JPA Mapping Guide (v5.0)

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To implement a persistence layer with JPA you firstly need to map the classes and fields/properties that are involved in the persistence process. This can be as simple as marking the classes as an @Entity, or you can configure down to the fine detail of precisely what schema it maps on to. The following sections deal with the many options available. This guide takes you through the many metadata options.

When mapping a class for JPA you can make use of *metadata*. This *metadata* can be Java annotations, or can be XML metadata, or a mixture of both. This is very much down to your own personal preference but we try to present both ways here.

We advise trying to keep schema information out of annotations, so that you avoid tying compiled code to a specific datastore. That way you retain datastore-independence. This may not be a concern for your project however.

Whilst the JPA spec only allows you to specify your mapping information using JPA metadata (annotations, or `orm.xml`), DataNucleus JPA also allows you the option of using JDO metadata (annotations or JDO XML metadata). This is provided as a way of easily migrating across to JPA from JDO, for example. Consult the DataNucleus JDO mappings docs for details.

Classes

We have the following types of classes in DataNucleus JPA.

- Entity - persistable class with full control over its persistence.
- MappedSuperclass - persistable class that will not be persisted into its own table simply providing some fields to be persisted. Consequently an inheritance tree cannot just have a mapped superclass on its own.
- Embeddable - persistable class that is only persistable embedded into an entity class.
- PersistenceAware - a class that is not itself persisted, but that needs to access internals of persistable classes. **This is a DataNucleus extension, not part of the JPA standard**.

In strict JPA all persistable classes need to have a *default constructor*. With DataNucleus JPA this is not necessary, since all classes are enhanced before persistence and the enhancer adds on a default constructor if one is not defined.

Entity Class

Let's take a sample class (*Hotel*) as an example. We can define a class as persistable using either annotations in the class, or XML metadata. Using annotations

```
@Entity
public class Hotel
{
    ...
}
```

or using XML metadata

```
<entity class="org.datanucleus.test.Hotel">
    ...
</entity>
```

MappedSuperclass

Say we have an abstract base class *Building* with concrete subclass *Hotel* (as above). We want to persist some fields of *Building*, but it is abstract so will not have any objects of that type. So we make the class a *MappedSuperclass*, like this

```
@MappedSuperclass
public abstract class Building
{
    ...
}
```

or using XML metadata

```
<mapped-superclass class="org.datanucleus.test.Building">
    ...
</mapped-superclass>
```

This is of particular relevance when considering inheritance.

Embeddable Class

Here we have a class *ConstructionDetails* that we never need to persist individually, and it will only ever be persisted as part of an owner object (in this case *Building*). Since information from objects of this class will be persisted, we need to mark the class as *Embeddable*, like this

```
@Embeddable
public class ConstructionDetails
{
    ...
}
```

or using XML metadata

```
<embeddable class="org.datanucleus.test.ConstructionDetails">
    ...
</embeddable>
```

and hereafter we can persist fields of type *ConstructionDetails*, as per the Embedded Object guide.

Persistence Aware Class

With JPA you cannot access *public* fields of classes. DataNucleus allows an extension to permit this, but such classes need special enhancement. To allow this you need to annotate the class that will access these public fields (assuming it isn't an Entity) with the DataNucleus extension annotation @PersistenceAware, as follows

```
@PersistenceAware
public class MyClassThatAccessesPublicFields
{
    ...
}
```

See also :-

- Annotations reference for @PersistenceAware

Read-Only Class

You can, if you wish, make a class *read-only*. This is a DataNucleus extension and you set it as follows

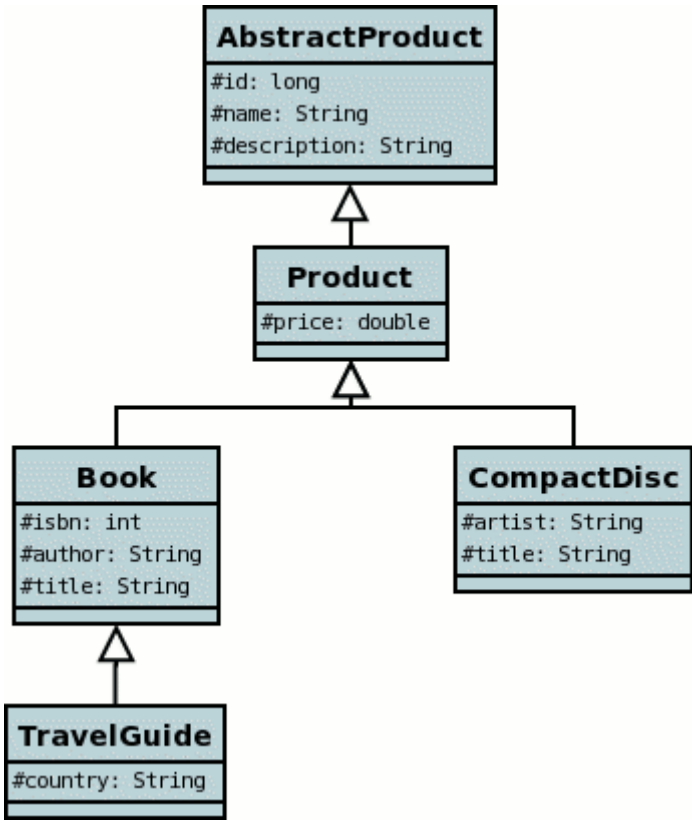
```
@Entity
@Extension(key="read-only", value="true")
public class MyClass
{
    ...
}
```

Inheritance

In Java it is a normal situation to have inheritance between classes. With JPA you have choices to make as to how you want to persist your classes for the inheritance tree. For each inheritance tree (for the root class) you select how you want to persist those classes information. You have the following choices.

