.
 * @param selections selection items
 * @return array-valued compound selection
 * @throws IllegalArgumentException if an argument is a
 *         tuple- or array-valued selection item
 */
CompoundSelection<Object[]> array(Selection<?>... selections);

/**
 * Create an array-valued selection item.
 * @param selections list of selection items
 * @return array-valued compound selection
 * @throws IllegalArgumentException if an argument is a
 *         tuple- or array-valued selection item
 * @since 3.2
 */
CompoundSelection<Object[]> array(List<Selection<?>> selections);

//ordering:

/**
 * Create an ordering by the ascending value of the expression.

```

```

* @param expression expression used to define the ordering
* @return ascending ordering corresponding to the expression
*/
Order asc(Expression<?> expression);

/**
 * Create an ordering by the descending value of the expression.
 * @param expression expression used to define the ordering
 * @return descending ordering corresponding to the expression
 */
Order desc(Expression<?> expression);

/**
 * Create an ordering by the ascending value of the expression.
 * @param expression expression used to define the ordering
 * @param nullPrecedence the precedence of null values
 * @return ascending ordering corresponding to the expression
 * @since 3.2
 */
Order asc(Expression<?> expression, Nulls nullPrecedence);

/**
 * Create an ordering by the descending value of the expression.
 * @param expression expression used to define the ordering
 * @param nullPrecedence the precedence of null values
 * @return descending ordering corresponding to the expression
 * @since 3.2
 */
Order desc(Expression<?> expression, Nulls nullPrecedence);

//aggregate functions:

/**
 * Create an aggregate expression applying the avg operation.
 * @param x expression representing input value to avg operation
 * @return avg expression
 */
<N extends Number> Expression<Double> avg(Expression<N> x);

/**
 * Create an aggregate expression applying the sum operation.
 * @param x expression representing input value to sum operation
 * @return sum expression
 */
<N extends Number> Expression<N> sum(Expression<N> x);

/**
 * Create an aggregate expression applying the sum operation to an
 * Integer-valued expression, returning a Long result.
 * @param x expression representing input value to sum operation
 * @return sum expression
 */
Expression<Long> sumAsLong(Expression<Integer> x);

/**
 * Create an aggregate expression applying the sum operation to a
 * Float-valued expression, returning a Double result.
 * @param x expression representing input value to sum operation
 * @return sum expression
 */
Expression<Double> sumAsDouble(Expression<Float> x);

/**
 * Create an aggregate expression applying the numerical max
 * operation.
 * @param x expression representing input value to max operation

```

```

* @return max expression
*/
<N extends Number> Expression<N> max(Expression<N> x);

/**
 * Create an aggregate expression applying the numerical min
 * operation.
 * @param x expression representing input value to min operation
 * @return min expression
 */
<N extends Number> Expression<N> min(Expression<N> x);

/**
 * Create an aggregate expression for finding the greatest of
 * the values (strings, dates, etc).
 * @param x expression representing input value to greatest
 * operation
 * @return greatest expression
 */
<X extends Comparable<? super X>> Expression<X> greatest(Expression<X> x);

/**
 * Create an aggregate expression for finding the least of
 * the values (strings, dates, etc).
 * @param x expression representing input value to least
 * operation
 * @return least expression
 */
<X extends Comparable<? super X>> Expression<X> least(Expression<X> x);

/**
 * Create an aggregate expression applying the count operation.
 * @param x expression representing input value to count
 * operation
 * @return count expression
 */
Expression<Long> count(Expression<?> x);

/**
 * Create an aggregate expression applying the count distinct
 * operation.
 * @param x expression representing input value to
 * count distinct operation
 * @return count distinct expression
 */
Expression<Long> countDistinct(Expression<?> x);

//subqueries:

/**
 * Create a predicate testing the existence of a subquery result.
 * @param subquery subquery whose result is to be tested
 * @return exists predicate
 */
Predicate exists(Subquery<?> subquery);

/**
 * Create an all expression over the subquery results.
 * @param subquery subquery
 * @return all expression
 */
<Y> Expression<Y> all(Subquery<Y> subquery);

/**
 * Create a some expression over the subquery results.

```

```

* This expression is equivalent to an {@code any} expression.
* @param subquery subquery
* @return some expression
*/
<Y> Expression<Y> some(Subquery<Y> subquery);

/**
 * Create an any expression over the subquery results.
 * This expression is equivalent to a {@code some} expression.
 * @param subquery subquery
 * @return any expression
 */
<Y> Expression<Y> any(Subquery<Y> subquery);

//boolean functions:

/**
 * Create a conjunction of the given boolean expressions.
 * @param x boolean expression
 * @param y boolean expression
 * @return and predicate
 */
Predicate and(Expression<Boolean> x, Expression<Boolean> y);

/**
 * Create a conjunction of the given restriction predicates.
 * A conjunction of zero predicates is true.
 * @param restrictions zero or more restriction predicates
 * @return and predicate
 */
Predicate and(Predicate... restrictions);

/**
 * Create a conjunction of the given restriction predicates.
 * A conjunction of zero predicates is true.
 * @param restrictions a list of zero or more restriction predicates
 * @return and predicate
 * @since 3.2
 */
Predicate and(List<Predicate> restrictions);

/**
 * Create a disjunction of the given boolean expressions.
 * @param x boolean expression
 * @param y boolean expression
 * @return or predicate
 */
Predicate or(Expression<Boolean> x, Expression<Boolean> y);

/**
 * Create a disjunction of the given restriction predicates.
 * A disjunction of zero predicates is false.
 * @param restrictions zero or more restriction predicates
 * @return or predicate
 */
Predicate or(Predicate... restrictions);

/**
 * Create a disjunction of the given restriction predicates.
 * A disjunction of zero predicates is false.
 * @param restrictions a list of zero or more restriction predicates
 * @return or predicate
 * @since 3.2
 */
Predicate or(List<Predicate> restrictions);

```

```

/**
 * Create a negation of the given restriction.
 * @param restriction restriction expression
 * @return not predicate
 */
Predicate not(Expression<Boolean> restriction);

/**
 * Create a conjunction (with zero conjuncts).
 * A conjunction with zero conjuncts is true.
 * @return and predicate
 */
Predicate conjunction();

/**
 * Create a disjunction (with zero disjuncts).
 * A disjunction with zero disjuncts is false.
 * @return or predicate
 */
Predicate disjunction();

//turn Expression<Boolean> into a Predicate
//useful for use with varargs methods

/**
 * Create a predicate testing for a true value.
 * @param x expression to be tested
 * @return predicate
 */
Predicate isTrue(Expression<Boolean> x);

/**
 * Create a predicate testing for a false value.
 * @param x expression to be tested
 * @return predicate
 */
Predicate isFalse(Expression<Boolean> x);

//null tests:

/**
 * Create a predicate to test whether the expression is null.
 * @param x expression
 * @return is-null predicate
 */
Predicate isNull(Expression<?> x);

/**
 * Create a predicate to test whether the expression is not null.
 * @param x expression
 * @return is-not-null predicate
 */
Predicate isNotNull(Expression<?> x);

//equality:

/**
 * Create a predicate for testing the arguments for equality.
 * @param x expression
 * @param y expression
 * @return equality predicate
 */
Predicate equal(Expression<?> x, Expression<?> y);

/**

```

```

* Create a predicate for testing the arguments for equality.
* @param x expression
* @param y object
* @return equality predicate
*/
Predicate equal(Expression<?> x, Object y);

/**
 * Create a predicate for testing the arguments for inequality.
 * @param x expression
 * @param y expression
 * @return inequality predicate
 */
Predicate notEqual(Expression<?> x, Expression<?> y);

/**
 * Create a predicate for testing the arguments for inequality.
 * @param x expression
 * @param y object
 * @return inequality predicate
 */
Predicate notEqual(Expression<?> x, Object y);

//comparisons for generic (non-numeric) operands:

/**
 * Create a predicate for testing whether the first argument is
 * greater than the second.
 * @param x expression
 * @param y expression
 * @return greater-than predicate
 */
<Y extends Comparable<? super Y>> Predicate greaterThan(Expression<? extends Y> x, Expression<? extends Y> y);

/**
 * Create a predicate for testing whether the first argument is
 * greater than the second.
 * @param x expression
 * @param y value
 * @return greater-than predicate
 */
<Y extends Comparable<? super Y>> Predicate greaterThan(Expression<? extends Y> x, Y y);

/**
 * Create a predicate for testing whether the first argument is
 * greater than or equal to the second.
 * @param x expression
 * @param y expression
 * @return greater-than-or-equal predicate
 */
<Y extends Comparable<? super Y>> Predicate greaterThanOrEqualTo(Expression<? extends Y> x, Expression<?
extends Y> y);

/**
 * Create a predicate for testing whether the first argument is
 * greater than or equal to the second.
 * @param x expression
 * @param y value
 * @return greater-than-or-equal predicate
 */
<Y extends Comparable<? super Y>> Predicate greaterThanOrEqualTo(Expression<? extends Y> x, Y y);

/**
 * Create a predicate for testing whether the first argument is
 * less than the second.
 * @param x expression

```



```

* @param y expression
* @return less-than predicate
*/
<Y extends Comparable<? super Y>> Predicate lessThan(Expression<? extends Y> x, Expression<? extends Y> y);

/**
 * Create a predicate for testing whether the first argument is
 * less than the second.
 * @param x expression
 * @param y value
 * @return less-than predicate
 */
<Y extends Comparable<? super Y>> Predicate lessThan(Expression<? extends Y> x, Y y);

/**
 * Create a predicate for testing whether the first argument is
 * less than or equal to the second.
 * @param x expression
 * @param y expression
 * @return less-than-or-equal predicate
 */
<Y extends Comparable<? super Y>> Predicate lessThanOrEqualTo(Expression<? extends Y> x, Expression<? extends
Y> y);

/**
 * Create a predicate for testing whether the first argument is
 * less than or equal to the second.
 * @param x expression
 * @param y value
 * @return less-than-or-equal predicate
 */
<Y extends Comparable<? super Y>> Predicate lessThanOrEqualTo(Expression<? extends Y> x, Y y);

/**
 * Create a predicate for testing whether the first argument is
 * between the second and third arguments in value.
 * @param v expression
 * @param x expression
 * @param y expression
 * @return between predicate
 */
<Y extends Comparable<? super Y>> Predicate between(Expression<? extends Y> v, Expression<? extends Y> x,
Expression<? extends Y> y);

/**
 * Create a predicate for testing whether the first argument is
 * between the second and third arguments in value.
 * @param v expression
 * @param x value
 * @param y value
 * @return between predicate
 */
<Y extends Comparable<? super Y>> Predicate between(Expression<? extends Y> v, Y x, Y y);

//comparisons for numeric operands:

/**
 * Create a predicate for testing whether the first argument is
 * greater than the second.
 * @param x expression
 * @param y expression
 * @return greater-than predicate
 */
Predicate gt(Expression<? extends Number> x, Expression<? extends Number> y);

/**

```

```

* Create a predicate for testing whether the first argument is
* greater than the second.
* @param x expression
* @param y value
* @return greater-than predicate
*/
Predicate gt(Expression<? extends Number> x, Number y);

/**
* Create a predicate for testing whether the first argument is
* greater than or equal to the second.
* @param x expression
* @param y expression
* @return greater-than-or-equal predicate
*/
Predicate ge(Expression<? extends Number> x, Expression<? extends Number> y);

/**
* Create a predicate for testing whether the first argument is
* greater than or equal to the second.
* @param x expression
* @param y value
* @return greater-than-or-equal predicate
*/
Predicate ge(Expression<? extends Number> x, Number y);

/**
* Create a predicate for testing whether the first argument is
* less than the second.
* @param x expression
* @param y expression
* @return less-than predicate
*/
Predicate lt(Expression<? extends Number> x, Expression<? extends Number> y);

/**
* Create a predicate for testing whether the first argument is
* less than the second.
* @param x expression
* @param y value
* @return less-than predicate
*/
Predicate lt(Expression<? extends Number> x, Number y);

/**
* Create a predicate for testing whether the first argument is
* less than or equal to the second.
* @param x expression
* @param y expression
* @return less-than-or-equal predicate
*/
Predicate le(Expression<? extends Number> x, Expression<? extends Number> y);

/**
* Create a predicate for testing whether the first argument is
* less than or equal to the second.
* @param x expression
* @param y value
* @return less-than-or-equal predicate
*/
Predicate le(Expression<? extends Number> x, Number y);

//numerical operations:

/**
* Create an expression that returns the sign of its

```

```

* argument, that is, {1} if its argument is
* positive, {-1} if its argument is negative,
* or {0} if its argument is exactly zero.
* @param x expression
* @return sign
*/
Expression<Integer> sign(Expression<? extends Number> x);

/**
 * Create an expression that returns the arithmetic negation
 * of its argument.
 * @param x expression
 * @return arithmetic negation
 */
<N extends Number> Expression<N> neg(Expression<N> x);

/**
 * Create an expression that returns the absolute value
 * of its argument.
 * @param x expression
 * @return absolute value
 */
<N extends Number> Expression<N> abs(Expression<N> x);

/**
 * Create an expression that returns the ceiling of its
 * argument, that is, the smallest integer greater than
 * or equal to its argument.
 * @param x expression
 * @return ceiling
 */
<N extends Number> Expression<N> ceiling(Expression<N> x);

/**
 * Create an expression that returns the floor of its
 * argument, that is, the largest integer smaller than
 * or equal to its argument.
 * @param x expression
 * @return floor
 */
<N extends Number> Expression<N> floor(Expression<N> x);

/**
 * Create an expression that returns the sum
 * of its arguments.
 * @param x expression
 * @param y expression
 * @return sum
 */
<N extends Number> Expression<N> sum(Expression<? extends N> x, Expression<? extends N> y);

/**
 * Create an expression that returns the sum
 * of its arguments.
 * @param x expression
 * @param y value
 * @return sum
 */
<N extends Number> Expression<N> sum(Expression<? extends N> x, N y);

/**
 * Create an expression that returns the sum
 * of its arguments.
 * @param x value
 * @param y expression
 * @return sum
 */
<N extends Number> Expression<N> sum(N x, Expression<? extends N> y);

```

```

/**
 * Create an expression that returns the product
 * of its arguments.
 * @param x expression
 * @param y expression
 * @return product
 */
<N extends Number> Expression<N> prod(Expression<? extends N> x, Expression<? extends N> y);

/**
 * Create an expression that returns the product
 * of its arguments.
 * @param x expression
 * @param y value
 * @return product
 */
<N extends Number> Expression<N> prod(Expression<? extends N> x, N y);

/**
 * Create an expression that returns the product
 * of its arguments.
 * @param x value
 * @param y expression
 * @return product
 */
<N extends Number> Expression<N> prod(N x, Expression<? extends N> y);

/**
 * Create an expression that returns the difference
 * between its arguments.
 * @param x expression
 * @param y expression
 * @return difference
 */
<N extends Number> Expression<N> diff(Expression<? extends N> x, Expression<? extends N> y);

/**
 * Create an expression that returns the difference
 * between its arguments.
 * @param x expression
 * @param y value
 * @return difference
 */
<N extends Number> Expression<N> diff(Expression<? extends N> x, N y);

/**
 * Create an expression that returns the difference
 * between its arguments.
 * @param x value
 * @param y expression
 * @return difference
 */
<N extends Number> Expression<N> diff(N x, Expression<? extends N> y);

/**
 * Create an expression that returns the quotient
 * of its arguments.
 * @param x expression
 * @param y expression
 * @return quotient
 */
Expression<Number> quot(Expression<? extends Number> x, Expression<? extends Number> y);

/**
 * Create an expression that returns the quotient
 * of its arguments.

```

```

* @param x expression
* @param y value
* @return quotient
*/
Expression<Number> quot(Expression<? extends Number> x, Number y);

/**
 * Create an expression that returns the quotient
 * of its arguments.
 * @param x value
 * @param y expression
 * @return quotient
 */
Expression<Number> quot(Number x, Expression<? extends Number> y);

/**
 * Create an expression that returns the modulus
 * (remainder under integer division) of its
 * arguments.
 * @param x expression
 * @param y expression
 * @return modulus
 */
Expression<Integer> mod(Expression<Integer> x, Expression<Integer> y);

/**
 * Create an expression that returns the modulus
 * (remainder under integer division) of its
 * arguments.
 * @param x expression
 * @param y value
 * @return modulus
 */
Expression<Integer> mod(Expression<Integer> x, Integer y);

/**
 * Create an expression that returns the modulus
 * (remainder under integer division) of its
 * arguments.
 * @param x value
 * @param y expression
 * @return modulus
 */
Expression<Integer> mod(Integer x, Expression<Integer> y);

/**
 * Create an expression that returns the square root
 * of its argument.
 * @param x expression
 * @return square root
 */
Expression<Double> sqrt(Expression<? extends Number> x);

/**
 * Create an expression that returns the exponential
 * of its argument, that is, Euler's number e
 * raised to the power of its argument.
 * @param x expression
 * @return exponential
 */
Expression<Double> exp(Expression<? extends Number> x);

/**
 * Create an expression that returns the natural logarithm
 * of its argument.
 * @param x expression
 * @return natural logarithm

```

```

*/
Expression<Double> ln(Expression<? extends Number> x);

/**
 * Create an expression that returns the first argument
 * raised to the power of its second argument.
 * @param x base
 * @param y exponent
 * @return the base raised to the power of the exponent
 */
Expression<Double> power(Expression<? extends Number> x, Expression<? extends Number> y);

/**
 * Create an expression that returns the first argument
 * raised to the power of its second argument.
 * @param x base
 * @param y exponent
 * @return the base raised to the power of the exponent
 */
Expression<Double> power(Expression<? extends Number> x, Number y);

/**
 * Create an expression that returns the first argument
 * rounded to the number of decimal places given by the
 * second argument.
 * @param x base
 * @param n number of decimal places
 * @return the rounded value
 */
<T extends Number> Expression<T> round(Expression<T> x, Integer n);

//typecasts:

/**
 * Typecast. Returns same expression object.
 * @param number numeric expression
 * @return {@literal Expression<Long>}
 */
Expression<Long> toLong(Expression<? extends Number> number);

/**
 * Typecast. Returns same expression object.
 * @param number numeric expression
 * @return {@literal Expression<Integer>}
 */
Expression<Integer> toInteger(Expression<? extends Number> number);

/**
 * Typecast. Returns same expression object.
 * @param number numeric expression
 * @return {@literal Expression<Float>}
 */
Expression<Float> toFloat(Expression<? extends Number> number);

/**
 * Typecast. Returns same expression object.
 * @param number numeric expression
 * @return {@literal Expression<Double>}
 */
Expression<Double> toDouble(Expression<? extends Number> number);

/**
 * Typecast. Returns same expression object.
 * @param number numeric expression
 * @return {@literal Expression<BigDecimal>}
 */

```

```

Expression<BigDecimal> toBigDecimal(Expression<? extends Number> number);

/**
 * Typecast. Returns same expression object.
 * @param number numeric expression
 * @return {@literal Expression<BigInteger>}
 */
Expression<BigInteger> toBigInteger(Expression<? extends Number> number);

/**
 * Typecast. Returns same expression object.
 * @param character expression
 * @return {@literal Expression<String>}
 */
Expression<String> toString(Expression<Character> character);

//literals:

/**
 * Create an expression for a literal.
 * @param value value represented by the expression
 * @return expression literal
 * @throws IllegalArgumentException if value is null
 */
<T> Expression<T> literal(T value);

/**
 * Create an expression for a null literal with the given type.
 * @param resultClass type of the null literal
 * @return null expression literal
 */
<T> Expression<T> nullLiteral(Class<T> resultClass);

//parameters:

/**
 * Create a parameter expression.
 * @param paramClass parameter class
 * @return parameter expression
 */
<T> ParameterExpression<T> parameter(Class<T> paramClass);

/**
 * Create a parameter expression with the given name.
 * @param paramClass parameter class
 * @param name name that can be used to refer to
 *           the parameter
 * @return parameter expression
 */
<T> ParameterExpression<T> parameter(Class<T> paramClass, String name);

//collection operations:

/**
 * Create a predicate that tests whether a collection is empty.
 * @param collection expression
 * @return is-empty predicate
 */
<C extends Collection<?>> Predicate isEmpty(Expression<C> collection);

/**
 * Create a predicate that tests whether a collection is
 * not empty.
 * @param collection expression
 * @return is-not-empty predicate

```

```

*/
<C extends Collection<?>> Predicate isEmpty(Expression<C> collection);

/**
 * Create an expression that tests the size of a collection.
 * @param collection expression
 * @return size expression
 */
<C extends Collection<?>> Expression<Integer> size(Expression<C> collection);

/**
 * Create an expression that tests the size of a collection.
 * @param collection collection
 * @return size expression
 */
<C extends Collection<?>> Expression<Integer> size(C collection);

/**
 * Create a predicate that tests whether an element is
 * a member of a collection.
 * If the collection is empty, the predicate will be false.
 * @param elem element expression
 * @param collection expression
 * @return is-member predicate
 */
<E, C extends Collection<E>> Predicate isMember(Expression<E> elem, Expression<C> collection);

/**
 * Create a predicate that tests whether an element is
 * a member of a collection.
 * If the collection is empty, the predicate will be false.
 * @param elem element
 * @param collection expression
 * @return is-member predicate
 */
<E, C extends Collection<E>> Predicate isMember(E elem, Expression<C> collection);

/**
 * Create a predicate that tests whether an element is
 * not a member of a collection.
 * If the collection is empty, the predicate will be true.
 * @param elem element expression
 * @param collection expression
 * @return is-not-member predicate
 */
<E, C extends Collection<E>> Predicate isNotMember(Expression<E> elem, Expression<C> collection);

/**
 * Create a predicate that tests whether an element is
 * not a member of a collection.
 * If the collection is empty, the predicate will be true.
 * @param elem element
 * @param collection expression
 * @return is-not-member predicate
 */
<E, C extends Collection<E>> Predicate isNotMember(E elem, Expression<C> collection);

//get the values and keys collections of the Map, which may then
//be passed to size(), isMember(), isEmpty(), etc

/**
 * Create an expression that returns the values of a map.
 * @param map map
 * @return collection expression
 */
<V, M extends Map<?, V>> Expression<Collection<V>> values(M map);

```



```

/**
 * Create an expression that returns the keys of a map.
 * @param map map
 * @return set expression
 */
<K, M extends Map<K, ?>> Expression<Set<K>> keys(M map);

//string functions:

/**
 * Create a predicate for testing whether the expression
 * satisfies the given pattern.
 * @param x string expression
 * @param pattern string expression
 * @return like predicate
 */
Predicate like(Expression<String> x, Expression<String> pattern);

/**
 * Create a predicate for testing whether the expression
 * satisfies the given pattern.
 * @param x string expression
 * @param pattern string
 * @return like predicate
 */
Predicate like(Expression<String> x, String pattern);

/**
 * Create a predicate for testing whether the expression
 * satisfies the given pattern.
 * @param x string expression
 * @param pattern string expression
 * @param escapeChar escape character expression
 * @return like predicate
 */
Predicate like(Expression<String> x, Expression<String> pattern, Expression<Character> escapeChar);

/**
 * Create a predicate for testing whether the expression
 * satisfies the given pattern.
 * @param x string expression
 * @param pattern string expression
 * @param escapeChar escape character
 * @return like predicate
 */
Predicate like(Expression<String> x, Expression<String> pattern, char escapeChar);

/**
 * Create a predicate for testing whether the expression
 * satisfies the given pattern.
 * @param x string expression
 * @param pattern string
 * @param escapeChar escape character expression
 * @return like predicate
 */
Predicate like(Expression<String> x, String pattern, Expression<Character> escapeChar);

/**
 * Create a predicate for testing whether the expression
 * satisfies the given pattern.
 * @param x string expression
 * @param pattern string
 * @param escapeChar escape character
 * @return like predicate
 */

```

```

Predicate like(Expression<String> x, String pattern, char escapeChar);

/**
 * Create a predicate for testing whether the expression
 * does not satisfy the given pattern.
 * @param x string expression
 * @param pattern string expression
 * @return not-like predicate
 */
Predicate notLike(Expression<String> x, Expression<String> pattern);

/**
 * Create a predicate for testing whether the expression
 * does not satisfy the given pattern.
 * @param x string expression
 * @param pattern string
 * @return not-like predicate
 */
Predicate notLike(Expression<String> x, String pattern);

/**
 * Create a predicate for testing whether the expression
 * does not satisfy the given pattern.
 * @param x string expression
 * @param pattern string expression
 * @param escapeChar escape character expression
 * @return not-like predicate
 */
Predicate notLike(Expression<String> x, Expression<String> pattern, Expression<Character> escapeChar);

/**
 * Create a predicate for testing whether the expression
 * does not satisfy the given pattern.
 * @param x string expression
 * @param pattern string expression
 * @param escapeChar escape character
 * @return not-like predicate
 */
Predicate notLike(Expression<String> x, Expression<String> pattern, char escapeChar);

/**
 * Create a predicate for testing whether the expression
 * does not satisfy the given pattern.
 * @param x string expression
 * @param pattern string
 * @param escapeChar escape character expression
 * @return not-like predicate
 */
Predicate notLike(Expression<String> x, String pattern, Expression<Character> escapeChar);

/**
 * Create a predicate for testing whether the expression
 * does not satisfy the given pattern.
 * @param x string expression
 * @param pattern string
 * @param escapeChar escape character
 * @return not-like predicate
 */
Predicate notLike(Expression<String> x, String pattern, char escapeChar);

/**
 * Create an expression for string concatenation.
 * If the given list of expressions is empty, returns
 * an expression equivalent to {@code literal("")}.
 * @param expressions string expressions
 * @return expression corresponding to concatenation
 */

```

```

Expression<String> concat(List<Expression<String>> expressions);

/**
 * Create an expression for string concatenation.
 * @param x string expression
 * @param y string expression
 * @return expression corresponding to concatenation
 */
Expression<String> concat(Expression<String> x, Expression<String> y);

/**
 * Create an expression for string concatenation.
 * @param x string expression
 * @param y string
 * @return expression corresponding to concatenation
 */
Expression<String> concat(Expression<String> x, String y);

/**
 * Create an expression for string concatenation.
 * @param x string
 * @param y string expression
 * @return expression corresponding to concatenation
 */
Expression<String> concat(String x, Expression<String> y);

/**
 * Create an expression for substring extraction.
 * Extracts a substring starting at the specified position
 * through to end of the string.
 * First position is 1.
 * @param x string expression
 * @param from start position expression
 * @return expression corresponding to substring extraction
 */
Expression<String> substring(Expression<String> x, Expression<Integer> from);

/**
 * Create an expression for substring extraction.
 * Extracts a substring starting at the specified position
 * through to end of the string.
 * First position is 1.
 * @param x string expression
 * @param from start position
 * @return expression corresponding to substring extraction
 */
Expression<String> substring(Expression<String> x, int from);

/**
 * Create an expression for substring extraction.
 * Extracts a substring of given length starting at the
 * specified position.
 * First position is 1.
 * @param x string expression
 * @param from start position expression
 * @param len length expression
 * @return expression corresponding to substring extraction
 */
Expression<String> substring(Expression<String> x, Expression<Integer> from, Expression<Integer> len);

/**
 * Create an expression for substring extraction.
 * Extracts a substring of given length starting at the
 * specified position.
 * First position is 1.
 * @param x string expression
 * @param from start position

```

```

* @param len length
* @return expression corresponding to substring extraction
*/
Expression<String> substring(Expression<String> x, int from, int len);

/**
 * Used to specify how strings are trimmed.
 */
enum Trimspec {

    /**
     * Trim from leading end.
     */
    LEADING,

    /**
     * Trim from trailing end.
     */
    TRAILING,

    /**
     * Trim from both ends.
     */
    BOTH
}

/**
 * Create expression to trim blanks from both ends of
 * a string.
 * @param x expression for string to trim
 * @return trim expression
 */
Expression<String> trim(Expression<String> x);

/**
 * Create expression to trim blanks from a string.
 * @param ts trim specification
 * @param x expression for string to trim
 * @return trim expression
 */
Expression<String> trim(Trimspec ts, Expression<String> x);

/**
 * Create expression to trim character from both ends of
 * a string.
 * @param t expression for character to be trimmed
 * @param x expression for string to trim
 * @return trim expression
 */
Expression<String> trim(Expression<Character> t, Expression<String> x);

/**
 * Create expression to trim character from a string.
 * @param ts trim specification
 * @param t expression for character to be trimmed
 * @param x expression for string to trim
 * @return trim expression
 */
Expression<String> trim(Trimspec ts, Expression<Character> t, Expression<String> x);

/**
 * Create expression to trim character from both ends of
 * a string.
 * @param t character to be trimmed
 * @param x expression for string to trim
 * @return trim expression
 */

```

```

Expression<String> trim(char t, Expression<String> x);

/**
 * Create expression to trim character from a string.
 * @param ts trim specification
 * @param t character to be trimmed
 * @param x expression for string to trim
 * @return trim expression
 */
Expression<String> trim(Trimspec ts, char t, Expression<String> x);

/**
 * Create expression for converting a string to lowercase.
 * @param x string expression
 * @return expression to convert to lowercase
 */
Expression<String> lower(Expression<String> x);

/**
 * Create expression for converting a string to uppercase.
 * @param x string expression
 * @return expression to convert to uppercase
 */
Expression<String> upper(Expression<String> x);

/**
 * Create expression to return length of a string.
 * @param x string expression
 * @return length expression
 */
Expression<Integer> length(Expression<String> x);

/**
 * Create an expression for the leftmost substring of a string,
 * @param x string expression
 * @param len length of the substring to return
 * @return expression for the leftmost substring
 */
Expression<String> left(Expression<String> x, int len);

/**
 * Create an expression for the rightmost substring of a string,
 * @param x string expression
 * @param len length of the substring to return
 * @return expression for the rightmost substring
 */
Expression<String> right(Expression<String> x, int len);

/**
 * Create an expression for the leftmost substring of a string,
 * @param x string expression
 * @param len length of the substring to return
 * @return expression for the leftmost substring
 */
Expression<String> left(Expression<String> x, Expression<Integer> len);

/**
 * Create an expression for the rightmost substring of a string,
 * @param x string expression
 * @param len length of the substring to return
 * @return expression for the rightmost substring
 */
Expression<String> right(Expression<String> x, Expression<Integer> len);

/**
 * Create an expression replacing every occurrence of a substring
 * within a string.

```

```

* @param x string expression
* @param substring the literal substring to replace
* @param replacement the replacement string
* @return expression for the resulting string
*/
Expression<String> replace(Expression<String> x, Expression<String> substring, Expression<String> replacement);

/**
 * Create an expression replacing every occurrence of a substring
 * within a string.
 * @param x string expression
 * @param substring the literal substring to replace
 * @param replacement the replacement string
 * @return expression for the resulting string
 */
Expression<String> replace(Expression<String> x, String substring, Expression<String> replacement);

/**
 * Create an expression replacing every occurrence of a substring
 * within a string.
 * @param x string expression
 * @param substring the literal substring to replace
 * @param replacement the replacement string
 * @return expression for the resulting string
 */
Expression<String> replace(Expression<String> x, Expression<String> substring, String replacement);

/**
 * Create an expression replacing every occurrence of a substring
 * within a string.
 * @param x string expression
 * @param substring the literal substring to replace
 * @param replacement the replacement string
 * @return expression for the resulting string
 */
Expression<String> replace(Expression<String> x, String substring, String replacement);

/**
 * Create expression to locate the position of one string
 * within another, returning position of first character
 * if found.
 * The first position in a string is denoted by 1. If the
 * string to be located is not found, 0 is returned.
 * <p><strong>Warning:</strong> the order of the parameters
 * of this method is reversed compared to the corresponding
 * function in JPQL.
 * @param x expression for string to be searched
 * @param pattern expression for string to be located
 * @return expression corresponding to position
 */
Expression<Integer> locate(Expression<String> x, Expression<String> pattern);

/**
 * Create expression to locate the position of one string
 * within another, returning position of first character
 * if found.
 * The first position in a string is denoted by 1. If the
 * string to be located is not found, 0 is returned.
 * <p><strong>Warning:</strong> the order of the parameters
 * of this method is reversed compared to the corresponding
 * function in JPQL.
 * @param x expression for string to be searched
 * @param pattern string to be located
 * @return expression corresponding to position
 */
Expression<Integer> locate(Expression<String> x, String pattern);

```

```

/**
 * Create expression to locate the position of one string
 * within another, returning position of first character
 * if found.
 * The first position in a string is denoted by 1. If the
 * string to be located is not found, 0 is returned.
 * <p><strong>Warning:</strong> the order of the first two
 * parameters of this method is reversed compared to the
 * corresponding function in JPQL.
 * @param x expression for string to be searched
 * @param pattern expression for string to be located
 * @param from expression for position at which to start search
 * @return expression corresponding to position
 */
Expression<Integer> locate(Expression<String> x, Expression<String> pattern, Expression<Integer> from);

/**
 * Create expression to locate the position of one string
 * within another, returning position of first character
 * if found.
 * The first position in a string is denoted by 1. If the
 * string to be located is not found, 0 is returned.
 * <p><strong>Warning:</strong> the order of the first two
 * parameters of this method is reversed compared to the
 * corresponding function in JPQL.
 * @param x expression for string to be searched
 * @param pattern string to be located
 * @param from position at which to start search
 * @return expression corresponding to position
 */
Expression<Integer> locate(Expression<String> x, String pattern, int from);

// Date/time/timestamp functions:

/**
 * Create expression to return current date.
 * @return expression for current date
 */
Expression<java.sql.Date> currentDate();

/**
 * Create expression to return current timestamp.
 * @return expression for current timestamp
 */
Expression<java.sql.Timestamp> currentTimestamp();

/**
 * Create expression to return current time.
 * @return expression for current time
 */
Expression<java.sql.Time> currentTime();

/**
 * Create expression to return current local date.
 * @return expression for current date
 */
Expression<java.time.LocalDate> localDate();

/**
 * Create expression to return current local datetime.
 * @return expression for current timestamp
 */
Expression<java.time.LocalDateTime> localDateTime();

/**

```

```

* Create expression to return current local time.
* @return expression for current time
*/
Expression<java.time.LocalDateTime> localTime();

/**
 * Create an expression that returns the value of a
 * field extracted from a date, time, or datetime.
 * @param field a temporal field type
 * @param temporal a date, time, or datetime
 * @return expression for the value of the extracted field
 * @since 3.2
 */
<N,T extends Temporal> Expression<N> extract(TemporalField<N,T> field, Expression<T> temporal);

//in builders:

/**
 * Interface used to build in predicates.
 */
interface In<T> extends Predicate {

    /**
     * Return the expression to be tested against the
     * list of values.
     * @return expression
     */
    Expression<T> getExpression();

    /**
     * Add to list of values to be tested against.
     * @param value value
     * @return in predicate
     */
    In<T> value(T value);

    /**
     * Add to list of values to be tested against.
     * @param value expression
     * @return in predicate
     */
    In<T> value(Expression<? extends T> value);
}

/**
 * Create predicate to test whether given expression
 * is contained in a list of values.
 * @param expression to be tested against list of values
 * @return in predicate
 */
<T> In<T> in(Expression<? extends T> expression);

// coalesce, nullif:

/**
 * Create an expression that returns null if all its arguments
 * evaluate to null, and the value of the first non-null argument
 * otherwise.
 * @param x expression
 * @param y expression
 * @return coalesce expression
 */
<Y> Expression<Y> coalesce(Expression<? extends Y> x, Expression<? extends Y> y);

/**

```



```

* Create an expression that returns null if all its arguments
* evaluate to null, and the value of the first non-null argument
* otherwise.
* @param x expression
* @param y value
* @return coalesce expression
*/
<Y> Expression<Y> coalesce(Expression<? extends Y> x, Y y);

/**
* Create an expression that tests whether its argument are
* equal, returning null if they are and the value of the
* first expression if they are not.
* @param x expression
* @param y expression
* @return nullif expression
*/
<Y> Expression<Y> nullif(Expression<Y> x, Expression<?> y);

/**
* Create an expression that tests whether its argument are
* equal, returning null if they are and the value of the
* first expression if they are not.
* @param x expression
* @param y value
* @return nullif expression
*/
<Y> Expression<Y> nullif(Expression<Y> x, Y y);

// coalesce builder:

/**
* Interface used to build coalesce expressions.
*
* A coalesce expression is equivalent to a case expression
* that returns null if all its arguments evaluate to null,
* and the value of its first non-null argument otherwise.
*/
interface Coalesce<T> extends Expression<T> {

    /**
     * Add an argument to the coalesce expression.
     * @param value value
     * @return coalesce expression
     */
    Coalesce<T> value(T value);

    /**
     * Add an argument to the coalesce expression.
     * @param value expression
     * @return coalesce expression
     */
    Coalesce<T> value(Expression<? extends T> value);
}

/**
* Create a coalesce expression.
* @return coalesce expression
*/
<T> Coalesce<T> coalesce();

//case builders:

/**
* Interface used to build simple case expressions.

```

```

* Case conditions are evaluated in the order in which
* they are specified.
*/
interface SimpleCase<C,R> extends Expression<R> {

    /**
     * Return the expression to be tested against the
     * conditions.
     * @return expression
     */
    Expression<C> getExpression();

    /**
     * Add a when/then clause to the case expression.
     * @param condition "when" condition
     * @param result "then" result value
     * @return simple case expression
     */
    SimpleCase<C, R> when(C condition, R result);

    /**
     * Add a when/then clause to the case expression.
     * @param condition "when" condition
     * @param result "then" result expression
     * @return simple case expression
     */
    SimpleCase<C, R> when(C condition, Expression<? extends R> result);

    /**
     * Add a when/then clause to the case expression.
     * @param condition "when" condition
     * @param result "then" result value
     * @return simple case expression
     */
    SimpleCase<C, R> when(Expression<? extends C> condition, R result);

    /**
     * Add a when/then clause to the case expression.
     * @param condition "when" condition
     * @param result "then" result expression
     * @return simple case expression
     */
    SimpleCase<C, R> when(Expression<? extends C> condition, Expression<? extends R> result);

    /**
     * Add an "else" clause to the case expression.
     * @param result "else" result
     * @return expression
     */
    Expression<R> otherwise(R result);

    /**
     * Add an "else" clause to the case expression.
     * @param result "else" result expression
     * @return expression
     */
    Expression<R> otherwise(Expression<? extends R> result);
}

/**
 * Create a simple case expression.
 * @param expression to be tested against the case conditions
 * @return simple case expression
 */
<C, R> SimpleCase<C,R> selectCase(Expression<? extends C> expression);

```

```

/**
 * Interface used to build general case expressions.
 * Case conditions are evaluated in the order in which
 * they are specified.
 */
interface Case<R> extends Expression<R> {

    /**
     * Add a when/then clause to the case expression.
     * @param condition "when" condition
     * @param result "then" result value
     * @return general case expression
     */
    Case<R> when(Expression<Boolean> condition, R result);

    /**
     * Add a when/then clause to the case expression.
     * @param condition "when" condition
     * @param result "then" result expression
     * @return general case expression
     */
    Case<R> when(Expression<Boolean> condition, Expression<? extends R> result);

    /**
     * Add an "else" clause to the case expression.
     * @param result "else" result
     * @return expression
     */
    Expression<R> otherwise(R result);

    /**
     * Add an "else" clause to the case expression.
     * @param result "else" result expression
     * @return expression
     */
    Expression<R> otherwise(Expression<? extends R> result);
}

/**
 * Create a general case expression.
 * @return general case expression
 */
<R> Case<R> selectCase();

/**
 * Create an expression for the execution of a database
 * function.
 * @param name function name
 * @param type expected result type
 * @param args function arguments
 * @return expression
 */
<T> Expression<T> function(String name, Class<T> type,
Expression<?>... args);

// methods for downcasting:

/**
 * Downcast Join object to the specified type.
 * @param join Join object
 * @param type type to be downcast to
 * @return Join object of the specified type
 * @since 2.1
 */
<X, T, V extends T> Join<X, V> treat(Join<X, T> join, Class<V> type);

```

```

/**
 * Downcast CollectionJoin object to the specified type.
 * @param join CollectionJoin object
 * @param type type to be downcast to
 * @return CollectionJoin object of the specified type
 * @since 2.1
 */
<X, T, E extends T> CollectionJoin<X, E> treat(CollectionJoin<X, T> join, Class<E> type);

/**
 * Downcast SetJoin object to the specified type.
 * @param join SetJoin object
 * @param type type to be downcast to
 * @return SetJoin object of the specified type
 * @since 2.1
 */
<X, T, E extends T> SetJoin<X, E> treat(SetJoin<X, T> join, Class<E> type);

/**
 * Downcast ListJoin object to the specified type.
 * @param join ListJoin object
 * @param type type to be downcast to
 * @return ListJoin object of the specified type
 * @since 2.1
 */
<X, T, E extends T> ListJoin<X, E> treat(ListJoin<X, T> join, Class<E> type);

/**
 * Downcast MapJoin object to the specified type.
 * @param join MapJoin object
 * @param type type to be downcast to
 * @return MapJoin object of the specified type
 * @since 2.1
 */
<X, K, T, V extends T> MapJoin<X, K, V> treat(MapJoin<X, K, T> join, Class<V> type);

/**
 * Downcast Path object to the specified type.
 * @param path path
 * @param type type to be downcast to
 * @return Path object of the specified type
 * @since 2.1
 */
<X, T extends X> Path<T> treat(Path<X> path, Class<T> type);

/**
 * Downcast Root object to the specified type.
 * @param root root
 * @param type type to be downcast to
 * @return Root object of the specified type
 * @since 2.1
 */
<X, T extends X> Root<T> treat(Root<X> root, Class<T> type);

/**
 * Create a query which is the union of the given queries.
 * @return a new criteria query which returns the union of
 *         the results of the given queries
 * @since 3.2
 */
<T> CriteriaSelect<T> union(CriteriaSelect<? extends T> left, CriteriaSelect<? extends T> right);

/**
 * Create a query which is the union of the given queries,
 * without elimination of duplicate results.
 * @return a new criteria query which returns the union of

```

```

*         the results of the given queries
* @since 3.2
*/
<T> CriteriaSelect<T> unionAll(CriteriaSelect<? extends T> left, CriteriaSelect<? extends T> right);

/**
 * Create a query which is the intersection of the given queries.
 * @return a new criteria query which returns the intersection of
 *         the results of the given queries
 * @since 3.2
 */
<T> CriteriaSelect<T> intersect(CriteriaSelect<? super T> left, CriteriaSelect<? super T> right);

/**
 * Create a query which is the intersection of the given queries,
 * without elimination of duplicate results.
 * @return a new criteria query which returns the intersection of
 *         the results of the given queries
 * @since 3.2
 */
<T> CriteriaSelect<T> intersectAll(CriteriaSelect<? super T> left, CriteriaSelect<? super T> right);

/**
 * Create a query by (setwise) subtraction of the second query
 * from the first query.
 * @return a new criteria query which returns the result of
 *         subtracting the results of the second query from the
 *         results of the first query
 * @since 3.2
 */
<T> CriteriaSelect<T> except(CriteriaSelect<T> left, CriteriaSelect<?> right);

/**
 * Create a query by (setwise) subtraction of the second query
 * from the first query, without elimination of duplicate results.
 * @return a new criteria query which returns the result of
 *         subtracting the results of the second query from the
 *         results of the first query
 * @since 3.2
 */
<T> CriteriaSelect<T> exceptAll(CriteriaSelect<T> left, CriteriaSelect<?> right);
}

```

C.2. CriteriaDelete

```

import jakarta.persistence.metamodel.EntityType;

/**
 * The {@code CriteriaDelete} interface defines functionality for
 * performing bulk delete operations using the Criteria API
 *
 * <p>Criteria API bulk delete operations map directly to database
 * delete operations. The persistence context is not synchronized
 * with the result of the bulk delete.
 *
 * <p> A {@code CriteriaDelete} object must have a single root.
 *
 * @param <T> the entity type that is the target of the DELETE
 *
 * @since 2.1
 */
public interface CriteriaDelete<T> extends CommonAbstractCriteria {

    /**

```

```

    * Create and add a query root corresponding to the entity
    * that is the target of the DELETE.
    * A {@code CriteriaDelete} object has a single root, the entity that
    * is being deleted.
    * @param entityClass the entity class
    * @return query root corresponding to the given entity
    */
    Root<T> from(Class<T> entityClass);

    /**
     * Create and add a query root corresponding to the entity
     * that is the target of the DELETE.
     * A {@code CriteriaDelete} object has a single root, the entity that
     * is being deleted.
     * @param entity metamodel entity representing the entity
     *                of type X
     * @return query root corresponding to the given entity
     */
    Root<T> from(EntityType<T> entity);

    /**
     * Return the query root.
     * @return the query root
     */
    Root<T> getRoot();

    /**
     * Modify the DELETE query to restrict the target of the deletion
     * according to the specified boolean expression.
     * Replaces the previously added restriction(s), if any.
     * @param restriction a simple or compound boolean expression
     * @return the modified delete query
     */
    CriteriaDelete<T> where(Expression<Boolean> restriction);

    /**
     * Modify the DELETE query to restrict the target of the deletion
     * according to the conjunction of the specified restriction
     * predicates.
     * Replaces the previously added restriction(s), if any.
     * If no restrictions are specified, any previously added
     * restrictions are simply removed.
     * @param restrictions zero or more restriction predicates
     * @return the modified delete query
     */
    CriteriaDelete<T> where(Predicate... restrictions);
}

```

C.3. CriteriaQuery

```

package jakarta.persistence.criteria;

import jakarta.persistence.Tuple;

import java.util.List;

/**
 * The {@code CriteriaQuery} interface defines functionality that is
 * specific to top-level queries.
 *
 * @param <T> the type of the defined result
 *
 * @since 2.0
 */

```

```

public interface CriteriaQuery<T> extends AbstractQuery<T>, CriteriaSelect<T> {

    /**
     * Specify the item that is to be returned in the query result.
     * Replaces the previously specified selection(s), if any.
     *
     * <p> Note: Applications using the string-based API may need to
     * specify the type of the select item when it results from
     * a get or join operation and the query result type is
     * specified.
     *
     * <p>For example:
     * {@snippet :
     * CriteriaQuery<String> q = cb.createQuery(String.class);
     * Root<Order> order = q.from(Order.class);
     * q.select(order.get("shippingAddress").<String>get("state"));
     *
     * CriteriaQuery<Product> q2 = cb.createQuery(Product.class);
     * q2.select(q2.from(Order.class)
     *         .join("items")
     *         .<Item, Product>join("product"));
     * }
     *
     * @param selection selection specifying the item that is
     *                   to be returned in the query result
     * @return the modified query
     * @throws IllegalArgumentException if the selection is
     *         a compound selection and more than one selection
     *         item has the same assigned alias
     */
    CriteriaQuery<T> select(Selection<? extends T> selection);

    /**
     * Specify the selection items that are to be returned in the query result.
     * Replaces the previously specified selection(s), if any.
     *
     * <p> The type of the result of the query execution depends on the specification
     * of the type of the criteria query object created as well as the arguments
     * to the {@code multiselect} method.
     *
     * <p> An argument to the multiselect method must not be a tuple- or array-valued
     * compound selection item.
     *
     * <p>The semantics of this method are as follows:
     * <ul>
     * <li>
     * If the type of the criteria query is {@code CriteriaQuery<Tuple>}
     * (i.e., a criteria query object created by either the {@code createTupleQuery}
     * method or by passing a {@link Tuple} class argument to the {@code createQuery}
     * method), a {@link Tuple} object corresponding to the arguments of the
     * {@code multiselect} method, in the specified order, will be instantiated and
     * returned for each row that results from the query execution.
     *
     * <li> If the type of the criteria query is {@code CriteriaQuery<X>}
     * for some user-defined class X (i.e., a criteria query object created by
     * passing a X class argument to the {@code createQuery} method), the arguments
     * to the {@code multiselect} method will be passed to the X constructor and an
     * instance of type X will be returned for each row.
     *
     * <li> If the type of the criteria query is {@code CriteriaQuery<X[]>}
     * for some class X, an instance of type {@code X[]} will be returned for each row.
     * The elements of the array will correspond to the arguments of the
     * {@code multiselect} method, in the specified order.
     *
     * <li> If the type of the criteria query is {@code CriteriaQuery<Object>}
     * or if the criteria query was created without specifying a type, and only a single
     * argument is passed to the {@code multiselect} method, an instance of type

```

```

* {@code Object} will be returned for each row.
*
* <li> If the type of the criteria query is {@code CriteriaQuery<Object>}
* or if the criteria query was created without specifying a type, and more than one
* argument is passed to the {@code multiselect} method, an instance of type
* {@code Object[]} will be instantiated and returned for each row. The elements of
* the array will correspond to the arguments to the {@code multiselect} method, in
* the specified order.
* </ul>
*
* @param selections selection items corresponding to the
* results to be returned by the query
* @return the modified query
* @throws IllegalArgumentException if a selection item is
* not valid or if more than one selection item has
* the same assigned alias
*
* @deprecated Since this method is not typesafe, the use of
* {@link CriteriaBuilder#array} or {@link CriteriaBuilder#tuple}
* with {@link #select} is strongly preferred.
*/
@Deprecated(since = "3.2")
CriteriaQuery<T> multiselect(Selection<?>... selections);

/**
* Specify the selection items that are to be returned in the query result.
* Replaces the previously specified selection(s), if any.
*
* <p> The type of the result of the query execution depends on the specification
* of the type of the criteria query object created as well as the argument to the
* {@code multiselect} method. An element of the list passed to the {@code multiselect}
* method must not be a tuple- or array-valued compound selection item.
*
* <p> The semantics of this method are as follows:
* <ul>
* <li> If the type of the criteria query is {@code CriteriaQuery<Tuple>}
* (i.e., a criteria query object created by either the {@code createTupleQuery}
* method or by passing a {@link Tuple} class argument to the {@code createQuery}
* method), a {@code Tuple} object corresponding to the elements of the list passed
* to the {@code multiselect} method, in the specified order, will be instantiated
* and returned for each row that results from the query execution.
*
* <li> If the type of the criteria query is {@code CriteriaQuery<X>}
* for some user-defined class X (i.e., a criteria query object created by passing
* a X class argument to the {@code createQuery} method), the elements of the list
* passed to the {@code multiselect} method will be passed to the X constructor
* and an instance of type X will be returned for each row.
*
* <li> If the type of the criteria query is {@code CriteriaQuery<X[]>}
* for some class X, an instance of type {@code X[]} will be returned for
* each row. The elements of the array will correspond to the elements of
* the list passed to the {@code multiselect} method, in the specified order.
*
* <li> If the type of the criteria query is {@code CriteriaQuery<Object>}
* or if the criteria query was created without specifying a type, and the list
* passed to the {@code multiselect} method contains only a single element, an
* instance of type {@code Object} will be returned for each row.
*
* <li> If the type of the criteria query is {@code CriteriaQuery<Object>}
* or if the criteria query was created without specifying a type, and the list
* passed to the {@code multiselect} method contains more than one element, an
* instance of type {@code Object[]} will be instantiated and returned for each row.
* The elements of the array will correspond to the elements of the list passed to
* the {@code multiselect} method, in the specified order.
* </ul>
*

```



```

* @param selectionList list of selection items corresponding
*                       to the results to be returned by the
*                       query
* @return the modified query
* @throws IllegalArgumentException if a selection item is
*         not valid or if more than one selection item has
*         the same assigned alias
*
* @deprecated Since this method is not typesafe, the use of
* {@link CriteriaBuilder#array} or {@link CriteriaBuilder#tuple}
* with {@link #select} is strongly preferred.
*/
@Deprecated(since = "3.2")
CriteriaQuery<T> multiselect(List<Selection<?>> selectionList);

/**
 * Modify the query to restrict the query result according
 * to the specified boolean expression.
 * Replaces the previously added restriction(s), if any.
 * This method only overrides the return type of the
 * corresponding {@code AbstractQuery} method.
 * @param restriction a simple or compound boolean expression
 * @return the modified query
 */
CriteriaQuery<T> where(Expression<Boolean> restriction);

/**
 * Modify the query to restrict the query result according
 * to the conjunction of the specified restriction predicates.
 * Replaces the previously added restriction(s), if any.
 * If no restrictions are specified, any previously added
 * restrictions are simply removed.
 * This method only overrides the return type of the
 * corresponding {@code AbstractQuery} method.
 * @param restrictions zero or more restriction predicates
 * @return the modified query
 */
CriteriaQuery<T> where(Predicate... restrictions);

/**
 * Modify the query to restrict the query result according
 * to the conjunction of the specified restriction predicates.
 * Replaces the previously added restriction(s), if any.
 * If no restrictions are specified, any previously added
 * restrictions are simply removed.
 * This method only overrides the return type of the
 * corresponding {@code AbstractQuery} method.
 * @param restrictions a list of zero or more restriction predicates
 * @return the modified query
 * @since 3.2
 */
CriteriaQuery<T> where(List<Predicate> restrictions);

/**
 * Specify the expressions that are used to form groups over
 * the query results.
 * Replaces the previous specified grouping expressions, if any.
 * If no grouping expressions are specified, any previously
 * added grouping expressions are simply removed.
 * This method only overrides the return type of the
 * corresponding {@code AbstractQuery} method.
 * @param grouping zero or more grouping expressions
 * @return the modified query
 */
CriteriaQuery<T> groupBy(Expression<?>... grouping);

/**

```

```

* Specify the expressions that are used to form groups over
* the query results.
* Replaces the previous specified grouping expressions, if any.
* If no grouping expressions are specified, any previously
* added grouping expressions are simply removed.
* This method only overrides the return type of the
* corresponding {@code AbstractQuery} method.
* @param grouping list of zero or more grouping expressions
* @return the modified query
*/
CriteriaQuery<T> groupBy(List<Expression<?>> grouping);

/**
* Specify a restriction over the groups of the query.
* Replaces the previous having restriction(s), if any.
* This method only overrides the return type of the
* corresponding {@code AbstractQuery} method.
* @param restriction a simple or compound boolean expression
* @return the modified query
*/
CriteriaQuery<T> having(Expression<Boolean> restriction);

/**
* Specify restrictions over the groups of the query
* according the conjunction of the specified restriction
* predicates.
* Replaces the previously added having restriction(s), if any.
* If no restrictions are specified, any previously added
* restrictions are simply removed.
* This method only overrides the return type of the
* corresponding {@code AbstractQuery} method.
* @param restrictions zero or more restriction predicates
* @return the modified query
*/
CriteriaQuery<T> having(Predicate... restrictions);

/**
* Specify restrictions over the groups of the query
* according the conjunction of the specified restriction
* predicates.
* Replaces the previously added having restriction(s), if any.
* If no restrictions are specified, any previously added
* restrictions are simply removed.
* This method only overrides the return type of the
* corresponding {@code AbstractQuery} method.
* @param restrictions a list of zero or more restriction predicates
* @return the modified query
* @since 3.2
*/
CriteriaQuery<T> having(List<Predicate> restrictions);

/**
* Specify the ordering expressions that are used to
* order the query results.
* Replaces the previous ordering expressions, if any.
* If no ordering expressions are specified, the previous
* ordering, if any, is simply removed, and results will
* be returned in no particular order.
* The left-to-right sequence of the ordering expressions
* determines the precedence, whereby the leftmost has the
* highest precedence.
* @param o zero or more ordering expressions
* @return the modified query
*/
CriteriaQuery<T> orderBy(Order... o);

/**

```

```

    * Specify the ordering expressions that are used to
    * order the query results.
    * Replaces the previous ordering expressions, if any.
    * If no ordering expressions are specified, the previous
    * ordering, if any, is simply removed, and results will
    * be returned in no particular order.
    * The order of the ordering expressions in the list
    * determines the precedence, whereby the first element in
    * the list has the highest precedence.
    * @param o list of zero or more ordering expressions
    * @return the modified query
    */
CriteriaQuery<T> orderBy(List<Order> o);

/**
 * Specify whether duplicate query results are eliminated.
 * A true value will cause duplicates to be eliminated.
 * A false value will cause duplicates to be retained.
 * If distinct has not been specified, duplicate results must
 * be retained.
 * This method only overrides the return type of the
 * corresponding {@code AbstractQuery} method.
 * @param distinct boolean value specifying whether duplicate
 * results must be eliminated from the query result or
 * whether they must be retained
 * @return the modified query.
 */
CriteriaQuery<T> distinct(boolean distinct);

/**
 * Return the ordering expressions in order of precedence.
 * Returns empty list if no ordering expressions have been
 * specified.
 * Modifications to the list do not affect the query.
 * @return the list of ordering expressions
 */
List<Order> getOrderList();
}

```

C.4. CriteriaSelect

```

/**
 * Abstracts over {@linkplain CriteriaQuery top-level queries} and
 * {@linkplain CriteriaBuilder#union unions} and
 * {@linkplain CriteriaBuilder#intersect intersections} of top-level
 * queries.
 *
 * @param <T> the type returned by the query
 *
 * @since 3.2
 */
public interface CriteriaSelect<T> {
}

```

C.5. CriteriaUpdate

```

import jakarta.persistence.metamodel.SingularAttribute;
import jakarta.persistence.metamodel.EntityType;

/**
 * The {@code CriteriaUpdate} interface defines functionality for
 * performing bulk update operations using the Criteria API.
 *

```

```

* <p>Criteria API bulk update operations map directly to database
* update operations, bypassing any optimistic locking checks.
* Portable applications using bulk update operations must manually
* update the value of the version column, if desired, and/or manually
* validate the value of the version column. The persistence context
* is not automatically synchronized with the result of the bulk update.
*
* <p> A {@code CriteriaUpdate} object must have a single root.
*
* @param <T> the entity type that is the target of the update
*
* @since 2.1
*/

```

```

public interface CriteriaUpdate<T> extends CommonAbstractCriteria {

    /**
     * Create and add a query root corresponding to the entity
     * that is the target of the update.
     * A {@code CriteriaUpdate} object has a single root, the
     * entity that is being updated.
     * @param entityClass the entity class
     * @return query root corresponding to the given entity
     */
    Root<T> from(Class<T> entityClass);

    /**
     * Create and add a query root corresponding to the entity
     * that is the target of the update.
     * A {@code CriteriaUpdate} object has a single root, the
     * entity that is being updated.
     * @param entity metamodel entity representing the entity
     *                of type X
     * @return query root corresponding to the given entity
     */
    Root<T> from(EntityType<T> entity);

    /**
     * Return the query root.
     * @return the query root
     */
    Root<T> getRoot();

    /**
     * Update the value of the specified attribute.
     * @param attribute attribute to be updated
     * @param value new value
     * @return the modified update query
     */
    <Y, X extends Y> CriteriaUpdate<T> set( SingularAttribute<? super T, Y> attribute, X value);

    /**
     * Update the value of the specified attribute.
     * @param attribute attribute to be updated
     * @param value new value
     * @return the modified update query
     */
    <Y> CriteriaUpdate<T> set( SingularAttribute<? super T, Y> attribute, Expression<? extends Y> value);

    /**
     * Update the value of the specified attribute.
     * @param attribute attribute to be updated
     * @param value new value
     * @return the modified update query
     */
    <Y, X extends Y> CriteriaUpdate<T> set(Path<Y> attribute, X value);

    /**

```

```

    * Update the value of the specified attribute.
    * @param attribute attribute to be updated
    * @param value new value
    * @return the modified update query
    */
    <Y> CriteriaUpdate<T> set(Path<Y> attribute, Expression<? extends Y> value);

    /**
     * Update the value of the specified attribute.
     * @param attributeName name of the attribute to be updated
     * @param value new value
     * @return the modified update query
     */
    CriteriaUpdate<T> set(String attributeName, Object value);