- The *default strategy* is to select a class to have its fields persisted in the table of the base class. There is only one table per inheritance hierarchy. In JPA this is known as SINGLE_TABLE
- The next way is to have a table for each class in the inheritance hierarchy, and for each table to only hold columns for the fields of that class. Fields of superclasses are persisted into the table of the superclass. Consequently to get all field values for a subclass object a join is made of all tables of superclasses. In JPA this is referred to as JOINED
- The third way is like *JOINED* except that each table will also contain columns for all inherited fields. In JPA this is referred to as TABLE_PER_CLASS

In order to demonstrate the various inheritance strategies we need an example. Here are a few simple classes representing products in a (online) store. We have an abstract base class, extending this to provide something that we can represent any product by. We then provide a few specialisations for typical products. We will use these classes later when defining how to persistent these objects in the different inheritance strategies



As mentioned, the default JPA strategy is "SINGLE_TABLE", namely that the base class will have a table and all subclasses will be persisted into that same table. So if you don't specify an "inheritance strategy" in your root class this is what you will get.

You must specify the identity of objects in the root persistable class of the inheritance hierarchy. You cannot redefine it down the inheritance tree

See also:-

- MetaData reference for <inheritance> element
- MetaData reference for <discriminator-column> element
- Annotations reference for @Inheritance
- Annotations reference for @DiscriminatorColumn

Discriminator

Applicable to RDBMS, HBase, MongoDB

A *discriminator* is an extra "column" stored alongside data to identify the class of which that information is part. It is useful when storing objects which have inheritance to provide a quick way of determining the object type on retrieval. A discriminator in JPA will store the specified value (or the class name if you provide no value). You specify a discriminator as follows

```
<entity name="mydomain.Product">
    <discriminator-column name="OBJECT" discriminator-type="STRING"/>
    <discriminator-value>MyClass</discriminator-value>
    ...
```

or with annotations

```
@Entity
@DiscriminatorColumn(name="OBJECT_TYPE", discriminatorType=DiscriminatorType.STRING)
@DiscriminatorValue("MyClass")
public class Product {...}
```

Strategy : SINGLE_TABLE

Applicable to RDBMS

"SINGLE_TABLE" strategy is where the root class has a table and all subclasses are also persisted into that table. This corresponds to JDOs "new-table" for the root class and "superclass-table" for all subclasses. This has the advantage that retrieval of an object is a single DB call to a single table. It also has the disadvantage that the single table can have a very large number of columns, and database readability and performance can suffer, and additionally that a discriminator column is required.

When using SINGLE-TABLE DataNucleus will always use a discriminator (default column name is DTYPE).

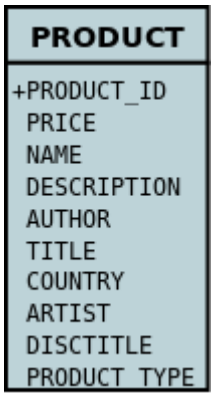
In our example, lets ignore the **AbstractProduct** class for a moment and assume that **Product** is the base class (with the "id"). We have no real interest in having separate tables for the **Book** and **CompactDisc** classes and want everything stored in a single table *PRODUCT*. We change our MetaData as follows

```
<entity name="Product">
    <inheritance strategy="SINGLE_TABLE"/>
    <discriminator-value>PRODUCT</discriminator-value>
    <discriminator-column name="PRODUCT_TYPE" discriminator-type="STRING"/>
    <attributes>
        <id name="id">
            <column name="PRODUCT_ID"/>
        </id>
        ...
    </attributes>
</entity>
<entity name="Book">
    <discriminator-value>BOOK</discriminator-value>
     ...
</entity>
<entity name="TravelGuide">
    <discriminator-value>TRAVELGUIDE</discriminator-value>
    ...
</entity>
<entity name="CompactDisc">
    <discriminator-value>COMPACTDISC</discriminator-value>
    ...
</entity>
```

or using annotations

```
@Entity
@Inheritance(strategy=InheritanceType.SINGLE_TABLE)
@DiscriminatorValue("PRODUCT")
@DiscriminatorColumn(name="PRODUCT_TYPE", discriminatorType=DiscriminatorType.STRING)
public class Product {...}

@Entity
@DiscriminatorValue("BOOK")
public class Book {...}

@Entity
@DiscriminatorValue("TRAVELGUIDE")
public class TravelGuide {...}

@Entity
@DiscriminatorValue("COMPACTDISC")
public class CompactDisc {...}
```

This change of use of the **inheritance** element has the effect of using the PRODUCT table for all classes, containing the fields of **Product**, **Book**, **CompactDisc**, and **TravelGuide**. You will also note that we used a /discriminator-column_ element for the **Product** class. The specification above will result in an extra column (called PRODUCT_TYPE) being added to the PRODUCT table, and containing the "discriminator-value" of the object stored. So for a Book it will have "BOOK" in that column for example. This column is used in discriminating which row in the database is of which type. The final thing to note is that in our classes **Book** and **CompactDisc** we have a field that is identically named. With **CompactDisc** we have defined that its column will be called DISCTITLE since both of these fields will be persisted into the same table and would have had identical names otherwise - this gets around the problem.



In the above example, when we insert a TravelGuide object into the datastore, a row will be inserted into the PRODUCT table only.

Strategy : JOINED

Applicable to RDBMS

"JOINED" strategy means that each entity in the inheritance hierarchy has its own table and that the

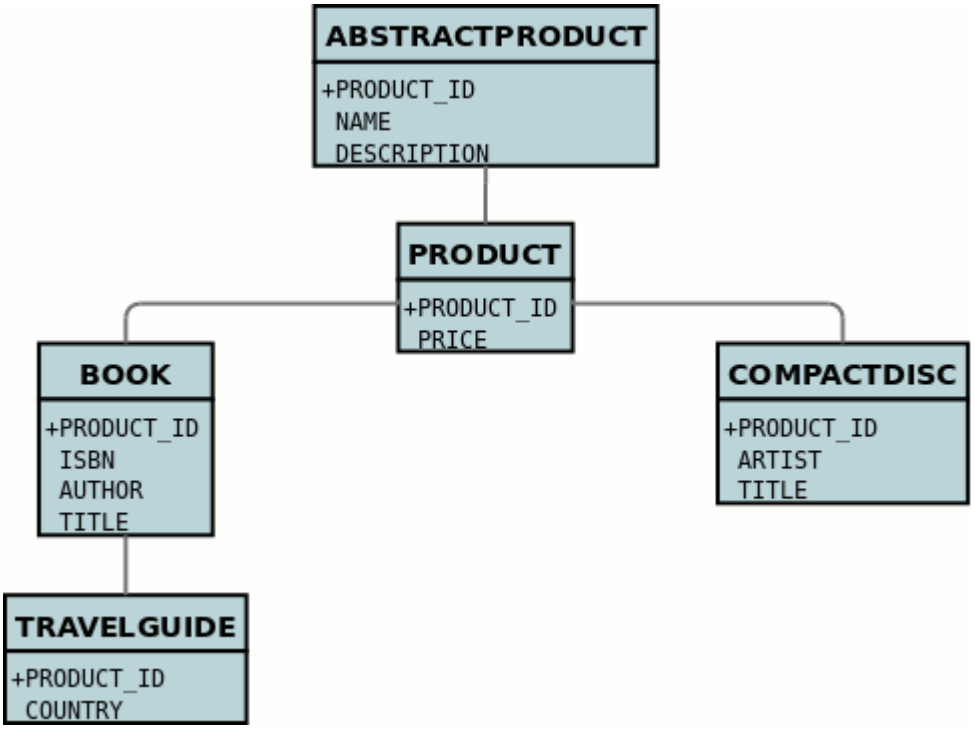
table of each class only contains columns for that class. Inherited fields are persisted into the tables of the superclass(es). This corresponds to JDOs "new-table" (for all classes in the inheritance hierarchy). This has the advantage of being the most normalised data definition. It also has the disadvantage of being slower in performance since multiple tables will need to be accessed to retrieve an object of a sub-type. Let's try an example using the simplest to understand strategy **JOINED**. We have the classes defined above, and we want to persist our classes each in their own table. We define the Meta-Data for our classes like this</p>

```
<entity class="AbstractProduct">
    <inheritance strategy="JOINED"/>
    <attributes>
        <id name="id">
            <column name="PRODUCT_ID"/>
        </id>
        ...
    </attributes>
</entity>
<entity class="Product">
    ...
</entity>
<entity class="Book">
    ...
</entity>
<entity class="TravelGuide">
    ...
</entity>
<entity class="CompactDisc">
    ...
</entity>
```

or using annotations

```
@Entity
@Inheritance(strategy=InheritanceType.JOINED)
public class Product {...}
```

So we will have 5 tables - ABSTRACTPRODUCT, PRODUCT, BOOK, COMPACTDISC, and TRAVELGUIDE. They each contain just the fields for that class (and not any inherited fields, except the identity to join with).



In the above example, when we insert a TravelGuide object into the datastore, a row will be inserted into ABSTRACTPRODUCT, PRODUCT, BOOK, and TRAVELGUIDE.

Strategy : TABLE_PER_CLASS

Applicable to all datastores

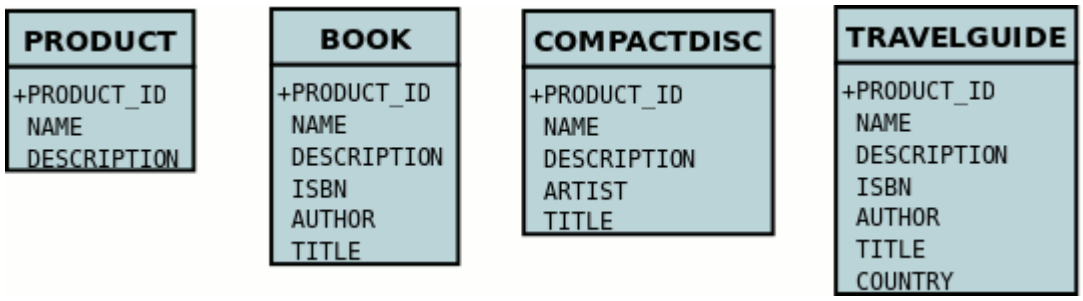
This strategy is like "JOINED" except that in addition to each class having its own table, the table also holds columns for all inherited fields. So taking the same classes as used above

```
<entity class="AbstractProduct">
    <inheritance strategy="TABLE_PER_CLASS"/>
    <attributes>
        <id name="id">
            <column name="PRODUCT_ID"/>
        </id>
        ...
    </attributes>
</entity>
<entity class="Product">
    ...
</entity>
<entity class="Book">
    ...
</entity>
<entity class="TravelGuide">
    ...
</entity>
<entity class="CompactDisc">
    ...
</entity>
```

or using annotations

```
@Entity
@Inheritance(strategy=InheritanceType.TABLE_PER_CLASS)
public class Product {...}
```

This then implies a datastore schema as follows



So any object of explicit type **Book** is persisted into the table BOOK. Similarly any **TravelGuide** is persisted into the table TRAVELGUIDE, etc. In addition if any class in the inheritance tree is abstract then it won't have a table since there cannot be any instances of that type. **DataNucleus currently has limitations when using a class using this inheritance as the element of a collection.**

Mapped Superclasses

JPA defines entities called "mapped superclasses" for the situation where you dont persist an actual object of a superclass type but that all subclasses of that type that are entities will also persist the values for the fields of the "mapped superclass". That is a "mapped superclass" has no table to store

its objects in a datastore. Instead its fields are stored in the tables of its subclasses. Let's take an example

```
<mapped-superclass class="AbstractProduct">
    <attributes>
        <id name="id">
            <column name="PRODUCT_ID"/>
        </id>
        ...
    </attributes>
</mapped-superclass>

<entity class="Product">
    ...
</entity>
```

In this case we will have a table for **Product** and the fields of **AbstractProduct** will be stored in this table. If the mapping information (column names etc) for these fields need setting then you should use <attribute-override> in the MetaData for **Product**.