    /**
     * Modify the update query to restrict the target of the
     * update according to the specified boolean expression.
     * Replaces the previously added restriction(s), if any.
     * @param restriction a simple or compound boolean expression
     * @return the modified update query
     */
    CriteriaUpdate<T> where(Expression<Boolean> restriction);

    /**
     * Modify the update query to restrict the target of the
     * update according to the conjunction of the specified
     * restriction predicates.
     * Replaces the previously added restriction(s), if any.
     * If no restrictions are specified, any previously added
     * restrictions are simply removed.
     * @param restrictions zero or more restriction predicates
     * @return the modified update query
     */
    CriteriaUpdate<T> where(Predicate... restrictions);
}

```

C.6. AbstractQuery

```

package jakarta.persistence.criteria;

import java.util.List;
import java.util.Set;
import jakarta.persistence.metamodel.EntityType;

/**
 * The {@code AbstractQuery} interface defines functionality that is common
 * to both top-level queries and subqueries.
 * It is not intended to be used directly in query construction.
 *
 * <p> All queries must have:
 *     a set of root entities (which may in turn own joins).
 * <p> All queries may have:
 *     a conjunction of restrictions.
 *
 * @param <T> the type of the result
 *
 * @since 2.0
 */
public interface AbstractQuery<T> extends CommonAbstractCriteria {

    /**
     * Create and add a query root corresponding to the given entity,
     * forming a cartesian product with any existing roots.
     * @param entityClass the entity class
     */

```

```

* @return query root corresponding to the given entity
*/
<X> Root<X> from(Class<X> entityClass);

/**
 * Create and add a query root corresponding to the given entity,
 * forming a cartesian product with any existing roots.
 * @param entity metamodel entity representing the entity
 *             of type X
 * @return query root corresponding to the given entity
 */
<X> Root<X> from(EntityType<X> entity);

/**
 * Modify the query to restrict the query results according
 * to the specified boolean expression.
 * Replaces the previously added restriction(s), if any.
 * @param restriction a simple or compound boolean expression
 * @return the modified query
 */
AbstractQuery<T> where(Expression<Boolean> restriction);

/**
 * Modify the query to restrict the query results according
 * to the conjunction of the specified restriction predicates.
 * Replaces the previously added restriction(s), if any.
 * If no restrictions are specified, any previously added
 * restrictions are simply removed.
 * @param restrictions zero or more restriction predicates
 * @return the modified query
 */
AbstractQuery<T> where(Predicate... restrictions);

/**
 * Modify the query to restrict the query result according
 * to the conjunction of the specified restriction predicates.
 * Replaces the previously added restriction(s), if any.
 * If no restrictions are specified, any previously added
 * restrictions are simply removed.
 * @param restrictions a list of zero or more restriction predicates
 * @return the modified query
 * @since 3.2
 */
AbstractQuery<T> where(List<Predicate> restrictions);

/**
 * Specify the expressions that are used to form groups over
 * the query results.
 * Replaces the previous specified grouping expressions, if any.
 * If no grouping expressions are specified, any previously
 * added grouping expressions are simply removed.
 * @param grouping zero or more grouping expressions
 * @return the modified query
 */
AbstractQuery<T> groupBy(Expression<?>... grouping);

/**
 * Specify the expressions that are used to form groups over
 * the query results.
 * Replaces the previous specified grouping expressions, if any.
 * If no grouping expressions are specified, any previously
 * added grouping expressions are simply removed.
 * @param grouping list of zero or more grouping expressions
 * @return the modified query
 */
AbstractQuery<T> groupBy(List<Expression<?>> grouping);

```

```

/**
 * Specify a restriction over the groups of the query.
 * Replaces the previous having restriction(s), if any.
 * @param restriction a simple or compound boolean expression
 * @return the modified query
 */
AbstractQuery<T> having(Expression<Boolean> restriction);

/**
 * Specify restrictions over the groups of the query
 * according to the conjunction of the specified restriction
 * predicates.
 * Replaces the previously having added restriction(s), if any.
 * If no restrictions are specified, any previously added
 * restrictions are simply removed.
 * @param restrictions zero or more restriction predicates
 * @return the modified query
 */
AbstractQuery<T> having(Predicate... restrictions);

/**
 * Specify restrictions over the groups of the query
 * according to the conjunction of the specified restriction
 * predicates.
 * Replaces the previously added having restriction(s), if any.
 * If no restrictions are specified, any previously added
 * restrictions are simply removed.
 * @param restrictions a list of zero or more restriction predicates
 * @return the modified query
 * @since 3.2
 */
AbstractQuery<T> having(List<Predicate> restrictions);

/**
 * Specify whether duplicate query results are eliminated.
 * A true value will cause duplicates to be eliminated.
 * A false value will cause duplicates to be retained.
 * If distinct has not been specified, duplicate results must
 * be retained.
 * @param distinct boolean value specifying whether duplicate
 * results must be eliminated from the query result or
 * whether they must be retained
 * @return the modified query
 */
AbstractQuery<T> distinct(boolean distinct);

/**
 * Return the query roots. These are the roots that are
 * defined for the {@link CriteriaQuery} or {@link Subquery}
 * itself, including any subquery roots defined as a result of
 * correlation. Returns an empty set if no roots have been
 * defined. Modifications to the set do not affect the query.
 * @return the set of query roots
 */
Set<Root?>> getRoots();

/**
 * Return the selection of the query, or null if no selection
 * has been set.
 * @return selection item
 */
Selection<T> getSelection();

/**
 * Return a list of the grouping expressions. Returns empty
 * list if no grouping expressions have been specified.
 * Modifications to the list do not affect the query.

```

```

    * @return the list of grouping expressions
    */
    List<Expression<?>> getGroupList();

    /**
     * Return the predicate that corresponds to the restriction(s)
     * over the grouping items, or null if no restrictions have
     * been specified.
     * @return having clause predicate
     */
    Predicate getGroupRestriction();

    /**
     * Return whether duplicate query results must be eliminated or
     * retained.
     * @return boolean indicating whether duplicate query results
     *         must be eliminated
     */
    boolean isDistinct();

    /**
     * Return the result type of the query or subquery. If
     * a result type was specified as an argument to the
     * {@code createQuery} or {@code subquery} method, that
     * type is returned. If the query was created using the
     * {@code createTupleQuery} method, the result type is
     * {@code Tuple}. Otherwise, the result type is
     * {@code Object}.
     * @return result type
     */
    Class<T> getResultType();
}

```

C.7. CollectionJoin

```

package jakarta.persistence.criteria;

import java.util.Collection;
import jakarta.persistence.metamodel.CollectionAttribute;

/**
 * The {@code CollectionJoin} interface is the type of the result of
 * joining to a collection over an association or element
 * collection that has been specified as a {@link java.util.Collection}.
 *
 * @param <Z> the source type of the join
 * @param <E> the element type of the target {@code Collection}
 *
 * @since 2.0
 */
public interface CollectionJoin<Z, E>
    extends PluralJoin<Z, Collection<E>, E> {

    /**
     * Modify the join to restrict the result according to the
     * specified ON condition and return the join object.
     * Replaces the previous ON condition, if any.
     * @param restriction a simple or compound boolean expression
     * @return the modified join object
     * @since 2.1
     */
    CollectionJoin<Z, E> on(Expression<Boolean> restriction);

    /**
     * Modify the join to restrict the result according to the

```



```

    * specified ON condition and return the join object.
    * Replaces the previous ON condition, if any.
    * @param restrictions zero or more restriction predicates
    * @return the modified join object
    * @since 2.1
    */
    CollectionJoin<Z, E> on(Predicate... restrictions);

    /**
     * Return the metamodel representation for the collection
     * attribute.
     * @return metamodel type representing the {@code Collection} that is
     *         the target of the join
     */
    CollectionAttribute<? super Z, E> getModel();
}

```

C.8. CommonAbstractCriteria

```

import jakarta.persistence.metamodel.EntityType;

import java.util.Set;

/**
 * The {@code CommonAbstractCriteria} interface defines functionality
 * that is common to both top-level criteria queries and subqueries as
 * well as to update and delete criteria operations.
 * It is not intended to be used directly in query construction.
 *
 * <p> Note that criteria queries and criteria update and delete operations
 * are typed differently.
 * Criteria queries are typed according to the query result type.
 * Update and delete operations are typed according to the target of the
 * update or delete.
 *
 * @since 2.1
 */
public interface CommonAbstractCriteria {

    /**
     * Create a subquery of the query.
     * @param type the subquery result type
     * @return subquery
     */
    <U> Subquery<U> subquery(Class<U> type);

    /**
     * Create a subquery of the query.
     * @param type the subquery result type
     * @return subquery
     */
    <U> Subquery<U> subquery(EntityType<U> type);

    /**
     * Return the predicate that corresponds to the where clause
     * restriction(s), or null if no restrictions have been
     * specified.
     * @return where clause predicate
     */
    Predicate getRestriction();

    /**
     * Return the parameters of the query. Returns empty set if
     * there are no parameters.
     * Modifications to the set do not affect the query.

```

```

    * @return the query parameters
    */
    Set<ParameterExpression<?>> getParameters();
}

```

C.9. CompoundSelection

```

/**
 * The {@code CompoundSelection} interface defines a compound
 * selection item (a tuple, array, or result of a constructor).
 *
 * @param <X> the type of the selection item
 *
 * @since 2.0
 */
public interface CompoundSelection<X> extends Selection<X> {}

```

C.10. Expression

```

package jakarta.persistence.criteria;

import java.util.Collection;

/**
 * Type for query expressions.
 *
 * @param <T> the type of the expression
 *
 * @since 2.0
 */
public interface Expression<T> extends Selection<T> {

    /**
     * Create a predicate to test whether the expression is null.
     * @return predicate testing whether the expression is null
     */
    Predicate isNull();

    /**
     * Create a predicate to test whether the expression is
     * not null.
     * @return predicate testing whether the expression is not null
     */
    Predicate isNotNull();

    /**
     * Create a predicate to test whether the expression is equal to
     * the argument.
     * @param value expression to be tested against
     * @return predicate testing for equality
     * @since 3.2
     */
    Predicate equalTo(Expression<?> value);

    /**
     * Create a predicate to test whether the expression is equal to
     * the argument.
     * @param value value to be tested against
     * @return predicate testing for equality
     * @since 3.2
     */
    Predicate equalTo(Object value);
}

```

```

/**
 * Create a predicate to test whether the expression is unequal
 * to the argument.
 * @param value expression to be tested against
 * @return predicate testing for inequality
 * @since 3.2
 */
Predicate notEqualTo(Expression<?> value);

/**
 * Create a predicate to test whether the expression is unequal
 * to the argument.
 * @param value value to be tested against
 * @return predicate testing for inequality
 * @since 3.2
 */
Predicate notEqualTo(Object value);

/**
 * Create a predicate to test whether the expression is a member
 * of the argument list.
 * @param values values to be tested against
 * @return predicate testing for membership
 */
Predicate in(Object... values);

/**
 * Create a predicate to test whether the expression is a member
 * of the argument list.
 * @param values expressions to be tested against
 * @return predicate testing for membership
 */
Predicate in(Expression<?>... values);

/**
 * Create a predicate to test whether the expression is a member
 * of the collection.
 * @param values collection of values to be tested against
 * @return predicate testing for membership
 */
Predicate in(Collection<?> values);

/**
 * Create a predicate to test whether the expression is a member
 * of the collection.
 * @param values expression corresponding to collection to be
 *         tested against
 * @return predicate testing for membership
 */
Predicate in(Expression<Collection<?>> values);

/**
 * Perform a typecast upon the expression, returning a new
 * expression object.
 * Unlike {@link #cast(Class)}, this method does not cause
 * type conversion: the runtime type is not changed.
 * <p><em>Warning: may result in a runtime failure.</em></p>
 * @param type intended type of the expression
 * @return new expression of the given type
 * @see #cast(Class)
 */
<X> Expression<X> as(Class<X> type);

/**
 * Cast this expression to the specified type, returning a
 * new expression object.
 * Unlike {@link #as(Class)}, this method <em>does</em>

```

```

    * result in a runtime type conversion.
    * <p><em>Providers are required to support casting
    * scalar expressions to {@link String}, and
    * {@code String} expressions to {@link Integer},
    * {@link Long}, {@link Float}, and {@link Double}.
    * Support for typecasts between other basic types is
    * not required.</em>
    * @param type a basic type
    * @return a scalar expression of the given basic type
    * @since 3.2
    */
    <X> Expression<X> cast(Class<X> type);
}

```

C.11. Fetch

```

import jakarta.persistence.metamodel.Attribute;

/**
 * Represents a join-fetched association or attribute.
 *
 * @param <Z> the source type of the fetch
 * @param <X> the target type of the fetch
 *
 * @since 2.0
 */
public interface Fetch<Z, X> extends FetchParent<Z, X> {

    /**
     * Return the metamodel attribute corresponding to the
     * fetch join.
     * @return metamodel attribute for the join
     */
    Attribute<? super Z, ?> getAttribute();

    /**
     * Return the parent of the fetched item.
     * @return fetch parent
     */
    FetchParent<?, Z> getParent();

    /**
     * Return the join type used in the fetch join.
     * @return join type
     */
    JoinType getJoinType();
}

```

C.12. FetchParent

```

import jakarta.persistence.metamodel.PluralAttribute;
import jakarta.persistence.metamodel.SingularAttribute;

/**
 * Represents an element of the from clause which may
 * function as the parent of Fetches.
 *
 * @param <Z> the source type
 * @param <X> the target type
 *
 * @since 2.0
 */
public interface FetchParent<Z, X> {

```

```

/**
 * Return the fetch joins that have been made from this type.
 * Returns empty set if no fetch joins have been made from
 * this type.
 * Modifications to the set do not affect the query.
 * @return fetch joins made from this type
 */
java.util.Set<Fetch<X, ?>> getFetches();

/**
 * Create a fetch join to the specified single-valued attribute
 * using an inner join.
 * @param attribute target of the join
 * @return the resulting fetch join
 */
<Y> Fetch<X, Y> fetch(SingularAttribute<? super X, Y> attribute);

/**
 * Create a fetch join to the specified single-valued attribute
 * using the given join type.
 * @param attribute target of the join
 * @param jt join type
 * @return the resulting fetch join
 */
<Y> Fetch<X, Y> fetch(SingularAttribute<? super X, Y> attribute, JoinType jt);

/**
 * Create a fetch join to the specified collection-valued
 * attribute using an inner join.
 * @param attribute target of the join
 * @return the resulting join
 */
<Y> Fetch<X, Y> fetch(PluralAttribute<? super X, ?, Y> attribute);

/**
 * Create a fetch join to the specified collection-valued
 * attribute using the given join type.
 * @param attribute target of the join
 * @param jt join type
 * @return the resulting join
 */
<Y> Fetch<X, Y> fetch(PluralAttribute<? super X, ?, Y> attribute, JoinType jt);

//String-based:

/**
 * Create a fetch join to the specified attribute using an
 * inner join.
 * @param attributeName name of the attribute for the
 * target of the join
 * @return the resulting fetch join
 * @throws IllegalArgumentException if attribute of the given
 * name does not exist
 */
@SuppressWarnings("hiding")
<X, Y> Fetch<X, Y> fetch(String attributeName);

/**
 * Create a fetch join to the specified attribute using
 * the given join type.
 * @param attributeName name of the attribute for the
 * target of the join
 * @param jt join type
 * @return the resulting fetch join
 * @throws IllegalArgumentException if attribute of the given

```

```

    *         name does not exist
    */
    @SuppressWarnings("hiding")
    <X, Y> Fetch<X, Y> fetch(String attributeName, JoinType jt);
}

```

C.13. AbstractQuery

```

package jakarta.persistence.criteria;

import jakarta.persistence.metamodel.EntityType;
import jakarta.persistence.metamodel.SingularAttribute;
import jakarta.persistence.metamodel.CollectionAttribute;
import jakarta.persistence.metamodel.ListAttribute;
import jakarta.persistence.metamodel.MapAttribute;
import jakarta.persistence.metamodel.SetAttribute;

import java.util.Collection;
import java.util.List;
import java.util.Map;
import java.util.Set;

/**
 * Represents a bound type, usually an entity that appears in
 * the from clause, but may also be an embeddable belonging to
 * an entity in the from clause.
 * <p> Serves as a factory for {@link Join}s of associations,
 * embeddables, and collections belonging to the type, and for
 * {@link Path}s of attributes belonging to the type.
 *
 * @param <Z> the source type
 * @param <X> the target type
 *
 * @since 2.0
 */
@SuppressWarnings("hiding")
public interface From<Z, X> extends Path<X>, FetchParent<Z, X> {

    /**
     * Return the joins that have been made from this bound type.
     * Returns empty set if no joins have been made from this
     * bound type.
     * Modifications to the set do not affect the query.
     * @return joins made from this type
     */
    Set<Join<X, ?>> getJoins();

    /**
     * Whether the {@link From} object has been obtained as a result
     * of correlation (use of a {@link Subquery#correlate} method).
     * @return boolean indicating whether the object has been
     *         obtained through correlation
     */
    boolean isCorrelated();

    /**
     * Returns the parent {@link From} object from which the correlated
     * {@link From} object has been obtained through correlation (use
     * of {@link Subquery#correlate} method).
     * @return the parent of the correlated {@code From} object
     * @throws IllegalStateException if the {@code From} object has
     *         not been obtained through correlation
     */
    From<Z, X> getCorrelationParent();
}

```

```

/**
 * Create and add an inner join to the given entity.
 * @param entityClass the target entity class
 * @return the resulting join
 * @since 3.2
 */
<Y> Join<X, Y> join(Class<Y> entityClass);

/**
 * Create and add a join to the given entity.
 * @param entityClass the target entity class
 * @param joinType join type
 * @return the resulting join
 * @since 3.2
 */
<Y> Join<X, Y> join(Class<Y> entityClass, JoinType joinType);

/**
 * Create and add an inner join to the given entity.
 * @param entity metamodel entity representing the join target
 * @return the resulting join
 * @since 3.2
 */
<Y> Join<X, Y> join(EntityType<Y> entity);

/**
 * Create and add a join to the given entity.
 * @param entity metamodel entity representing the join target
 * @param joinType join type
 * @return the resulting join
 * @since 3.2
 */
<Y> Join<X, Y> join(EntityType<Y> entity, JoinType joinType);

/**
 * Create an inner join to the specified single-valued
 * attribute.
 * @param attribute target of the join
 * @return the resulting join
 */
<Y> Join<X, Y> join(SingularAttribute<? super X, Y> attribute);

/**
 * Create a join to the specified single-valued attribute
 * using the given join type.
 * @param attribute target of the join
 * @param jt join type
 * @return the resulting join
 */
<Y> Join<X, Y> join(SingularAttribute<? super X, Y> attribute, JoinType jt);

/**
 * Create an inner join to the specified {@link Collection}-valued
 * attribute.
 * @param collection target of the join
 * @return the resulting join
 */
<Y> CollectionJoin<X, Y> join(CollectionAttribute<? super X, Y> collection);

/**
 * Create an inner join to the specified {@link Set}-valued
 * attribute.
 * @param set target of the join
 * @return the resulting join
 */
<Y> SetJoin<X, Y> join(SetAttribute<? super X, Y> set);

```

```

/**
 * Create an inner join to the specified
 * {@link List}-valued attribute.
 * @param list target of the join
 * @return the resulting join
 */
<Y> ListJoin<X, Y> join(ListAttribute<? super X, Y> list);

/**
 * Create an inner join to the specified {@link Map}-valued
 * attribute.
 * @param map target of the join
 * @return the resulting join
 */
<K, V> MapJoin<X, K, V> join(MapAttribute<? super X, K, V> map);

/**
 * Create a join to the specified {@link Collection}-valued
 * attribute using the given join type.
 * @param collection target of the join
 * @param jt join type
 * @return the resulting join
 */
<Y> CollectionJoin<X, Y> join(CollectionAttribute<? super X, Y> collection, JoinType jt);