Auditing

Applicable to RDBMS

With standard JPA you have no annotations available to automativelly add timestamps into the datastore against each record when it is persisted or updated. Whilst you can do this manually, setting the field(s) in prePersist callbacks etc, DataNucleus provides some simple annotations to make it simpler still.

```
import org.datanucleus.api.jpa.annotations.CreateTimestamp;
import org.datanucleus.api.jpa.annotations.UpdateTimestamp;

@Entity
public class Hotel
{
    @Id
    long id;

    @CreateTimestamp
    Timestamp createTimestamp;

    @UpdateTimestamp
    Timestamp updateTimestamp;

    ...
}
```

In the above example we have 2 fields in the class that will have columns in the datastore. The field *createTimestamp* will be persisted at INSERT with the Timestamp of the insert. The field *updateTimestamp* will be persisted whenever any update is made to the object in the datastore, with the Timestamp of the update.

Fields/Properties

Once we have defined a class to be persistable (as either *Entity*, *MappedSuperclass*, or *Embedded*), we need to define how to persist the different fields/properties that are to be persisted. There are two distinct modes of persistence definition; the most common uses **fields**, whereas an alternative uses **properties**.

Persistent Fields

The most common form of persistence is where you have a **field** in a class and want to persist it to the datastore. With this mode of operation DataNucleus will persist the values stored in the fields into the datastore, and will set the values of the fields when extracting it from the datastore.

Requirement : you have a field in the class. This can be public, protected, private or package access, but cannot be static or final.

An example of how to define the persistence of a field is shown below

```
@Entity
public class MyClass
{
    @Basic
    Date birthday;

    @Transient
    String someOtherField;
}
```

So, using annotations, we have marked this class as persistent, and the field *birthday* also as persistent, whereas field *someOtherField* is not persisted. Using XML MetaData we would have done

```
<entity name="mydomain.MyClass">
    <attributes>
        <basic name="birthday"/>
        <transient name="someOtherField"/>
    </attributes>
</entity>
```

Please note that the field Java type defines whether it is, by default, persistable.

Persistent Properties

A second mode of operation is where you have Java Bean-style getter/setter for a **property**. In this situation you want to persist the output from *getXXX* to the datastore, and use the *setXXX* to load up the value into the object when extracting it from the datastore.

Requirement : you have a property in the class with Java Bean getter/setter methods. These methods can be public, protected, private or package access, but cannot be static. The class must have BOTH getter AND setter methods.

An example of how to define the persistence of a property is shown below

```
@Entity
public class MyClass
{
    @Basic
    Date getBirthday()
    {
        ...
    }

    void setBirthday(Date date)
    {
        ...
    }
}
```

So, using annotations, we have marked this class as persistent, and the getter is marked as persistent. By default a property is non-persistent, so we have no need in specifying the *someOtherField* as transient. Using XML MetaData we would have done

```
<entity name="mydomain.MyClass">
    <attributes>
        <basic name="birthday"/>
    </attributes>
</entity>
```

Making a field/property non-persistent

If you have a field/property that you don't want to persist, just mark it as *transient*, like this

```
    @Transient
    String unimportantField;
```

Field/Property Positioning

With some datastores (notably spreadsheets) it is desirable to be able to specify the relative position of a column. The default (for DataNucleus) is just to put them in ascending alphabetical order. JPA doesn't allow configuration of this, but DataNucleus provides the following vendor extension. It is

currently only possible using (DataNucleus) annotations

```
@Entity
@Table(name="People")
public class Person
{
    @Id
    @ColumnPosition(0)
    long personNum;

    @ColumnPosition(1)
    String firstName;

    @ColumnPosition(2)
    String lastName;
}
```

Making a field/property read-only

If you want to make a member read-only you can do it like this.

```
<entity name="mydomain.MyClass">
    <attributes>
        <basic name="myField">
            <column insertable="false" updatable="false"/>
        </basic>
    </attributes>
</entity>
```

or with Annotations

```
import org.datanucleus.api.jdo.annotations.ReadOnly;

@Entity
public class MyClass
{
    @ReadOnly
    String myField;

}
```

Field Types

When persisting a class, a persistence solution needs to know how to persist the types of each field in the class. Clearly a persistence solution can only support a finite number of Java types; it cannot know how to persist every possible type creatable. The JPA specification define lists of types that are required to be supported by all implementations of those specifications. This support can be conveniently split into two parts

- **Primary Types** : An object that can be *referred to* (object reference, providing a relation) and that has an "identity" is termed a **primary type**. DataNucleus supports the following Java types as primary : any *Entity* that has its own identity, *interface* where it represents an *Entity*, or **java.lang.Object** where it represents an *Entity*.
- **Secondary Types** : An object that does not have an "identity" is termed a **secondary type**. This is something like a String or Date field in a class, or alternatively a Collection (that contains other objects), or an embedded *Entity*. The sections below shows the currently supported secondary java types in DataNucleus. The tables in these sections show
  - **EAGER** : whether the field is retrieved by default when retrieving the object itself.
  - **Proxy** : whether the field is represented by a "proxy" that intercepts any operations to detect whether it has changed internally (such as Collection, Map).
  - **PK** : whether the field can be used as part of the primary-key

With DataNucleus, all types that we have a way of persisting (i.e listed below) are default persistent (meaning that you don't need to annotate them in any way to persist them). The only field types where this is not always true is for java.lang.Object, some Serializable types, array of persistables, and java.io.File so always safer to mark those as persistent.

If you have support for any additional types and would either like to contribute them, or have them listed here, let us know. Supporting a new type is easy, typically involving a JPA AttributeConverter if you can easily convert the type into a String or Long. See also the Java Types plugin-point. You can also define more specific support for it with RDBMS datastores - the RDBMS Java Types plugin-point

Handling of second-class types uses wrappers and bytecode enhancement with DataNucleus. This contrasts to what Hibernate uses (proxies), and what Hibernate imposes on you.