/**
 * Create a join to the specified {@link Set}-valued attribute
 * using the given join type.
 * @param set target of the join
 * @param jt join type
 * @return the resulting join
 */
<Y> SetJoin<X, Y> join(SetAttribute<? super X, Y> set, JoinType jt);

/**
 * Create a join to the specified {@link List}-valued attribute
 * using the given join type.
 * @param list target of the join
 * @param jt join type
 * @return the resulting join
 */
<Y> ListJoin<X, Y> join(ListAttribute<? super X, Y> list, JoinType jt);

/**
 * Create a join to the specified {@link Map}-valued attribute
 * using the given join type.
 * @param map target of the join
 * @param jt join type
 * @return the resulting join
 */
<K, V> MapJoin<X, K, V> join(MapAttribute<? super X, K, V> map, JoinType jt);

//String-based:

/**
 * Create an inner join to the specified attribute.
 * @param attributeName name of the attribute for the
 * target of the join
 * @return the resulting join
 * @throws IllegalArgumentException if attribute of the given
 * name does not exist
 */
<X, Y> Join<X, Y> join(String attributeName);

/**
 * Create an inner join to the specified {@link Collection}-valued

```



```

* attribute.
* @param attributeName name of the attribute for the
*                       target of the join
* @return the resulting join
* @throws IllegalArgumentException if attribute of the given
*         name does not exist
*/
<X, Y> CollectionJoin<X, Y> joinCollection(String attributeName);

/**
 * Create an inner join to the specified {@link Set}-valued
 * attribute.
 * @param attributeName name of the attribute for the
 *                       target of the join
 * @return the resulting join
 * @throws IllegalArgumentException if attribute of the given
 *         name does not exist
 */
<X, Y> SetJoin<X, Y> joinSet(String attributeName);

/**
 * Create an inner join to the specified {@link List}-valued
 * attribute.
 * @param attributeName name of the attribute for the
 *                       target of the join
 * @return the resulting join
 * @throws IllegalArgumentException if attribute of the given
 *         name does not exist
 */
<X, Y> ListJoin<X, Y> joinList(String attributeName);

/**
 * Create an inner join to the specified {@link Map}-valued
 * attribute.
 * @param attributeName name of the attribute for the
 *                       target of the join
 * @return the resulting join
 * @throws IllegalArgumentException if attribute of the given
 *         name does not exist
 */
<X, K, V> MapJoin<X, K, V> joinMap(String attributeName);

/**
 * Create a join to the specified attribute using the given
 * join type.
 * @param attributeName name of the attribute for the
 *                       target of the join
 * @param jt join type
 * @return the resulting join
 * @throws IllegalArgumentException if attribute of the given
 *         name does not exist
 */
<X, Y> Join<X, Y> join(String attributeName, JoinType jt);

/**
 * Create a join to the specified {@link Collection}-valued
 * attribute using the given join type.
 * @param attributeName name of the attribute for the
 *                       target of the join
 * @param jt join type
 * @return the resulting join
 * @throws IllegalArgumentException if attribute of the given
 *         name does not exist
 */
<X, Y> CollectionJoin<X, Y> joinCollection(String attributeName, JoinType jt);

/**

```

```

    * Create a join to the specified {@link Set}-valued attribute
    * using the given join type.
    * @param attributeName name of the attribute for the
    *                       target of the join
    * @param jt join type
    * @return the resulting join
    * @throws IllegalArgumentException if attribute of the given
    *         name does not exist
    */
    <X, Y> SetJoin<X, Y> joinSet(String attributeName, JoinType jt);

    /**
    * Create a join to the specified {@link List}-valued attribute
    * using the given join type.
    * @param attributeName name of the attribute for the
    *                       target of the join
    * @param jt join type
    * @return the resulting join
    * @throws IllegalArgumentException if attribute of the given
    *         name does not exist
    */
    <X, Y> ListJoin<X, Y> joinList(String attributeName, JoinType jt);

    /**
    * Create a join to the specified {@link Map}-valued attribute
    * using the given join type.
    * @param attributeName name of the attribute for the
    *                       target of the join
    * @param jt join type
    * @return the resulting join
    * @throws IllegalArgumentException if attribute of the given
    *         name does not exist
    */
    <X, K, V> MapJoin<X, K, V> joinMap(String attributeName, JoinType jt);
}

```

C.14. Join

```

import jakarta.persistence.metamodel.Attribute;

/**
 * A join to an entity, embeddable, or basic type.
 *
 * @param <Z> the source type of the join
 * @param <X> the target type of the join
 *
 * @since 2.0
 */
public interface Join<Z, X> extends From<Z, X> {

    /**
     * Modify the join to restrict the result according to the
     * specified ON condition and return the join object.
     * Replaces the previous ON condition, if any.
     * @param restriction a simple or compound boolean expression
     * @return the modified join object
     * @since 2.1
     */
    Join<Z, X> on(Expression<Boolean> restriction);

    /**
     * Modify the join to restrict the result according to the
     * specified ON condition and return the join object.
     * Replaces the previous ON condition, if any.
     * @param restrictions zero or more restriction predicates

```

```

    * @return the modified join object
    * @since 2.1
    */
Join<Z, X> on(Predicate... restrictions);

/**
 * Return the predicate that corresponds to the ON
 * restriction(s) on the join, or null if no ON condition
 * has been specified.
 * @return the ON restriction predicate
 * @since 2.1
 */
Predicate getOn();

/**
 * Return the metamodel attribute representing the join
 * target, if any, or null if the target of the join is an
 * entity type.
 * @return metamodel attribute or null
 */
Attribute<? super Z, ?> getAttribute();

/**
 * Return the parent of the join.
 * @return join parent
 */
From<?, Z> getParent();

/**
 * Return the join type.
 * @return join type
 */
JoinType getJoinType();
}

```

C.15. JoinType

```

/**
 * Defines the three varieties of join.
 *
 * <p>Support for {@link #RIGHT} outer joins is not required. Applications
 * which make use of right joins might not be portable between providers or
 * between SQL databases.
 *
 * @since 2.0
 */
public enum JoinType {

    /**
     * Inner join.
     */
    INNER,

    /**
     * Left outer join.
     */
    LEFT,

    /**
     * Right outer join.
     */
    RIGHT,
}

```

C.16. ListJoin

```
package jakarta.persistence.criteria;

import java.util.List;
import jakarta.persistence.metamodel.ListAttribute;

/**
 * The {@code ListJoin} interface is the type of the result of
 * joining to a collection over an association or element
 * collection that has been specified as a {@link java.util.List}.
 *
 * @param <Z> the source type of the join
 * @param <E> the element type of the target List
 *
 * @since 2.0
 */
public interface ListJoin<Z, E>
    extends PluralJoin<Z, List<E>, E> {

    /**
     * Modify the join to restrict the result according to the
     * specified ON condition and return the join object.
     * Replaces the previous ON condition, if any.
     * @param restriction a simple or compound boolean expression
     * @return the modified join object
     * @since 2.1
     */
    ListJoin<Z, E> on(Expression<Boolean> restriction);

    /**
     * Modify the join to restrict the result according to the
     * specified ON condition and return the join object.
     * Replaces the previous ON condition, if any.
     * @param restrictions zero or more restriction predicates
     * @return the modified join object
     * @since 2.1
     */
    ListJoin<Z, E> on(Predicate... restrictions);

    /**
     * Return the metamodel representation for the list attribute.
     * @return metamodel type representing the {@code List} that is
     *         the target of the join
     */
    ListAttribute<? super Z, E> getModel();

    /**
     * Create an expression that corresponds to the index of
     * the object in the referenced association or element
     * collection.
     * This method must only be invoked upon an object that
     * represents an association or element collection for
     * which an order column has been defined.
     * @return expression denoting the index
     */
    Expression<Integer> index();
}
```

C.17. LocalDateField

```
import java.time.LocalDate;

/**
```

```

* Each instance represents a type of field which can be
* extracted from a {@link LocalDate}.
*
* @param <N> the resulting type of the extracted value
*
* @since 3.2
*/
public class LocalDateField<N> implements TemporalField<N, LocalDate> {

    private final String name;

    private LocalDateField(String name) {
        this.name = name;
    }

    @Override
    public String toString() {
        return name;
    }

    /**
     * The calendar year.
     */
    public static final LocalDateField<Integer> YEAR = new LocalDateField<>("year");
    /**
     * The calendar quarter, numbered from 1 to 4.
     */
    public static final LocalDateField<Integer> QUARTER = new LocalDateField<>("quarter");
    /**
     * The calendar month of the year, numbered from 1.
     */
    public static final LocalDateField<Integer> MONTH = new LocalDateField<>("month");
    /**
     * The ISO-8601 week number.
     */
    public static final LocalDateField<Integer> WEEK = new LocalDateField<>("week");
    /**
     * The calendar day of the month, numbered from 1.
     */
    public static final LocalDateField<Integer> DAY = new LocalDateField<>("day");
}

```

C.18. LocalDateTimeField

```

import java.time.LocalDate;
import java.time.LocalDateTime;
import java.time.LocalTime;

/**
 * Each instance represents a type of field which can be
 * extracted from a {@link LocalDateTime}.
 *
 * @param <N> the resulting type of the extracted value
 *
 * @since 3.2
 */
public class LocalDateTimeField<N> implements TemporalField<N, LocalDateTime> {

    private final String name;

    private LocalDateTimeField(String name) {
        this.name = name;
    }

    @Override

```

```

public String toString() {
    return name;
}

/**
 * The calendar year.
 */
public static final LocalDateTimeField<Integer> YEAR = new LocalDateTimeField<>("year");
/**
 * The calendar quarter, numbered from 1 to 4.
 */
public static final LocalDateTimeField<Integer> QUARTER = new LocalDateTimeField<>("quarter");
/**
 * The calendar month of the year, numbered from 1.
 */
public static final LocalDateTimeField<Integer> MONTH = new LocalDateTimeField<>("month");
/**
 * The ISO-8601 week number.
 */
public static final LocalDateTimeField<Integer> WEEK = new LocalDateTimeField<>("week");
/**
 * The calendar day of the month, numbered from 1.
 */
public static final LocalDateTimeField<Integer> DAY = new LocalDateTimeField<>("day");

/**
 * The hour of the day in 24-hour time, numbered from 0 to 23.
 */
public static final LocalDateTimeField<Integer> HOUR = new LocalDateTimeField<>("hour");
/**
 * The minute of the hour, numbered from 0 to 59.
 */
public static final LocalDateTimeField<Integer> MINUTE = new LocalDateTimeField<>("minute");
/**
 * The second of the minute, numbered from 0 to 59, including a fractional
 * part representing fractions of a second
 */
public static final LocalDateTimeField<Double> SECOND = new LocalDateTimeField<>("second");

/**
 * The {@linkplain LocalDate date} part of a datetime.
 */
public static final LocalDateTimeField<LocalDate> DATE = new LocalDateTimeField<>("date");
/**
 * The {@linkplain LocalTime time} part of a datetime.
 */
public static final LocalDateTimeField<LocalTime> TIME = new LocalDateTimeField<>("time");
}

```

C.19. LocalTimeField

```

import java.time.LocalTime;

/**
 * Each instance represents a type of field which can be
 * extracted from a {@link LocalTime}.
 *
 * @param <N> the resulting type of the extracted value
 *
 * @since 3.2
 */
public class LocalTimeField<N> implements TemporalField<N, LocalTime> {

    private final String name;

```

```

private LocalTimeField(String name) {
    this.name = name;
}

@Override
public String toString() {
    return name;
}

/**
 * The hour of the day in 24-hour time, numbered from 0 to 23.
 */
public static final LocalTimeField<Integer> HOUR = new LocalTimeField<>("hour");
/**
 * The minute of the hour, numbered from 0 to 59.
 */
public static final LocalTimeField<Integer> MINUTE = new LocalTimeField<>("minute");
/**
 * The second of the minute, numbered from 0 to 59, including a fractional
 * part representing fractions of a second
 */
public static final LocalTimeField<Double> SECOND = new LocalTimeField<>("second");
}

```

C.20. MapJoin

```

import java.util.Map;
import jakarta.persistence.metamodel.MapAttribute;

/**
 * The {@code MapJoin} interface is the type of the result of
 * joining to a collection over an association or element
 * collection that has been specified as a {@link java.util.Map}.
 *
 * @param <Z> the source type of the join
 * @param <K> the type of the target Map key
 * @param <V> the type of the target Map value
 *
 * @since 2.0
 */
public interface MapJoin<Z, K, V>
    extends PluralJoin<Z, Map<K, V>, V> {

    /**
     * Modify the join to restrict the result according to the
     * specified ON condition and return the join object.
     * Replaces the previous ON condition, if any.
     * @param restriction a simple or compound boolean expression
     * @return the modified join object
     * @since 2.1
     */
    MapJoin<Z, K, V> on(Expression<Boolean> restriction);

    /**
     * Modify the join to restrict the result according to the
     * specified ON condition and return the join object.
     * Replaces the previous ON condition, if any.
     * @param restrictions zero or more restriction predicates
     * @return the modified join object
     * @since 2.1
     */
    MapJoin<Z, K, V> on(Predicate... restrictions);

    /**
     * Return the metamodel representation for the map attribute.

```

```

    * @return metamodel type representing the {@code Map} that is
    *         the target of the join
    */
    MapAttribute<? super Z, K, V> getModel();

    /**
     * Create a path expression that corresponds to the map key.
     * @return path corresponding to map key
     */
    Path<K> key();

    /**
     * Create a path expression that corresponds to the map value.
     * This method is for stylistic use only: it just returns this.
     * @return path corresponding to the map value
     */
    Path<V> value();

    /**
     * Create an expression that corresponds to the map entry.
     * @return expression corresponding to the map entry
     */
    Expression<Map.Entry<K, V>> entry();
}

```

C.21. Nulls

```

/**
 * Specifies the precedence of null values within query result sets.
 *
 * @see CriteriaBuilder#asc(Expression, Nulls)
 * @see CriteriaBuilder#desc(Expression, Nulls)
 *
 * @since 3.2
 */
public enum Nulls {
    /**
     * Null precedence not specified.
     */
    NONE,
    /**
     * Null values occur at the beginning of the result set.
     */
    FIRST,
    /**
     * Null values occur at the end of the result set.
     */
    LAST
}

```

C.22. Order

```

/**
 * An object that defines an ordering over the query results.
 *
 * @since 2.0
 */
public interface Order {

    /**
     * Switch the ordering.
     * @return a new {@code Order} instance with the reversed ordering
     */
}

```



```

    Order reverse();

    /**
     * Whether ascending ordering is in effect.
     * @return boolean indicating whether ordering is ascending
     */
    boolean isAscending();

    /**
     * Return the precedence of null values.
     * @return the {@linkplain Nulls precedence of null values}
     * @since 3.2
     */
    Nulls getNullPrecedence();

    /**
     * Return the expression that is used for ordering.
     * @return expression used for ordering
     */
    Expression<?> getExpression();
}

```

C.23. ParameterExpression

```

import jakarta.persistence.Parameter;

/**
 * Type of criteria query parameter expressions.
 *
 * @param <T> the type of the parameter expression
 *
 * @since 2.0
 */
public interface ParameterExpression<T> extends Parameter<T>, Expression<T> {}

```

C.24. Path

```

import jakarta.persistence.metamodel.PluralAttribute;
import jakarta.persistence.metamodel.SingularAttribute;
import jakarta.persistence.metamodel.Bindable;
import jakarta.persistence.metamodel.MapAttribute;

/**
 * Represents a simple or compound attribute path from a
 * bound type or collection, and is a "primitive" expression.
 *
 * @param <X> the type referenced by the path
 *
 * @since 2.0
 */
public interface Path<X> extends Expression<X> {

    /**
     * Return the bindable object that corresponds to the path
     * expression.
     * @return bindable object corresponding to the path
     */
    Bindable<X> getModel();

    /**
     * Return the parent "node" in the path or null if no parent.
     * @return parent
     */
}

```

```

Path<?> getParentPath();

/**
 * Create a path corresponding to the referenced
 * single-valued attribute.
 * @param attribute single-valued attribute
 * @return path corresponding to the referenced attribute
 */
<Y> Path<Y> get(SingularAttribute<? super X, Y> attribute);

/**
 * Create a path corresponding to the referenced
 * collection-valued attribute.
 * @param collection collection-valued attribute
 * @return expression corresponding to the referenced attribute
 */
<E, C extends java.util.Collection<E>> Expression<C> get(PluralAttribute<? super X, C, E> collection);

/**
 * Create a path corresponding to the referenced
 * map-valued attribute.
 * @param map map-valued attribute
 * @return expression corresponding to the referenced attribute
 */
<K, V, M extends java.util.Map<K, V>> Expression<M> get(MapAttribute<? super X, K, V> map);

/**
 * Create an expression corresponding to the type of the path.
 * @return expression corresponding to the type of the path
 */
Expression<Class<? extends X>> type();

//String-based:

/**
 * Create a path corresponding to the referenced attribute.
 *
 * <p>Note: Applications using the string-based API may need to
 * specify the type resulting from the {@link #get} operation in
 * order to avoid the use of {@code Path} variables.
 *
 * <p>For example:
 * {@snippet :
 * CriteriaQuery<Person> q = cb.createQuery(Person.class);
 * Root<Person> p = q.from(Person.class);
 * q.select(p)
 *   .where(cb.isMember("joe",
 *                       p.<Set<String>>get("nicknames"))));
 * }
 * <p>rather than:
 * {@snippet :
 * CriteriaQuery<Person> q = cb.createQuery(Person.class);
 * Root<Person> p = q.from(Person.class);
 * Path<Set<String>> nicknames = p.get("nicknames");
 * q.select(p)
 *   .where(cb.isMember("joe", nicknames));
 * }
 *
 * @param attributeName name of the attribute
 * @return path corresponding to the referenced attribute
 * @throws IllegalStateException if invoked on a path that
 *         corresponds to a basic type
 * @throws IllegalArgumentException if attribute of the given
 *         name does not otherwise exist
 */
<Y> Path<Y> get(String attributeName);

```

```
}
```

C.25. PluralJoin

```
import jakarta.persistence.metamodel.PluralAttribute;

/**
 * The {@code PluralJoin} interface defines functionality
 * that is common to joins to all collection types. It is
 * not intended to be used directly in query construction.
 *
 * @param <Z> the source type
 * @param <C> the collection type
 * @param <E> the element type of the collection
 *
 * @since 2.0
 */
public interface PluralJoin<Z, C, E> extends Join<Z, E> {

    /**
     * Return the metamodel representation for the collection-valued
     * attribute corresponding to the join.
     * @return metamodel collection-valued attribute corresponding
     *         to the target of the join
     */
    PluralAttribute<? super Z, C, E> getModel();
}
```

C.26. Predicate

```
import java.util.List;

/**
 * The type of a simple or compound predicate: a conjunction or
 * disjunction of restrictions.
 * A simple predicate is considered to be a conjunction with a
 * single conjunct.
 *
 * @since 2.0
 */
public interface Predicate extends Expression<Boolean> {

    enum BooleanOperator {
        AND, OR
    }

    /**
     * Return the boolean operator for the predicate.
     * If the predicate is simple, this is {@code AND}.
     * @return boolean operator for the predicate
     */
    BooleanOperator getOperator();

    /**
     * Whether the predicate has been created from another
     * predicate by applying {@link Predicate#not()}
     * or by calling {@link CriteriaBuilder#not()}.
     * @return boolean indicating if the predicate is
     *         a negated predicate
     */
    boolean isNegated();
}
```

```

    * Return the top-level conjuncts or disjuncts of the
    * predicate. Returns empty list if there are no top-level
    * conjuncts or disjuncts of the predicate.
    * Modifications to the list do not affect the query.
    * @return list of boolean expressions forming the predicate
    */
    List<Expression<Boolean>> getExpressions();

    /**
     * Create a negation of the predicate.
     * @return negated predicate
     */
    Predicate not();
}

```

C.27. Root

```

import jakarta.persistence.metamodel.EntityType;

/**
 * A root type in the from clause.
 * Query roots always reference entities.
 *
 * @param <X> the entity type referenced by the root
 *
 * @since 2.0
 */
public interface Root<X> extends From<X, X> {

    /**
     * Return the metamodel entity corresponding to the root.
     * @return metamodel entity corresponding to the root
     */
    EntityType<X> getModel();
}

```

C.28. Selection

```

import jakarta.persistence.TupleElement;
import java.util.List;

/**
 * The {@code Selection} interface defines an item that is to be
 * returned in a query result.
 *
 * @param <X> the type of the selection item
 *
 * @since 2.0
 */
public interface Selection<X> extends TupleElement<X> {

    /**
     * Assigns an alias to the selection item.
     * Once assigned, an alias cannot be changed or reassigned.
     * Returns the same selection item.
     * @param name alias
     * @return selection item
     */
    Selection<X> alias(String name);

    /**
     * Whether the selection item is a compound selection.
     */
}

```

```

    * @return boolean indicating whether the selection is a compound
    *         selection
    */
    boolean isCompoundSelection();

    /**
     * Return the selection items composing a compound selection.
     * Modifications to the list do not affect the query.
     * @return list of selection items
     * @throws IllegalStateException if selection is not a
     *         compound selection
     */
    List<Selection<?>> getCompoundSelectionItems();
}

```

C.29. SetJoin

```

import java.util.Set;
import jakarta.persistence.metamodel.SetAttribute;

/**
 * The {@code SetJoin} interface is the type of the result of
 * joining to a collection over an association or element
 * collection that has been specified as a {@link java.util.Set}.
 *
 * @param <Z> the source type of the join
 * @param <E> the element type of the target {@code Set}
 *
 * @since 2.0
 */
public interface SetJoin<Z, E> extends PluralJoin<Z, Set<E>, E> {

    /**
     * Modify the join to restrict the result according to the
     * specified ON condition and return the join object.
     * Replaces the previous ON condition, if any.
     * @param restriction a simple or compound boolean expression
     * @return the modified join object
     * @since 2.1
     */
    SetJoin<Z, E> on(Expression<Boolean> restriction);

    /**
     * Modify the join to restrict the result according to the
     * specified ON condition and return the join object.
     * Replaces the previous ON condition, if any.
     * @param restrictions zero or more restriction predicates
     * @return the modified join object
     * @since 2.1
     */
    SetJoin<Z, E> on(Predicate... restrictions);

    /**
     * Return the metamodel representation for the set attribute.
     * @return metamodel type representing the {@code Set} that is
     *         the target of the join
     */
    SetAttribute<? super Z, E> getModel();
}

```

C.30. Subquery

```

package jakarta.persistence.criteria;

```

```

import java.util.List;
import java.util.Set;

/**
 * The {@code Subquery} interface defines functionality that is
 * specific to subqueries.
 *
 * <p>A subquery has an expression as its selection item.
 *
 * @param <T> the type of the selection item.
 *
 * @since 2.0
 */
public interface Subquery<T> extends AbstractQuery<T>, Expression<T> {

    /**
     * Specify the item that is to be returned as the subquery
     * result.
     * Replaces the previously specified selection, if any.
     * @param expression expression specifying the item that
     *     is to be returned as the subquery result
     * @return the modified subquery
     */
    Subquery<T> select(Expression<T> expression);

    /**
     * Modify the subquery to restrict the result according
     * to the specified boolean expression.
     * Replaces the previously added restriction(s), if any.
     * This method only overrides the return type of the
     * corresponding {@code AbstractQuery} method.
     * @param restriction a simple or compound boolean expression
     * @return the modified subquery
     */
    Subquery<T> where(Expression<Boolean> restriction);

    /**
     * Modify the subquery to restrict the result according
     * to the conjunction of the specified restriction predicates.
     * Replaces the previously added restriction(s), if any.
     * If no restrictions are specified, any previously added
     * restrictions are simply removed.
     * This method only overrides the return type of the
     * corresponding {@code AbstractQuery} method.
     * @param restrictions zero or more restriction predicates
     * @return the modified subquery
     */
    Subquery<T> where(Predicate... restrictions);

    /**
     * Modify the query to restrict the query result according
     * to the conjunction of the specified restriction predicates.
     * Replaces the previously added restriction(s), if any.
     * If no restrictions are specified, any previously added
     * restrictions are simply removed.
     * This method only overrides the return type of the
     * corresponding {@code AbstractQuery} method.
     * @param restrictions a list of zero or more restriction predicates
     * @return the modified query
     * @since 3.2
     */
    Subquery<T> where(List<Predicate> restrictions);

    /**
     * Specify the expressions that are used to form groups over
     * the subquery results.

```

```

* Replaces the previous specified grouping expressions, if any.
* If no grouping expressions are specified, any previously
* added grouping expressions are simply removed.
* This method only overrides the return type of the
* corresponding {@code AbstractQuery} method.
* @param grouping zero or more grouping expressions
* @return the modified subquery
*/
Subquery<T> groupBy(Expression<?>... grouping);

/**
* Specify the expressions that are used to form groups over
* the subquery results.
* Replaces the previous specified grouping expressions, if any.
* If no grouping expressions are specified, any previously
* added grouping expressions are simply removed.
* This method only overrides the return type of the
* corresponding {@code AbstractQuery} method.
* @param grouping list of zero or more grouping expressions
* @return the modified subquery
*/
Subquery<T> groupBy(List<Expression<?>> grouping);

/**
* Specify a restriction over the groups of the subquery.
* Replaces the previous having restriction(s), if any.
* This method only overrides the return type of the
* corresponding {@code AbstractQuery} method.
* @param restriction a simple or compound boolean expression
* @return the modified subquery
*/
Subquery<T> having(Expression<Boolean> restriction);

/**
* Specify restrictions over the groups of the subquery
* according the conjunction of the specified restriction
* predicates.
* Replaces the previously added having restriction(s), if any.
* If no restrictions are specified, any previously added
* restrictions are simply removed.
* This method only overrides the return type of the
* corresponding {@code AbstractQuery} method.
* @param restrictions zero or more restriction predicates
* @return the modified subquery
*/
Subquery<T> having(Predicate... restrictions);

/**
* Specify restrictions over the groups of the query
* according the conjunction of the specified restriction
* predicates.
* Replaces the previously added having restriction(s), if any.
* If no restrictions are specified, any previously added
* restrictions are simply removed.
* This method only overrides the return type of the
* corresponding {@code AbstractQuery} method.
* @param restrictions a list of zero or more restriction predicates
* @return the modified query
* @since 3.2
*/
Subquery<T> having(List<Predicate> restrictions);

/**
* Specify whether duplicate query results are eliminated.
* A true value will cause duplicates to be eliminated.
* A false value will cause duplicates to be retained.
* If distinct has not been specified, duplicate results must

```

```

* be retained.
* This method only overrides the return type of the
* corresponding {@code AbstractQuery} method.
* @param distinct boolean value specifying whether duplicate
*       results must be eliminated from the subquery result or
*       whether they must be retained
* @return the modified subquery.
*/
Subquery<T> distinct(boolean distinct);

/**
 * Create a subquery root correlated to a root of the
 * enclosing query.
 * @param parentRoot a root of the containing query
 * @return subquery root
 */
<Y> Root<Y> correlate(Root<Y> parentRoot);

/**
 * Create a subquery join object correlated to a join object
 * of the enclosing query.
 * @param parentJoin join object of the containing query
 * @return subquery join
 */
<X, Y> Join<X, Y> correlate(Join<X, Y> parentJoin);

/**
 * Create a subquery collection join object correlated to a
 * collection join object of the enclosing query.
 * @param parentCollection join object of the containing query
 * @return subquery join
 */
<X, Y> CollectionJoin<X, Y> correlate(CollectionJoin<X, Y> parentCollection);

/**
 * Create a subquery set join object correlated to a set join
 * object of the enclosing query.
 * @param parentSet join object of the containing query
 * @return subquery join
 */
<X, Y> SetJoin<X, Y> correlate(SetJoin<X, Y> parentSet);

/**
 * Create a subquery list join object correlated to a list join
 * object of the enclosing query.
 * @param parentList join object of the containing query
 * @return subquery join
 */
<X, Y> ListJoin<X, Y> correlate(ListJoin<X, Y> parentList);

/**
 * Create a subquery map join object correlated to a map join
 * object of the enclosing query.
 * @param parentMap join object of the containing query
 * @return subquery join
 */
<X, K, V> MapJoin<X, K, V> correlate(MapJoin<X, K, V> parentMap);

/**
 * Return the query of which this is a subquery.
 * This must be a CriteriaQuery or a Subquery.
 * @return the enclosing query or subquery
 */
AbstractQuery<?> getParent();

/**
 * Return the query of which this is a subquery.

```



```

    * This may be a CriteriaQuery, CriteriaUpdate, CriteriaDelete,
    * or a Subquery.
    * @return the enclosing query or subquery
    * @since 2.1
    */
    CommonAbstractCriteria getContainingQuery();

    /**
     * Return the selection expression.
     * @return the item to be returned in the subquery result
     */
    Expression<T> getSelection();

    /**
     * Return the correlated joins of the subquery.
     * Returns empty set if the subquery has no correlated
     * joins.
     * Modifications to the set do not affect the query.
     * @return the correlated joins of the subquery
     */
    Set<Join<?, ?>> getCorrelatedJoins();
}

```

C.31. TemporalField

```

import java.time.temporal.Temporal;

/**
 * Each instance represents a type of field which can be
 * extracted from a date, time, or datetime.
 *
 * @param <N> the resulting type of the extracted value
 * @param <T> the temporal type (date, time, or datetime)
 *
 * @see LocalDateField
 * @see LocalTimeField
 * @see LocalDateTimeField
 * @see CriteriaBuilder#extract(TemporalField, Expression)
 *
 * @since 3.2
 */
public interface TemporalField<N,T extends Temporal> {}

```

Appendix D: Metamodel API Interfaces

The following APIs are defined in the package `jakarta.persistence.metamodel`.

D.1. Metamodel

```
package jakarta.persistence.metamodel;

import java.util.Set;

/**
 * Provides access to the metamodel of persistent entities in the
 * persistence unit.
 *
 * @since 2.0
 */
public interface Metamodel {

    /**
     * Return the metamodel entity type representing the entity.
     * @param entityName the name of the represented entity
     * @return the metamodel entity type
     * @throws IllegalArgumentException if not an entity
     * @see jakarta.persistence.Entity#name
     * @since 3.2
     */
    EntityType<?> entity(String entityName);

    /**
     * Return the metamodel entity type representing the entity.
     * @param cls the type of the represented entity
     * @return the metamodel entity type
     * @throws IllegalArgumentException if not an entity
     */
    <X> EntityType<X> entity(Class<X> cls);

    /**
     * Return the metamodel managed type representing the
     * entity, mapped superclass, or embeddable class.
     * @param cls the type of the represented managed class
     * @return the metamodel managed type
     * @throws IllegalArgumentException if not a managed class
     */
    <X> ManagedType<X> managedType(Class<X> cls);

    /**
     * Return the metamodel embeddable type representing the
     * embeddable class.
     * @param cls the type of the represented embeddable class
     * @return the metamodel embeddable type
     * @throws IllegalArgumentException if not an embeddable class
     */
    <X> EmbeddableType<X> embeddable(Class<X> cls);

    /**
     * Return the metamodel managed types.
     * @return the metamodel managed types
     */
    Set<ManagedType<?>> getManagedTypes();

    /**
     * Return the metamodel entity types.
     * @return the metamodel entity types
     */
}
```

```

Set<EntityType?>> getEntities();

/**
 * Return the metamodel embeddable types.
 * Returns an empty set if there are no embeddable types.
 * @return the metamodel embeddable types
 */
Set<EmbeddableType?>> getEmbeddables();
}

```

D.2. StaticMetamodel

```

package jakarta.persistence.metamodel;

import java.lang.annotation.ElementType;
import java.lang.annotation.Retention;
import java.lang.annotation.RetentionPolicy;
import java.lang.annotation.Target;

/**
 * The {@code StaticMetamodel} annotation specifies that the class is
 * a metamodel class that represents the entity, mapped superclass,
 * or embeddable class designated by the {@link #value} element.
 *
 * @since 2.0
 */
@Target(ElementType.TYPE)
@Retention(RetentionPolicy.RUNTIME)
public @interface StaticMetamodel {

    /**
     * Class being modelled by the annotated class.
     */
    Class<?> value();
}

```

D.3. Attribute

```

/**
 * Represents an attribute of a Java type.
 *
 * @param <X> The represented type that contains the attribute
 * @param <Y> The type of the represented attribute
 *
 * @since 2.0
 */
public interface Attribute<X, Y> {

    enum PersistentAttributeType {

        /** Many-to-one association */
        MANY_TO_ONE,

        /** One-to-one association */
        ONE_TO_ONE,

        /** Basic attribute */
        BASIC,

        /** Embeddable class attribute */
        EMBEDDED,

        /** Many-to-many association */

```

```

    MANY_TO_MANY,

    /** One-to-many association */
    ONE_TO_MANY,

    /** Element collection */
    ELEMENT_COLLECTION
}

/**
 * Return the name of the attribute.
 * @return name
 */
String getName();

/**
 * Return the persistent attribute type for the attribute.
 * @return persistent attribute type
 */
PersistentAttributeType getPersistentAttributeType();

/**
 * Return the managed type representing the type in which
 * the attribute was declared.
 * @return declaring type
 */
ManagedType<X> getDeclaringType();

/**
 * Return the Java type of the represented attribute.
 * @return Java type
 */
Class<Y> getJavaType();

/**
 * Return the {@link java.lang.reflect.Member} for the
 * represented attribute.
 * @return corresponding {@link java.lang.reflect.Member}
 */
java.lang.reflect.Member getJavaMember();

/**
 * Is the attribute an association.
 * @return boolean indicating whether the attribute
 * corresponds to an association
 */
boolean isAssociation();

/**
 * Is the attribute collection-valued (represents a
 * {@code Collection}, {@code Set}, {@code List}, or
 * {@code Map}).
 * @return boolean indicating whether the attribute is
 * collection-valued
 */
boolean isCollection();
}

```

D.4. BasicType

```

/**
 * An instance of {@code BasicType} represents a
 * {@linkplain jakarta.persistence.Basic basic type}
 * (possibly an {@linkplain jakarta.persistence.Enumerated
 * enumerated}, {@linkplain jakarta.persistence.Lob LOB}, or

```

```

* {@linkplain jakarta.persistence.Temporal temporal} type).
*
* @param <X> The represented basic type
*
* @since 2.0
*/
public interface BasicType<X> extends Type<X> {}

```

D.5. Bindable

```

import jakarta.persistence.criteria.Path;

/**
 * An instances of the type {@code Bindable} represents an object
 * or attribute type that can be bound into a {@link Path Path}.
 *
 * @param <T> The type of the represented object or attribute
 *
 * @since 2.0
 */
public interface Bindable<T> {

    enum BindableType {
        /**
         * Single-valued attribute type.
         *
         * @see SingularAttribute
         */
        SINGULAR_ATTRIBUTE,

        /**
         * Multivalued attribute type, that is, a collection.
         *
         * @see PluralAttribute
         */
        PLURAL_ATTRIBUTE,

        /**
         * Entity type.
         *
         * @see EntityType
         */
        ENTITY_TYPE
    }

    /**
     * Return the bindable type of the represented object.
     * @return bindable type
     */
    BindableType getBindableType();

    /**
     * Return the Java type of the represented object.
     * If the bindable type of the object is {@code PLURAL_ATTRIBUTE},
     * the Java element type is returned. If the bindable type is
     * {@code SINGULAR_ATTRIBUTE} or {@code ENTITY_TYPE},
     * the Java type of the
     * represented entity or attribute is returned.
     * @return Java type
     */
    Class<T> getBindableJavaType();
}

```

D.6. CollectionAttribute

```
/**
 * Instances of the type {@code CollectionAttribute} represent
 * persistent {@link java.util.Collection}-valued attributes.
 *
 * @param <X> The type the represented Collection belongs to
 * @param <E> The element type of the represented Collection
 *
 * @since 2.0
 */
public interface CollectionAttribute<X, E>
    extends PluralAttribute<X, java.util.Collection<E>, E> {}
```

D.7. EmbeddableType

```
/**
 * An instance of {@code EmbeddableType} represents an
 * {@linkplain jakarta.persistence.Embeddable embeddable}
 * type.
 *
 * @param <X> The represented embeddable type.
 *
 * @since 2.0
 */
public interface EmbeddableType<X> extends ManagedType<X> {}
```

D.8. EntityType

```
/**
 * An instance of {@code EntityType} represents
 * an {@linkplain jakarta.persistence.Entity entity}
 * type.
 *
 * @param <X> The represented entity type.
 *
 * @since 2.0
 */
public interface EntityType<X>
    extends IdentifiableType<X>, Bindable<X>{

    /**
     * Return the entity name.
     * @return entity name
     */
    String getName();
}
```

D.9. IdentifiableType

```
import java.util.Set;

/**
 * An instance of the type {@code IdentifiableType} represents an
 * entity or mapped superclass type.
 *
 * @param <X> The represented entity or mapped superclass type.
 *
 * @since 2.0
 */
```

```

*
*/
public interface IdentifiableType<X> extends ManagedType<X> {

    /**
     * Return the attribute that corresponds to the id attribute of
     * the entity or mapped superclass.
     * @param type the type of the represented id attribute
     * @return id attribute
     * @throws IllegalArgumentException if id attribute of the given
     *         type is not present in the identifiable type or if
     *         the identifiable type has an id class
     */
    <Y> SingularAttribute<? super X, Y> getId(Class<Y> type);

    /**
     * Return the attribute that corresponds to the id attribute
     * declared by the entity or mapped superclass.
     * @param type the type of the represented declared
     *         id attribute
     * @return declared id attribute
     * @throws IllegalArgumentException if id attribute of the given
     *         type is not declared in the identifiable type or if
     *         the identifiable type has an id class
     */
    <Y> SingularAttribute<X, Y> getDeclaredId(Class<Y> type);

    /**
     * Return the attribute that corresponds to the version
     * attribute of the entity or mapped superclass.
     * @param type the type of the represented version attribute
     * @return version attribute
     * @throws IllegalArgumentException if version attribute of the
     *         given type is not present in the identifiable type
     */
    <Y> SingularAttribute<? super X, Y> getVersion(Class<Y> type);

    /**
     * Return the attribute that corresponds to the version
     * attribute declared by the entity or mapped superclass.
     * @param type the type of the represented declared version
     *         attribute
     * @return declared version attribute
     * @throws IllegalArgumentException if version attribute of the
     *         type is not declared in the identifiable type
     */
    <Y> SingularAttribute<X, Y> getDeclaredVersion(Class<Y> type);

    /**
     * Return the identifiable type that corresponds to the most
     * specific mapped superclass or entity extended by the entity
     * or mapped superclass.
     * @return supertype of identifiable type or null if no
     *         such supertype
     */
    IdentifiableType<? super X> getSupertype();

    /**
     * Whether the identifiable type has a single id attribute.
     * Returns true for a simple id or embedded id; returns false
     * for an idclass.
     * @return boolean indicating whether the identifiable
     *         type has a single id attribute
     */
    boolean hasSingleIdAttribute();

    /**

```

```

    * Whether the identifiable type has a version attribute.
    * @return boolean indicating whether the identifiable
    *         type has a version attribute
    */
    boolean hasVersionAttribute();

    /**
     * Return the attributes corresponding to the id class of the
     * identifiable type.
     * @return id attributes
     * @throws IllegalArgumentException if the identifiable type
     *         does not have an id class
     */
    Set<SingularAttribute<? super X, ?>> getIdClassAttributes();

    /**
     * Return the type that represents the type of the id.
     * @return type of id
     */
    Type<?> getIdType();
}

```

D.10. ListAttribute

```

/**
 * Instances of the type {@code ListAttribute} represent persistent
 * {@link java.util.List}-valued attributes.
 *
 * @param <X> The type the represented List belongs to
 * @param <E> The element type of the represented List
 *
 * @since 2.0
 */
public interface ListAttribute<X, E>
    extends PluralAttribute<X, java.util.List<E>, E> {}

```

D.11. ManagedType