Primitive and java.lang Types

All primitive types and wrappers are supported and will be persisted into a single database "column". Arrays of these are also supported, and can either be serialised into a single column, or persisted into a join table (dependent on datastore).

Java Type	EAGER?	Proxy?	PK?	Comments
boolean	✔	✖	✔	Persisted as **BOOLEAN**, Integer (i.e 1,0), String (i.e 'Y','N').
byte	✔	✖	✔	
char	✔	✖	✔	
double	✔	✖	✖	
float	✔	✖	✖	
int	✔	✖	✔	
long	✔	✖	✔	
short	✔	✖	✔	
java.lang.Boolean	✔	✖	✔	Persisted as **BOOLEAN**, Integer (i.e 1,0), String (i.e 'Y','N').
java.lang.Byte	✔	✖	✔	
java.lang.Character	✔	✖	✔	
java.lang.Double	✔	✖	✖	
java.lang.Float	✔	✖	✖	
java.lang.Integer	✔	✖	✔	
java.lang.Long	✔	✖	✔	
java.lang.Short	✔	✖	✔	
java.lang.Number	✔	✖	✖	Persisted in a column capable of storing a BigDecimal, and will store to the precision of the object to be persisted. On reading back the object will be returned typically as a BigDecimal since there is no mechanism for determing the type of the object that was stored.
java.lang.String	✔	✖	✔	
java.lang.StringBuffer	✔	✖	✔	Persisted as String. The dirty check mechanism for this type is limited to immutable mode, which means if you change a StringBuffer object field, you must reassign it to the owner object field to make sure changes are propagated to the database.

Java Type	EAGER?	Proxy?	PK?	Comments
java.lang.StringBuilder	✔	✖	✔	Persisted as String. The dirty check mechanism for this type is limited to immutable mode, which means if you change a StringBuffer object field, you must reassign it to the owner object field to make sure changes are propagated to the database.
java.lang.Class	✔	✖	✖	Persisted as String.

java.math types

BigInteger and BigDecimal are supported and persisted into a single numeric column by default.

Java Type	EAGER?	Proxy?	PK?	Comments
java.math.BigDecimal	✔	✖	✖	Persisted as **DOUBLE** or String. String can be used to retain precision.
java.math.BigInteger	✔	✖	✔	Persisted as **INTEGER** or String. String can be used to retain precision.

Temporal Types (java.util, java.sql. java.time, Jodatime)

DataNucleus supports a very wide range of temporal types, with flexibility in how they are persisted.

Java Type	EAGER?	Proxy?	PK?	Comments
java.sql.Date	✔	✔	✔	Persisted as **DATE**, String, DATETIME or Long.
java.sql.Time	✔	✔	✔	Persisted as **TIME**, String, DATETIME or Long.
java.sql.Timestamp	✔	✔	✔	Persisted as **TIMESTAMP**, String or Long.
java.util.Calendar	✔	✔	✖	Persisted as **TIMESTAMP (inc Timezone)**, DATETIME, String, or as (Long, String) storing millis + timezone respectively
java.util.GregorianCalendar	✔	✔	✖	Persisted as **TIMESTAMP (inc Timezone)**, DATETIME, String, or as (Long, String) storing millis + timezone respectively
java.util.Date	✔	✔	✔	Persisted as **DATETIME**, String or Long.

Java Type	EAGER?	Proxy?	PK?	Comments
java.util.TimeZone	✔	✖	✔	Persisted as String.
java.time.LocalDateTime	✔	✖	✖	Persisted as **DATETIME**, String, or Timestamp.
java.time.LocalTime	✔	✖	✖	Persisted as **TIME**, String, or Long.
java.time.LocalDate	✔	✖	✖	Persisted as **DATE**, String, or DATETIME.
java.time.OffsetDateTime	✔	✖	✖	Persisted as **Timestamp**, String, or DATETIME.
java.time.OffsetTime	✔	✖	✖	Persisted as **TIME**, String, or Long.
java.time.MonthDay	✔	✖	✖	Persisted as **String**, DATE, or as (Integer,Integer) with the latter being month+day respectively.
java.time.YearMonth	✔	✖	✖	Persisted as **String**, DATE, or as (Integer,Integer) with the latter being year+month respectively.
java.time.Year	✔	✖	✖	Persisted as **Integer**, or String.
java.time.Period	✔	✖	✖	Persisted as **String**.
java.time.Instant	✔	✖	✖	Persisted as **TIMESTAMP**, String, Long, or DATETIME.
java.time.Duration	✔	✖	✖	Persisted as **String**, Double (secs.nanos), or Long (secs).
java.time.ZoneId	✔	✖	✖	Persisted as **String**.
java.time.ZoneOffset	✔	✖	✖	Persisted as **String**.
java.time.ZonedDateTime	✔	✖	✖	Persisted as **Timestamp**, or String.
org.joda.time.DateTime	✔	✖	✖	Requires **datanucleus-jodatime** plugin. Persisted as **TIMESTAMP** or String.
org.joda.time.LocalTime	✔	✖	✖	Requires **datanucleus-jodatime** plugin. Persisted as **TIME** or String.
org.joda.time.LocalDate	✔	✖	✖	Requires **datanucleus-jodatime** plugin. Persisted as **DATE** or String.
org.joda.time.LocalDateTime	✔	✖	✖	Requires **datanucleus-jodatime** plugin. Persisted as **TIMESTAMP**, or String.
org.joda.time.Duration	✔	✖	✖	Requires **datanucleus-jodatime** plugin. Persisted as **String** or Long.
org.joda.time.Interval	✔	✖	✖	Requires **datanucleus-jodatime** plugin. Persisted as **String** or (TIMESTAMP, TIMESTAMP).

Java Type	EAGER?	Proxy?	PK?	Comments
org.joda.time.Period	✔	✖	✖	Requires **datanucleus-jodatime** plugin. Persisted as **String**.