```

import java.util.Set;

/**
 * Instances of the type {@code ManagedType} represent entity, mapped
 * superclass, and embeddable types.
 *
 * @param <X> The represented type.
 *
 * @since 2.0
 */
public interface ManagedType<X> extends Type<X> {

    /**
     * Return the attributes of the managed type.
     * @return attributes of the managed type
     */
    Set<Attribute<? super X, ?>> getAttributes();

    /**
     * Return the attributes declared by the managed type.
     * Returns empty set if the managed type has no declared
     * attributes.
     * @return declared attributes of the managed type
     */
}

```



```

*/
Set<Attribute<X, ?>> getDeclaredAttributes();

/**
 * Return the single-valued attribute of the managed
 * type that corresponds to the specified name and Java type.
 * @param name the name of the represented attribute
 * @param type the type of the represented attribute
 * @return single-valued attribute with given name and type
 * @throws IllegalArgumentException if attribute of the given
 *         name and type is not present in the managed type
 */
<Y> SingularAttribute<? super X, Y> getSingularAttribute(String name, Class<Y> type);

/**
 * Return the single-valued attribute declared by the
 * managed type that corresponds to the specified name and
 * Java type.
 * @param name the name of the represented attribute
 * @param type the type of the represented attribute
 * @return declared single-valued attribute of the given
 *         name and type
 * @throws IllegalArgumentException if attribute of the given
 *         name and type is not declared in the managed type
 */
<Y> SingularAttribute<X, Y> getDeclaredSingularAttribute(String name, Class<Y> type);

/**
 * Return the single-valued attributes of the managed type.
 * Returns empty set if the managed type has no single-valued
 * attributes.
 * @return single-valued attributes
 */
Set<SingularAttribute<? super X, ?>> getSingularAttributes();

/**
 * Return the single-valued attributes declared by the managed
 * type.
 * Returns empty set if the managed type has no declared
 * single-valued attributes.
 * @return declared single-valued attributes
 */
Set<SingularAttribute<X, ?>> getDeclaredSingularAttributes();

/**
 * Return the Collection-valued attribute of the managed type
 * that corresponds to the specified name and Java element type.
 * @param name the name of the represented attribute
 * @param elementType the element type of the represented
 *         attribute
 * @return CollectionAttribute of the given name and element
 *         type
 * @throws IllegalArgumentException if attribute of the given
 *         name and type is not present in the managed type
 */
<E> CollectionAttribute<? super X, E> getCollection(String name, Class<E> elementType);

/**
 * Return the Collection-valued attribute declared by the
 * managed type that corresponds to the specified name and Java
 * element type.
 * @param name the name of the represented attribute
 * @param elementType the element type of the represented
 *         attribute
 * @return declared {code CollectionAttribute} of the given name and
 *         element type
 * @throws IllegalArgumentException if attribute of the given

```

```

*      name and type is not declared in the managed type
*/
<E> CollectionAttribute<X, E> getDeclaredCollection(String name, Class<E> elementType);

/**
 * Return the Set-valued attribute of the managed type that
 * corresponds to the specified name and Java element type.
 * @param name the name of the represented attribute
 * @param elementType the element type of the represented
 *      attribute
 * @return SetAttribute of the given name and element type
 * @throws IllegalArgumentException if attribute of the given
 *      name and type is not present in the managed type
 */
<E> SetAttribute<? super X, E> getSet(String name, Class<E> elementType);

/**
 * Return the Set-valued attribute declared by the managed type
 * that corresponds to the specified name and Java element type.
 * @param name the name of the represented attribute
 * @param elementType the element type of the represented
 *      attribute
 * @return declared SetAttribute of the given name and
 *      element type
 * @throws IllegalArgumentException if attribute of the given
 *      name and type is not declared in the managed type
 */
<E> SetAttribute<X, E> getDeclaredSet(String name, Class<E> elementType);

/**
 * Return the List-valued attribute of the managed type that
 * corresponds to the specified name and Java element type.
 * @param name the name of the represented attribute
 * @param elementType the element type of the represented
 *      attribute
 * @return ListAttribute of the given name and element type
 * @throws IllegalArgumentException if attribute of the given
 *      name and type is not present in the managed type
 */
<E> ListAttribute<? super X, E> getList(String name, Class<E> elementType);

/**
 * Return the List-valued attribute declared by the managed
 * type that corresponds to the specified name and Java
 * element type.
 * @param name the name of the represented attribute
 * @param elementType the element type of the represented
 *      attribute
 * @return declared ListAttribute of the given name and
 *      element type
 * @throws IllegalArgumentException if attribute of the given
 *      name and type is not declared in the managed type
 */
<E> ListAttribute<X, E> getDeclaredList(String name, Class<E> elementType);

/**
 * Return the Map-valued attribute of the managed type that
 * corresponds to the specified name and Java key and value
 * types.
 * @param name the name of the represented attribute
 * @param keyType the key type of the represented attribute
 * @param valueType the value type of the represented attribute
 * @return MapAttribute of the given name and key and value
 *      types
 * @throws IllegalArgumentException if attribute of the given
 *      name and type is not present in the managed type
 */

```

```

<K, V> MapAttribute<? super X, K, V> getMap(String name,
                                           Class<K> keyType,
                                           Class<V> valueType);

/**
 * Return the Map-valued attribute declared by the managed
 * type that corresponds to the specified name and Java key
 * and value types.
 * @param name the name of the represented attribute
 * @param keyType the key type of the represented attribute
 * @param valueType the value type of the represented attribute
 * @return declared MapAttribute of the given name and key
 *         and value types
 * @throws IllegalArgumentException if attribute of the given
 *         name and type is not declared in the managed type
 */
<K, V> MapAttribute<X, K, V> getDeclaredMap(String name,
                                           Class<K> keyType,
                                           Class<V> valueType);

/**
 * Return all multi-valued attributes (Collection-, Set-,
 * List-, and Map-valued attributes) of the managed type.
 * Returns empty set if the managed type has no multi-valued
 * attributes.
 * @return Collection-, Set-, List-, and Map-valued attributes
 */
Set<PluralAttribute<? super X, ?, ?>> getPluralAttributes();

/**
 * Return all multi-valued attributes (Collection-, Set-,
 * List-, and Map-valued attributes) declared by the
 * managed type.
 * Returns empty set if the managed type has no declared
 * multivalued attributes.
 * @return declared Collection-, Set-, List-, and Map-valued
 *         attributes
 */
Set<PluralAttribute<X, ?, ?>> getDeclaredPluralAttributes();

```

//String-based:

```

/**
 * Return the attribute of the managed
 * type that corresponds to the specified name.
 * @param name the name of the represented attribute
 * @return attribute with given name
 * @throws IllegalArgumentException if attribute of the given
 *         name is not present in the managed type
 */
Attribute<? super X, ?> getAttribute(String name);

/**
 * Return the attribute declared by the managed
 * type that corresponds to the specified name.
 * @param name the name of the represented attribute
 * @return attribute with given name
 * @throws IllegalArgumentException if attribute of the given
 *         name is not declared in the managed type
 */
Attribute<X, ?> getDeclaredAttribute(String name);

/**
 * Return the single-valued attribute of the managed type that
 * corresponds to the specified name.
 * @param name the name of the represented attribute

```

```

* @return single-valued attribute with the given name
* @throws IllegalArgumentException if attribute of the given
*         name is not present in the managed type
*/
SingularAttribute<? super X, ?> getSingularAttribute(String name);

/**
* Return the single-valued attribute declared by the managed
* type that corresponds to the specified name.
* @param name the name of the represented attribute
* @return declared single-valued attribute of the given
*         name
* @throws IllegalArgumentException if attribute of the given
*         name is not declared in the managed type
*/
SingularAttribute<X, ?> getDeclaredSingularAttribute(String name);

/**
* Return the Collection-valued attribute of the managed type
* that corresponds to the specified name.
* @param name the name of the represented attribute
* @return CollectionAttribute of the given name
* @throws IllegalArgumentException if attribute of the given
*         name is not present in the managed type
*/
CollectionAttribute<? super X, ?> getCollection(String name);

/**
* Return the Collection-valued attribute declared by the
* managed type that corresponds to the specified name.
* @param name the name of the represented attribute
* @return declared CollectionAttribute of the given name
* @throws IllegalArgumentException if attribute of the given
*         name is not declared in the managed type
*/
CollectionAttribute<X, ?> getDeclaredCollection(String name);

/**
* Return the Set-valued attribute of the managed type that
* corresponds to the specified name.
* @param name the name of the represented attribute
* @return SetAttribute of the given name
* @throws IllegalArgumentException if attribute of the given
*         name is not present in the managed type
*/
SetAttribute<? super X, ?> getSet(String name);

/**
* Return the Set-valued attribute declared by the managed type
* that corresponds to the specified name.
* @param name the name of the represented attribute
* @return declared SetAttribute of the given name
* @throws IllegalArgumentException if attribute of the given
*         name is not declared in the managed type
*/
SetAttribute<X, ?> getDeclaredSet(String name);

/**
* Return the List-valued attribute of the managed type that
* corresponds to the specified name.
* @param name the name of the represented attribute
* @return ListAttribute of the given name
* @throws IllegalArgumentException if attribute of the given
*         name is not present in the managed type
*/
ListAttribute<? super X, ?> getList(String name);

```

```

/**
 * Return the List-valued attribute declared by the managed
 * type that corresponds to the specified name.
 * @param name the name of the represented attribute
 * @return declared ListAttribute of the given name
 * @throws IllegalArgumentException if attribute of the given
 *         name is not declared in the managed type
 */
ListAttribute<X, ?> getDeclaredList(String name);

/**
 * Return the Map-valued attribute of the managed type that
 * corresponds to the specified name.
 * @param name the name of the represented attribute
 * @return MapAttribute of the given name
 * @throws IllegalArgumentException if attribute of the given
 *         name is not present in the managed type
 */
MapAttribute<? super X, ?, ?> getMap(String name);

/**
 * Return the Map-valued attribute declared by the managed
 * type that corresponds to the specified name.
 * @param name the name of the represented attribute
 * @return declared MapAttribute of the given name
 * @throws IllegalArgumentException if attribute of the given
 *         name is not declared in the managed type
 */
MapAttribute<X, ?, ?> getDeclaredMap(String name);
}

```

D.12. MapAttribute

```

/**
 * Instances of the type {@code MapAttribute} represent
 * persistent {@link java.util.Map}-valued attributes.
 *
 * @param <X> The type the represented Map belongs to
 * @param <K> The type of the key of the represented Map
 * @param <V> The type of the value of the represented Map
 *
 * @since 2.0
 */
public interface MapAttribute<X, K, V>
    extends PluralAttribute<X, java.util.Map<K, V>, V> {

    /**
     * Return the Java type of the map key.
     * @return Java key type
     */
    Class<K> getKeyJavaType();

    /**
     * Return the type representing the key type of the map.
     * @return type representing key type
     */
    Type<K> getKeyType();
}

```

D.13. MappedSuperclassType

```

package jakarta.persistence.metamodel;

```

```

/**
 * An instance of the type {@code MappedSuperclassType} represents a
 * {@linkplain jakarta.persistence.MappedSuperclass mapped superclass}
 * type.
 *
 * @param <X> The represented mapped superclass type
 *
 * @since 2.0
 */
public interface MappedSuperclassType<X> extends IdentifiableType<X> {}

```

D.14. PluralAttribute

```

/**
 * Instances of the type {@code PluralAttribute} represent
 * persistent collection-valued attributes.
 *
 * @param <X> The type the represented collection belongs to
 * @param <C> The type of the represented collection
 * @param <E> The element type of the represented collection
 *
 * @since 2.0
 */
public interface PluralAttribute<X, C, E>
    extends Attribute<X, C>, Bindable<E> {

    enum CollectionType {

        /** Collection-valued attribute */
        COLLECTION,

        /** Set-valued attribute */
        SET,

        /** List-valued attribute */
        LIST,

        /** Map-valued attribute */
        MAP
    }

    /**
     * Return the collection type.
     * @return collection type
     */
    CollectionType getCollectionType();

    /**
     * Return the type representing the element type of the
     * collection.
     * @return element type
     */
    Type<E> getElementType();
}

```

D.15. SetAttribute

```

/**
 * Instances of the type {@code SetAttribute} represent
 * persistent {@link java.util.Set}-valued attributes.
 *
 * @param <X> The type the represented Set belongs to

```

```

* @param <E> The element type of the represented Set
*
* @since 2.0
*/
public interface SetAttribute<X, E>
    extends PluralAttribute<X, java.util.Set<E>, E> {}

```

D.16. SingularAttribute

```

package jakarta.persistence.metamodel;

/**
 * Instances of the type {@code SingularAttribute} represents persistent
 * single-valued properties or fields.
 *
 * @param <X> The type containing the represented attribute
 * @param <T> The type of the represented attribute
 *
 * @since 2.0
 */
public interface SingularAttribute<X, T>
    extends Attribute<X, T>, Bindable<T> {

    /**
     * Is the attribute an id attribute? This method returns true
     * if the attribute is a {@linkplain jakarta.persistence.Id simple
     * id}, an {@linkplain jakarta.persistence.EmbeddedId embedded id},
     * or an attribute of an {@linkplain jakarta.persistence.IdClass
     * id class}.
     * @return boolean indicating whether the attribute is an id
     */
    boolean isId();

    /**
     * Is the attribute a {@linkplain jakarta.persistence.Version
     * version} attribute?
     * @return boolean indicating whether the attribute is a
     *         version attribute
     */
    boolean isVersion();

    /**
     * Can the attribute be null?
     * @return boolean indicating whether the attribute can
     *         be null
     * @see jakarta.persistence.Basic#optional
     */
    boolean isOptional();

    /**
     * Return the type that represents the type of the attribute.
     * @return type of attribute
     */
    Type<T> getType();
}

```

D.17. Type

```

/**
 * An instance of the type {@code Type} represents a persistent
 * object or attribute type.
 *
 * @param <X> The type of the represented object or attribute

```

```

*
* @since 2.0
*/
public interface Type<X> {

    enum PersistenceType {

        /** Entity class */
        ENTITY,

        /** Embeddable class */
        EMBEDDABLE,

        /** Mapped superclass */
        MAPPED_SUPERCLASS,

        /** Basic type */
        BASIC
    }

    /**
     * Return the persistence type.
     * @return persistence type
     */
    PersistenceType getPersistenceType();

    /**
     * Return the represented Java type.
     * @return Java type
     */
    Class<X> getJavaType();
}

```


Appendix E: Persistence SPI Interfaces

The following APIs are defined in the package `jakarta.persistence.spi`.

E.1. ClassTransformer

```
import java.security.ProtectionDomain;

/**
 * A persistence provider supplies an instance of this
 * interface to the {@link PersistenceUnitInfo#addTransformer}
 * method. The supplied transformer instance will get
 * called to transform entity class files when they are
 * loaded or redefined. The transformation occurs before
 * the class is defined by the JVM.
 *
 * @since 1.0
 */
public interface ClassTransformer {

    /**
     * Invoked when a class is being loaded or redefined.
     * The implementation of this method may transform the
     * supplied class file and return a new replacement class
     * file.
     *
     * @param loader the defining loader of the class to be
     * transformed, may be null if the bootstrap loader
     * @param className the name of the class in the internal form
     * of fully qualified class and interface names
     * @param classBeingRedefined if this is a redefine, the
     * class being redefined, otherwise null
     * @param protectionDomain the protection domain of the
     * class being defined or redefined
     * @param classfileBuffer the input byte buffer in class
     * file format - must not be modified
     * @return a well-formed class file buffer (the result of
     * the transform), or null if no transform is performed
     * @throws TransformerException if the input does
     * not represent a well-formed class file
     */
    byte[] transform(ClassLoader loader,
                    String className,
                    Class<?> classBeingRedefined,
                    ProtectionDomain protectionDomain,
                    byte[] classfileBuffer)
        throws TransformerException;
}
```

E.2. LoadState

```
/**
 * Load states returned by the {@link ProviderUtil} SPI methods.
 * @since 2.0
 */
public enum LoadState {
    /** The state of the element is known to have been loaded. */
    LOADED,
    /** The state of the element is known not to have been loaded. */
    NOT_LOADED,
    /** The load state of the element cannot be determined. */
}
```

```
UNKNOWN
```

```
}
```

E.3. PersistenceProvider

```
package jakarta.persistence.spi;

import jakarta.persistence.EntityManagerFactory;
import jakarta.persistence.Persistence;
import jakarta.persistence.PersistenceConfiguration;
import jakarta.persistence.PersistenceException;
import java.util.Map;

/**
 * Interface implemented by the persistence provider.
 *
 * <p> It is invoked by the container in Jakarta EE environments and
 * by the {@link Persistence} class in Java SE environments to create
 * an {@link EntityManagerFactory} and/or to cause schema generation
 * to occur.
 *
 * @since 1.0
 */
public interface PersistenceProvider {

    /**
     * Called by {@link Persistence} class when an
     * {@link EntityManagerFactory} is to be created.
     *
     * @param emName the name of the persistence unit
     * @param map a Map of properties for use by the
     * persistence provider. These properties may be used to
     * override the values of the corresponding elements in
     * the {@code persistence.xml} file or specify values for
     * properties not specified in the {@code persistence.xml}
     * (and may be null if no properties are specified).
     * @return EntityManagerFactory for the persistence unit,
     * or null if the provider is not the right provider
     *
     * @see Persistence#createEntityManagerFactory(String, Map)
     */
    EntityManagerFactory createEntityManagerFactory(String emName, Map<?, ?> map);

    /**
     * Called by {@link Persistence} class when an
     * {@link EntityManagerFactory} is to be created.
     *
     * @param configuration the configuration of the persistence unit
     * @return EntityManagerFactory for the persistence unit,
     * or null if the provider is not the right provider
     * @throws IllegalStateException if required configuration is missing
     *
     * @see Persistence#createEntityManagerFactory(PersistenceConfiguration)
     */
    @since 3.2
    EntityManagerFactory createEntityManagerFactory(PersistenceConfiguration configuration);

    /**
     * Called by the container when an {@link EntityManagerFactory}
     * is to be created.
     *
     * @param info metadata for use by the persistence provider
     * @param map a Map of integration-level properties for use
     * by the persistence provider (may be null if no properties
```

```

* are specified). These properties may include properties to
* control schema generation. If a Bean Validation provider is
* present in the classpath, the container must pass the
* {@code ValidatorFactory} instance in the map with the key
* {@code "jakarta.persistence.validation.factory"}. If the
* containing archive is a bean archive, the container must
* pass the {@code BeanManager} instance in the map with the
* key {@code "jakarta.persistence.bean.manager"}.
* @return {@link EntityManagerFactory} for the persistence unit
* specified by the metadata
*/

```

```
EntityManagerFactory createContainerEntityManagerFactory(PersistenceUnitInfo info, Map<?, ?> map);
```

```

/**
 * Create database schemas and/or tables and/or create DDL
 * scripts as determined by the supplied properties.
 * <p>
 * Called by the container when schema generation is to
 * occur as a separate phase from creation of the entity
 * manager factory.
 * <p>
 * @param info metadata for use by the persistence provider
 * @param map properties for schema generation; these may
 *         also include provider-specific properties
 * @throws PersistenceException if insufficient or inconsistent
 *         configuration information is provided or if schema
 *         generation otherwise fails
 *
 * @since 2.1
 */

```

```
void generateSchema(PersistenceUnitInfo info, Map<?, ?> map);
```

```

/**
 * Create database schemas and/or tables and/or create DDL
 * scripts as determined by the supplied properties.
 * <p>
 * Called by the {@link Persistence} class when schema generation
 * is to occur as a separate phase from creation of the entity
 * manager factory.
 * <p>
 * @param persistenceUnitName the name of the persistence unit
 * @param map properties for schema generation; these may
 *         also contain provider-specific properties. The
 *         value of these properties override any values that
 *         may have been configured elsewhere.
 * @return true if schema was generated, otherwise false
 * @throws PersistenceException if insufficient or inconsistent
 *         configuration information is provided or if schema
 *         generation otherwise fails
 *
 * @since 2.1
 */

```