Collection/Map types

DataNucleus supports a very wide range of collection, list and map types.

Java Type	EAGER?	Proxy?	PK?	Comments
java.util.ArrayList	✖	✔	✖	See the 1-N Lists Guide
java.util.BitSet	✖	✔	✖	Persisted as collection by default, but will be stored as String when the datastore doesn't provide for collection storage
java.util.Collection	✖	✔	✖	See the 1-N Collections Guide
java.util.HashMap	✖	✔	✖	See the 1-N Maps Guide
java.util.HashSet	✖	✔	✖	See the 1-N Collections Guide
java.util.Hashtable	✖	✔	✖	See the 1-N Maps Guide
java.util.LinkedHashMap	✖	✔	✖	Persisted as a Map currently. No List-ordering is supported. See the 1-N Maps Guide
java.util.LinkedHashSet	✖	✔	✖	Persisted as a Set currently. No List-ordering is supported. See the 1-N Collections Guide
java.util.LinkedList	✖	✔	✖	See the 1-N Lists Guide
java.util.List	✖	✔	✖	See the 1-N Lists Guide
java.util.Map	✖	✔	✖	See the 1-N Maps Guide
java.util.Properties	✖	✔	✖	See the 1-N Maps Guide
java.util.PriorityQueue	✖	✔	✖	The comparator is specifiable via the metadata extension *comparator-name* (see below). See the 1-N Lists Guide
java.util.Queue	✖	✔	✖	The comparator is specifiable via the metadata extension *comparator-name* (see below). See the 1-N Lists Guide
java.util.Set	✖	✔	✖	See the 1-N Collections Guide
java.util.SortedMap	✖	✔	✖	The comparator is specifiable via the metadata extension *comparator-name* (see below). See the 1-N Maps Guide

Java Type	EAGER?	Proxy?	PK?	Comments
java.util.SortedSet	✖	✔	✖	The comparator is specifiable via the metadata extension *comparator-name* (see below). See the 1-N Collections Guide
java.util.Stack	✖	✔	✖	See the 1-N Lists Guide
java.util.TreeMap	✖	✔	✖	The comparator is specifiable via the metadata extension *comparator-name* (see below). See the 1-N Maps Guide
java.util.TreeSet	✖	✔	✖	The comparator is specifiable via the metadata extension *comparator-name* (see below). See the 1-N Collections Guide
java.util.Vector	✖	✔	✖	See the 1-N Lists Guide
com.google.common.collect.Multiset	✖	✔	✖	Requires **datanucleus-guava** plugin. See the 1-N Collections Guide

Comparators

Containers that support a Comparator to order the elements of the set can specify it in metadata like this.

```
@OneToMany
@Extension(key="comparator-name", value="mydomain.model.MyComparator")
SortedSet<MyElementType> elements;
```

When instantiating the SortedSet field, it will create it with a comparator of the specified class (which must have a default constructor).

Enums

By default an Enum is persisted as either a String form (the name), or as an integer form (the ordinal). You control which form by specifying the **@Enumerated** annotation (or equivalent XML).

Java Type	EAGER?	Proxy?	PK?	Comments
java.lang.Enum	✔	✖	✔	Persisted as String (name) or int (ordinal). Specified via @Enumerated annotation or equivalent XML.

A DataNucleus extension to this is where you have an Enum that defines its own "value"s for the different enum options.

Applicable to RDBMS, MongoDB, Cassandra, Neo4j, HBase, Excel, ODF and JSON currently.

```
public enum MyColour
{
    RED((short)1), GREEN((short)3), BLUE((short)5), YELLOW((short)8);

    private short value;

    private MyColour(short value)
    {
        this.value = value;
    }

    public short getValue()
    {
        return value;
    }
}
```

With the default persistence it would persist as String-based, so persisting "RED" "GREEN" "BLUE" etc. With *@Enumerated* as ORDINAL it would persist 0, 1, 2, 3 being the ordinal values. If you define the metadata as

```
@Extension(key="enum-value-getter", value="getValue")
MyColour colour;
```

this will now persist 1, 3, 5, 8, being the "value" of each of the enum options. You can use this method to persist "int", "short", or "String" types.

A DataNucleus extension is available for RDBMS datastores where you are storing the *name* of the enum, and to put a CHECK constraint on the column. You specify it like this

```
@Extension(key="enum-check-constraint", value="true")
MyColour colour;
```

Geospatial Types

DataNucleus has extensive support for Geospatial types. The datanucleus-geospatial plugin allows using geospatial and traditional types simultaneously in persistent objects making DataNucleus a single interface to read and manipulate any business data. The implementation of many of these spatial types follows the OGC Simple Feature specification, but adds further types where the datastores support them.

Java Type	EAGER?	Proxy?	PK?	Comments
java.awt.Point	✔	✔	✖	Requires **datanucleus-geospatial** plugin. Persisted as (int, int) on RDBMS, or as String elsewhere.
java.awt.Rectangle	✔	✔	✖	Requires **datanucleus-geospatial** plugin. Persisted as (int, int, int, int) on RDBMS, or as String elsewhere.
java.awt.Polygon	✔	✔	✖	Requires **datanucleus-geospatial** plugin. Persisted as (int[], int[], int) on RDBMS, or as String elsewhere.
java.awt.geom.Line2D	✔	✔	✖	Requires **datanucleus-geospatial** plugin. Persisted as (double, double, double, double) or (float, float, float, float) on RDBMS, or as String elsewhere.
java.awt.geom.Point2D	✔	✔	✖	Requires **datanucleus-geospatial** plugin. Persisted as (double, double) or (float, float) on RDBMS, or as String elsewhere.
java.awt.geom.Rectangle2D	✔	✔	✖	Requires **datanucleus-geospatial** plugin. Persisted as (double, double, double, double) or (float, float, float, float) on RDBMS, or as String elsewhere.
java.awt.geom.Arc2D	✔	✔	✖	Requires **datanucleus-geospatial** plugin. Persisted as (double, double, double, double, double, double, int) or (float, float, float, float, float, float, int) on RDBMS, or as String elsewhere.
java.awt.geom.CubicCurve2D	✔	✔	✖	Requires **datanucleus-geospatial** plugin. Persisted as (double, double, double, double, double, double, doubel, double) or (float, float, float, float, float, float, float, float) on RDBMS, or as String elsewhere.
java.awt.geom.Ellipse2D	✔	✔	✖	Requires **datanucleus-geospatial** plugin Persisted as (double, double, double, double) or (float, float, float, float) on RDBMS, or as String elsewhere.
java.awt.geom.QuadCurve2D	✔	✔	✖	Requires **datanucleus-geospatial** plugin. Persisted as (double, double, double, double, double, double) or (float, float, float, float, float, float) on RDBMS, or as String elsewhere.

Java Type	EAGER?	Proxy?	PK?	Comments
java.awt.geom.RoundRectangle2D	✔	✔	✖	Requires **datanucleus-geospatial** plugin. Persisted as (double, double, double, double, double, double) or (float, float, float, float, float, float) on RDBMS, or as String elsewhere.
oracle.spatial.geometry.JGeometry	✔	✖	✖	Requires **datanucleus-geospatial** plugin. Dirty check limited to immutable mode (must reassign field to owner if you change it). Only on Oracle(SDO_GEOMETRY), MySQL(geometry)
com.vividsolutions.jts.geom.Geometry	✔	✖	✖	Requires **datanucleus-geospatial** plugin. Dirty check limited to immutable mode (must reassign field to owner if you change it). Only on Oracle(SDO_GEOMETRY), MySQL(geometry), PostGIS(geometry).
com.vividsolutions.jts.geom.GeometryCollection	✔	✖	✖	Requires **datanucleus-geospatial** plugin.Dirty check limited to immutable mode (must reassign field to owner if you change it). Only on Oracle(SDO_GEOMETRY), MySQL(geometry), PostGIS(geometry).
com.vividsolutions.jts.geom.LinearRing	✔	✖	✖	Requires **datanucleus-geospatial** plugin. Dirty check limited to immutable mode (must reassign field to owner if you change it). Only on Oracle(SDO_GEOMETRY), MySQL(geometry), PostGIS(geometry).
com.vividsolutions.jts.geom.LineString	✔	✖	✖	Requires **datanucleus-geospatial** plugin. Dirty check limited to immutable mode (must reassign field to owner if you change it). Only on Oracle(SDO_GEOMETRY), MySQL(geometry), PostGIS(geometry).
com.vividsolutions.jts.geom.MultiLineString	✔	✖	✖	Requires **datanucleus-geospatial** plugin. Dirty check limited to immutable mode (must reassign field to owner if you change it). Only on Oracle(SDO_GEOMETRY), MySQL(geometry), PostGIS(geometry).
com.vividsolutions.jts.geom.MultiPoint	✔	✖	✖	Requires **datanucleus-geospatial** plugin. Dirty check limited to immutable mode (must reassign field to owner if you change it). Only on Oracle(SDO_GEOMETRY), MySQL(geometry), PostGIS(geometry).

Java Type	EAGER?	Proxy?	PK?	Comments
com.vividsolutions.jts.geom.MultiPolygon	✔	✖	✖	Requires **datanucleus-geospatial** plugin. Dirty check limited to immutable mode (must reassign field to owner if you change it). Only on Oracle(SDO_GEOMETRY), MySQL(geometry), PostGIS(geometry).
com.vividsolutions.jts.geom.Point	✔	✖	✖	Requires **datanucleus-geospatial** plugin. Dirty check limited to immutable mode (must reassign field to owner if you change it). Only on Oracle(SDO_GEOMETRY), MySQL(geometry), PostGIS(geometry).
com.vividsolutions.jts.geom.Polygon	✔	✖	✖	Requires **datanucleus-geospatial** plugin. Dirty check limited to immutable mode (must reassign field to owner if you change it). Only on Oracle(SDO_GEOMETRY), MySQL(geometry), PostGIS(geometry).
org.postgis.Geometry	✔	✖	✖	Requires **datanucleus-geospatial** plugin. Dirty check limited to immutable mode (must reassign field to owner if you change it). Only on MySQL(geometry), PostGIS(geometry).
org.postgis.GeometryCollection	✔	✖	✖	Requires **datanucleus-geospatial** plugin. Dirty check limited to immutable mode (must reassign field to owner if you change it). Only on MySQL(geometry), PostGIS(geometry).
org.postgis.LinearRing	✔	✖	✖	Requires **datanucleus-geospatial** plugin. Dirty check limited to immutable mode (must reassign field to owner if you change it). Only on MySQL(geometry), PostGIS(geometry).
org.postgis.LineString	✔	✖	✖	Requires **datanucleus-geospatial** plugin. Dirty check limited to immutable mode (must reassign field to owner if you change it). Only on MySQL(geometry), PostGIS(geometry).
org.postgis.MultiLineString	✔	✖	✖	Requires **datanucleus-geospatial** plugin. Dirty check limited to immutable mode (must reassign field to owner if you change it). Only on MySQL(geometry), PostGIS(geometry).