```
boolean generateSchema(String persistenceUnitName, Map<?, ?> map);
```

```

/**
 * Return the utility interface implemented by the persistence
 * provider.
 * @return an instance of {@link ProviderUtil}
 *
 * @since 2.0
 */

```

```
ProviderUtil getProviderUtil();
```

```
}
```

E.4. PersistenceProviderResolver

```
import java.util.List;

/**
 * Provides a list of {@link PersistenceProvider persistence
 * providers} available in the runtime environment.
 *
 * <p> Implementations must be thread-safe.
 *
 * <p> Note that the {@link #getPersistenceProviders} method can
 * potentially be called many times: it is recommended that the
 * implementation of this method make use of caching.
 *
 * @see PersistenceProvider
 * @since 2.0
 */
public interface PersistenceProviderResolver {

    /**
     * Returns a list of the {@link PersistenceProvider
     * persistence provider} implementations available in the
     * runtime environment.
     *
     * @return list of the persistence providers available
     *         in the environment
     */
    List<PersistenceProvider> getPersistenceProviders();

    /**
     * Clear cache of providers.
     */
    void clearCachedProviders();
}
```

E.5. PersistenceProviderResolverHolder

```
package jakarta.persistence.spi;

import java.lang.ref.ReferenceQueue;
import java.lang.ref.SoftReference;
import java.lang.ref.WeakReference;
import java.security.AccessController;
import java.security.PrivilegedAction;
import java.util.ArrayList;
import java.util.List;
import java.util.HashMap;
import java.util.Iterator;
import java.util.ServiceConfigurationError;
import java.util.ServiceLoader;
import java.util.logging.Level;
import java.util.logging.Logger;

/**
 * Holds the global {@link PersistenceProviderResolver} instance.
 * If no {@code PersistenceProviderResolver} is set by the environment,
 * the default {@code PersistenceProviderResolver} is used.
 *
 * <p>Enable {@code "jakarta.persistence.spi"} logger to show diagnostic
 * information.
 *
 * <p>Implementations must be thread-safe.
 */
```

```

* @since 2.0
*/
public class PersistenceProviderResolverHolder {

    private static PersistenceProviderResolver singleton = new DefaultPersistenceProviderResolver();

    /**
     * Returns the current persistence provider resolver.
     *
     * @return the current persistence provider resolver
     */
    public static PersistenceProviderResolver getPersistenceProviderResolver() {
        return singleton;
    }

    /**
     * Defines the persistence provider resolver used.
     *
     * @param resolver persistence provider resolver to be used.
     */
    public static void setPersistenceProviderResolver(PersistenceProviderResolver resolver) {
        if (resolver == null) {
            singleton = new DefaultPersistenceProviderResolver();
        } else {
            singleton = resolver;
        }
    }

    /**
     * Default provider resolver class to use when none is explicitly set.
     *
     * <p>Uses service loading mechanism as described in the Jakarta Persistence
     * specification. A ServiceLoader.load() call is made with the current context
     * classloader to find the service provider files on the classpath.
     */
    private static class DefaultPersistenceProviderResolver implements PersistenceProviderResolver {

        /**
         * Cached list of available providers cached by CacheKey to ensure
         * there is not potential for provider visibility issues.
         */
        private volatile HashMap<CacheKey, PersistenceProviderReference> providers = new HashMap<CacheKey,
PersistenceProviderReference>();

        /**
         * Queue for reference objects referring to class loaders or persistence providers.
         */
        private static final ReferenceQueue referenceQueue = new ReferenceQueue();

        public List<PersistenceProvider> getPersistenceProviders() {
            // Before we do the real loading work, see whether we need to
            // do some cleanup: If references to class loaders or
            // persistence providers have been nulled out, remove all related
            // information from the cache.
            processQueue();

            ClassLoader loader = getContextClassLoader();
            CacheKey cacheKey = new CacheKey(loader);
            PersistenceProviderReference providersReferent = this.providers.get(cacheKey);
            List<PersistenceProvider> loadedProviders = null;

            if (providersReferent != null) {
                loadedProviders = providersReferent.get();
            }

            if (loadedProviders == null) {
                loadedProviders = new ArrayList<>();
            }
        }
    }
}

```

```

());

    Iterator<PersistenceProvider> ipp = ServiceLoader.load(PersistenceProvider.class, loader).iterator
    try {
        while (ipp.hasNext()) {
            try {
                PersistenceProvider pp = ipp.next();
                loadedProviders.add(pp);
            } catch (ServiceConfigurationError sce) {
                log(Level.FINEST, sce.toString());
            }
        }
    } catch (ServiceConfigurationError sce) {
        log(Level.FINEST, sce.toString());
    }

    // If none are found we'll log the provider names for diagnostic
    // purposes.
    if (loadedProviders.isEmpty()) {
        log(Level.WARNING, "No valid providers found.");
    }

    providersReferent = new PersistenceProviderReference(loadedProviders, referenceQueue, cacheKey);

    this.providers.put(cacheKey, providersReferent);
}

return loadedProviders;
}

/**
 * Remove garbage collected cache keys & providers.
 */
private void processQueue() {
    CacheKeyReference ref;
    while ((ref = (CacheKeyReference) referenceQueue.poll()) != null) {
        providers.remove(ref.getCacheKey());
    }
}

/**
 * Wraps {@code Thread.currentThread().getContextClassLoader()} into a
 * doPrivileged block if security manager is present
 */
private static ClassLoader getContextClassLoader() {
    if (System.getSecurityManager() == null) {
        return Thread.currentThread().getContextClassLoader();
    } else {
        return AccessController.doPrivileged(new PrivilegedAction<ClassLoader>() {
            public ClassLoader run() {
                return Thread.currentThread().getContextClassLoader();
            }
        });
    }
}

private static final String LOGGER_SUBSYSTEM = "jakarta.persistence.spi";

private Logger logger;

private void log(Level level, String message) {
    if (this.logger == null) {
        this.logger = Logger.getLogger(LOGGER_SUBSYSTEM);
    }
    this.logger.log(level, LOGGER_SUBSYSTEM + ":@" + message);
}

/**

```

```

    * Clear all cached providers
    */
    public void clearCachedProviders() {
        this.providers.clear();
    }

    /**
     * The common interface to get a CacheKey implemented by
     * LoaderReference and PersistenceProviderReference.
     */
    private interface CacheKeyReference {
        CacheKey getCacheKey();
    }

    /**
     * Key used for cached persistence providers. The key checks
     * the class loader to determine if the persistence providers
     * is a match to the requested one. The loader may be null.
     */
    private class CacheKey implements Cloneable {

        /* Weak Reference to ClassLoader */
        private LoaderReference loaderRef;

        /* Cached Hashcode */
        private int hashCodeCache;

        CacheKey(ClassLoader loader) {
            if (loader == null) {
                this.loaderRef = null;
            } else {
                loaderRef = new LoaderReference(loader, referenceQueue, this);
            }
            calculateHashCode();
        }

        ClassLoader getLoader() {
            return (loaderRef != null) ? loaderRef.get() : null;
        }

        public boolean equals(Object other) {
            if (this == other) {
                return true;
            }
            try {
                final CacheKey otherEntry = (CacheKey) other;
                // quick check to see if they are not equal
                if (hashCodeCache != otherEntry.hashCodeCache) {
                    return false;
                }
                // are refs (both non-null) or (both null)?
                if (loaderRef == null) {
                    return otherEntry.loaderRef == null;
                }
                ClassLoader loader = loaderRef.get();
                return (otherEntry.loaderRef != null)
                    // with a null reference we can no longer find
                    // out which class loader was referenced; so
                    // treat it as unequal
                    && (loader != null) && (loader == otherEntry.loaderRef.get());
            } catch (NullPointerException e) {
            } catch (ClassCastException e) {
            }

            return false;
        }
    }
}

```

```

public int hashCode() {
    return hashCodeCache;
}

private void calculateHashCode() {
    ClassLoader loader = getLoader();
    if (loader != null) {
        hashCodeCache = loader.hashCode();
    }
}

public Object clone() {
    try {
        CacheKey clone = (CacheKey) super.clone();
        if (loaderRef != null) {
            clone.loaderRef = new LoaderReference(loaderRef.get(), referenceQueue, clone);
        }
        return clone;
    } catch (CloneNotSupportedException e) {
        // this should never happen
        throw new InternalError();
    }
}

public String toString() {
    return "CacheKey[" + getLoader() + "]";
}
}

/**
 * References to class loaders are weak references, so that they can be
 * garbage collected when nobody else is using them. The DefaultPersistenceProviderResolver
 * class has no reason to keep class loaders alive.
 */
private class LoaderReference extends WeakReference<ClassLoader>
    implements CacheKeyReference {
    private CacheKey cacheKey;

    @SuppressWarnings("unchecked")
    LoaderReference(ClassLoader referent, ReferenceQueue q, CacheKey key) {
        super(referent, q);
        cacheKey = key;
    }

    public CacheKey getCacheKey() {
        return cacheKey;
    }
}

/**
 * References to persistence provider are soft references so that they can be garbage
 * collected when they have no hard references.
 */
private class PersistenceProviderReference extends SoftReference<List<PersistenceProvider>>
    implements CacheKeyReference {
    private CacheKey cacheKey;

    @SuppressWarnings("unchecked")
    PersistenceProviderReference(List<PersistenceProvider> referent, ReferenceQueue q, CacheKey key) {
        super(referent, q);
        cacheKey = key;
    }

    public CacheKey getCacheKey() {
        return cacheKey;
    }
}

```



```

    }
}

```

E.6. PersistenceUnitInfo

```

package jakarta.persistence.spi;

import javax.sql.DataSource;
import java.util.List;
import java.util.Properties;
import java.net.URL;
import jakarta.persistence.SharedCacheMode;
import jakarta.persistence.ValidationMode;
import jakarta.persistence.EntityManagerFactory;

/**
 * Interface implemented by the container and used by the persistence
 * provider when creating an {@link EntityManagerFactory}.
 *
 * @since 1.0
 */
public interface PersistenceUnitInfo {

    /**
     * Returns the name of the persistence unit. Corresponds to the
     * {@code name} attribute in the {@code persistence.xml} file.
     * @return the name of the persistence unit
     */
    String getPersistenceUnitName();

    /**
     * Returns the fully qualified name of the persistence provider
     * implementation class. Corresponds to the {@code provider} element
     * in the {@code persistence.xml} file.
     * @return the fully qualified name of the persistence provider
     * implementation class
     */
    String getPersistenceProviderClassName();

    /**
     * Returns the fully-qualified class name of an annotation annotated
     * {@code Scope} or {@code NormalScope}. Corresponds to the {@code scope}
     * element in {@code persistence.xml}.
     * @return the fully-qualified class name of the scope annotation,
     * or null if no scope was explicitly specified
     */
    public String getScopeAnnotationName();

    /**
     * Returns the fully-qualified class names of annotations annotated
     * {@code Qualifier}. Corresponds to the {@code qualifier} element in
     * {@code persistence.xml}.
     * @return the fully-qualified class names of the qualifier annotations,
     * or an empty list if no qualifier annotations were explicitly
     * specified
     */
    public List<String> getQualifierAnnotationNames();

    /**
     * Returns the transaction type of the entity managers created by
     * the {@link EntityManagerFactory}. The transaction type corresponds
     * to the {@code transaction-type} attribute in the {@code persistence.xml}
     * file.
     * @return transaction type of the entity managers created
     */
}

```

```

    * by the EntityManagerFactory
    *
    * <p>Note: This method will change its return type to {@link
jakarta.persistence.PersistenceUnitTransactionType}
    * in the next major version.
    */
    PersistenceUnitTransactionType getTransactionType();

/**
 * Returns the JTA-enabled data source to be used by the
 * persistence provider. The data source corresponds to the
 * {@code jta-data-source} element in the {@code persistence.xml}
 * file or is provided at deployment or by the container.
 * @return the JTA-enabled data source to be used by the
 * persistence provider
 */
    DataSource getJtaDataSource();

/**
 * Returns the non-JTA-enabled data source to be used by the
 * persistence provider for accessing data outside a JTA
 * transaction. The data source corresponds to the named
 * {@code non-jta-data-source} element in the {@code persistence.xml}
 * file or provided at deployment or by the container.
 * @return the non-JTA-enabled data source to be used by the
 * persistence provider for accessing data outside a JTA
 * transaction
 */
    DataSource getNonJtaDataSource();

/**
 * Returns the list of the names of the mapping files that the
 * persistence provider must load to determine the mappings for
 * the entity classes. The mapping files must be in the standard
 * XML mapping format, be uniquely named and be resource-loadable
 * from the application classpath. Each mapping file name
 * corresponds to a {@code mapping-file} element in the
 * {@code persistence.xml} file.
 * @return the list of mapping file names that the persistence
 * provider must load to determine the mappings for the entity
 * classes
 */
    List<String> getMappingFileNames();

/**
 * Returns a list of URLs for the jar files or exploded jar
 * file directories that the persistence provider must examine
 * for managed classes of the persistence unit. Each URL
 * corresponds to a {@code jar-file} element in the
 * {@code persistence.xml} file. A URL will either be a
 * file: URL referring to a jar file or referring to a directory
 * that contains an exploded jar file, or some other URL from
 * which an InputStream in jar format can be obtained.
 * @return a list of URL objects referring to jar files or
 * directories
 */
    List<URL> getJarFileUrls();

/**
 * Returns the URL for the jar file or directory that is the
 * root of the persistence unit. (If the persistence unit is
 * rooted in the WEB-INF/classes directory, this is the URL
 * of that directory.)
 * The URL will either be a file: URL referring to a jar file
 * or referring to a directory that contains an exploded jar
 * file, or some other URL from which an InputStream in jar
 * format can be obtained.

```

```

    * @return a URL referring to a jar file or directory
    */
    URL getPersistenceUnitRootUrl();

    /**
     * Returns the list of the names of the classes that the
     * persistence provider must add to its set of managed
     * classes. Each name corresponds to a named {@code class} element in the
     * {@code persistence.xml} file.
     * @return the list of the names of the classes that the
     * persistence provider must add to its set of managed
     * classes
     */
    List<String> getManagedClassNames();

    /**
     * Returns whether classes in the root of the persistence unit
     * that have not been explicitly listed are to be included in the
     * set of managed classes. This value corresponds to the
     * {@code exclude-unlisted-classes} element in the
     * {@code persistence.xml} file.
     * @return whether classes in the root of the persistence
     * unit that have not been explicitly listed are to be
     * included in the set of managed classes
     */
    boolean excludeUnlistedClasses();

    /**
     * Returns the specification of how the provider must use
     * a second-level cache for the persistence unit.
     * The result of this method corresponds to the {@code shared-cache-mode}
     * element in the {@code persistence.xml} file.
     * @return the second-level cache mode that must be used by the
     * provider for the persistence unit
     *
     * @since 2.0
     */
    SharedCacheMode getSharedCacheMode();

    /**
     * Returns the validation mode to be used by the persistence
     * provider for the persistence unit. The validation mode
     * corresponds to the {@code validation-mode} element in the
     * {@code persistence.xml} file.
     * @return the validation mode to be used by the
     * persistence provider for the persistence unit
     *
     * @since 2.0
     */
    ValidationMode getValidationMode();

    /**
     * Returns a properties object. Each property corresponds to a
     * {@code property} element in the {@code persistence.xml} file
     * or to a property set by the container.
     * @return Properties object
     */
    Properties getProperties();

    /**
     * Returns the schema version of the {@code persistence.xml} file.
     * @return {@code persistence.xml} schema version
     *
     * @since 2.0
     */
    String getPersistenceXMLSchemaVersion();

```

```

/**
 * Returns ClassLoader that the provider may use to load any
 * classes, resources, or open URLs.
 * @return ClassLoader that the provider may use to load any
 * classes, resources, or open URLs
 */
ClassLoader getClassLoader();

/**
 * Add a transformer supplied by the provider that is called for
 * every new class definition or class redefinition that gets
 * loaded by the loader returned by the
 * {@link PersistenceUnitInfo#getClassLoader} method. The
 * transformer has no effect on the result returned by the
 * {@link PersistenceUnitInfo#getNewTempClassLoader} method.
 * Classes are only transformed once within the same classloading
 * scope, regardless of how many persistence units they may be
 * a part of.
 * @param transformer provider-supplied transformer that the
 * container invokes at class-(re)definition time
 */
void addTransformer(ClassTransformer transformer);

/**
 * Return a new instance of a {@link ClassLoader} that the provider
 * may use to temporarily load any classes, resources, or open
 * URLs. The scope and classpath of this loader is exactly the
 * same as that of the loader returned by {@link
 * PersistenceUnitInfo#getClassLoader}. None of the classes loaded
 * by this class loader are visible to application components. The
 * provider may only use this {@code ClassLoader} within the scope
 * of the {@link PersistenceProvider#createContainerEntityManagerFactory}
 * call.
 * @return temporary {@code ClassLoader} with same visibility as
 * current loader
 */
ClassLoader getNewTempClassLoader();
}

```

E.7. ProviderUtil

```

import jakarta.persistence.FetchType;

/**
 * Utility interface implemented by the persistence provider. This
 * interface is invoked by the {@link jakarta.persistence.PersistenceUtil}
 * implementation to determine the load status of an entity or entity
 * attribute.
 *
 * @since 2.0
 */
public interface ProviderUtil {

    /**
     * If the provider determines that the entity has been provided by
     * itself and that the state of the specified attribute has been loaded,
     * this method returns {@link LoadState#LOADED}.
     * <p> If the provider determines that the entity has been provided
     * by itself and that either entity attributes with {@link FetchType#EAGER}
     * have not been loaded or that the state of the specified attribute has
     * not been loaded, this method returns {@link LoadState#NOT_LOADED}.
     * <p> If a provider cannot determine the load state, this method
     * returns {@link LoadState#UNKNOWN}.
     * <p> The provider's implementation of this method must not obtain a
     * reference to an attribute value, as this could trigger the loading

```

```

* of entity state if the entity has been provided by a different
* provider.
* @param entity entity instance
* @param attributeName name of attribute whose load status is
*     to be determined
* @return load status of the attribute
*/
LoadState isLoadingWithoutReference(Object entity, String attributeName);

/**
* If the provider determines that the entity has been provided by
* itself and that the state of the specified attribute has been loaded,
* this method returns {@link LoadState#LOADED}.
* <p> If a provider determines that the entity has been provided by
* itself and that either the entity attributes with {@link FetchType#EAGER}
* have not been loaded or that the state of the specified attribute has
* not been loaded, this method returns {@link LoadState#NOT_LOADED}.
* <p> If the provider cannot determine the load state, this method
* returns {@link LoadState#UNKNOWN}.
* <p> The provider's implementation of this method is permitted to
* obtain a reference to the attribute value. (This access is safe
* because providers which might trigger the loading of the attribute
* state will have already been determined by
* {@link #isLoadingWithoutReference}.)
*
* @param entity entity instance
* @param attributeName name of attribute whose load status is
*     to be determined
* @return load status of the attribute
*/
LoadState isLoadingWithReference(Object entity, String attributeName);

/**
* If the provider determines that the entity has been provided by
* itself and that the state of all attributes for which
* {@link FetchType#EAGER} has been specified have been loaded, this
* method returns {@link LoadState#LOADED}.
* <p> If the provider determines that the entity has been provided
* by itself and that not all attributes with {@link FetchType#EAGER}
* have been loaded, this method returns {@link LoadState#NOT_LOADED}.
* <p> If the provider cannot determine if the entity has been
* provided by itself, this method returns {@link LoadState#UNKNOWN}.
* <p> The provider's implementation of this method must not obtain
* a reference to any attribute value, as this could trigger the
* loading of entity state if the entity has been provided by a
* different provider.
* @param entity whose loaded status is to be determined
* @return load status of the entity
*/
LoadState isLoading(Object entity);
}

```