Java Type	EAGER?	Proxy?	PK?	Comments
org.postgis.MultiPoint	✔	✖	✖	Requires **datanucleus-geospatial** plugin. Dirty check limited to immutable mode (must reassign field to owner if you change it). Only on MySQL(geometry), PostGIS(geometry).
org.postgis.MultiPolygon	✔	✖	✖	Requires **datanucleus-geospatial** plugin. Dirty check limited to immutable mode (must reassign field to owner if you change it). Only on MySQL(geometry), PostGIS(geometry).
org.postgis.Point	✔	✖	✖	Requires **datanucleus-geospatial** plugin. Dirty check limited to immutable mode (must reassign field to owner if you change it). Only on MySQL(geometry), PostGIS(geometry).
org.postgis.Polygon	✔	✖	✖	Requires **datanucleus-geospatial** plugin. Dirty check limited to immutable mode (must reassign field to owner if you change it). Only on MySQL(geometry), PostGIS(geometry).
org.postgis.PGbox2d	✔	✖	✖	Requires **datanucleus-geospatial** plugin. Dirty check limited to immutable mode (must reassign field to owner if you change it). Only on PostGIS(geometry).
org.postgis.PGbox3d	✔	✖	✖	Requires **datanucleus-geospatial** plugin. Dirty check limited to immutable mode (must reassign field to owner if you change it). Only on PostGIS(geometry).

Some extra notes for implementation of JTS, JGeometry and PostGIS types support :-

- MySQL doesn't support 3-dimensional geometries. Trying to persist them anyway results in undefined behaviour, there may be an exception thrown or the z-ordinate might just get stripped.
- Oracle supports additional data types like circles and curves that are not defined in the OGC SF specification. Any attempt to read or persist one of those data types, if you're not using Oracle, will result in failure!
- PostGIS added support for curves in version 1.2.0, but at the moment the JDBC driver doesn't support them yet. Any attempt to read curves geometries will result in failure, for every mapping scenario!
- Both PostGIS and Oracle have a system to add user data to specific points of a geometry. In PostGIS these types are called measure types and the z-coordinate of every 2d-point can be used to store arbitrary (numeric) data of double precision associated with that point. In Oracle this user data is called LRS. datanucleus-geospatial tries to handle these types as gracefully as

possible. But the recommendation is to not use them, unless you have a mapping scenario that is known to support them.

- PostGIS supports two additional types called box2d and box3d, that are not defined in OGC SF. There are only mappings available for these types for PostGIS, any attempt to read or persist one of those data types in another mapping scenario will result in failure!

datanucleus-geospatial has defined some metadata extensions that can be used to give additional information about the geometry types in use. The position of these tags in the meta-data determines their scope. If you use them inside a <field>-tag the values are only used for that field specifically, if you use them inside the <package>-tag the values are in effect for all (geometry) fields of all classes inside that package, etc.

```
<entity-mappings>
    <package>mydomain.samples.jtsgeometry</package>

    <entity class="mydomain.samples.jtsgeometry.SampleGeometry">
        <extension vendor-name="datanucleus" key="spatial-dimension" value="2"/>
        <extension vendor-name="datanucleus" key="spatial-srid" value="4326"/>
        <attributes>
            <id name="id"/>
            <basic name="name"/>
            <basic name="geom">
                <extension vendor-name="datanucleus" key="mapping" value="no-
userdata"/> [2]
            </basic>
        </attributes>
    </entity>

    <entity class="mydomain.samples.jtsgeometry.SampleGeometryCollectionM">
        <extension vendor-name="datanucleus" key="spatial-dimension" value="2"/>
        <extension vendor-name="datanucleus" key="spatial-srid" value="4326"/>
        <extension vendor-name="datanucleus" key="postgis-hasMeasure" value="true"/>
[3]
        <attributes>
            <id name="id"/>
            <basic name="name"/>
            <basic name="geom"/>
        </attributes>
    </entity>

    <entity class="mydomain.samples.jtsgeometry.SampleGeometryCollection3D">
        <extension vendor-name="datanucleus" key="spatial-dimension" value="3"/>
        <extension vendor-name="datanucleus" key="spatial-srid" value="-1"/>
        <attributes>
            <id name="id"/>
            <basic name="name"/>
            <basic name="geom"/>
        </attributes>
    </entity>
</entity-mappings>
```

- **[1]** - The srid & dimension values are used in various places. One of them is schema creation, when using PostGIS, another is when you query the SpatialHelper.
- **[2]** - Every JTS geometry object can have a user data object attached to it. The default behaviour is to serialize that object and store it in a separate column in the database. If for some reason this isn't desired, the **mapping** extension can be used with value "no-mapping" and datanucleus-geospatial will ignore the user data objects.
- **[3]** - If you want to use measure types in PostGIS you have to define that using the **postgis-hasMeasure** extension.

Other Types

Many other types are supported.

Java Type	EAGER?	Proxy?	PK?	Comments
java.lang.Object	✖	✖	✖	Either persisted serialised, or represents multiple possible types
java.util.Currency	✔	✖	✔	Persisted as String.
java.util.Locale	✔	✖	✔	Persisted as String.
java.util.UUID	✔	✖	✔	Persisted as String, or alternatively as native *uuid* on PostgreSQL when specifying sql-type="uuid".
java.util.Optional<type>;	✔	✖	✖	Persisted as the type of the generic type that optional represents.
java.awt.Color	✔	✖	✖	Persisted as String or as (Integer,Integer,Integer,Integer) storing red,green,blue,alpha respectively.
java.awt.image.BufferedImage	✖	✖	✖	Persisted as serialised.
java.net.URI	✔	✖	✔	Persisted as String.
java.net.URL	✔	✖	✔	Persisted as String.
java.io.Serializable	✖	✖	✖	Persisted as serialised.
java.io.File	✖	✖	✖	Only for RDBMS, persisted to LONGVARBINARY, and retrieved as streamable so as not to adversely affect memory utilisation, hence suitable for large files.

Arrays

The vast majority of the secondary types can also be persisted as arrays of that type as well. Here we list a few of the combinations definitely supported as arrays, but others likely will work fine

Java Type	EAGER?	Proxy?	PK?	Comments
boolean[]	✖	✖	✖	See the Arrays Guide
byte[]	✖	✖	✖	See the Arrays Guide
char[]	✖	✖	✖	See the Arrays Guide
double[]	✖	✖	✖	See the Arrays Guide

Java Type	EAGER?	Proxy?	PK?	Comments
float[]	✖	✖	✖	See the Arrays Guide
int[]	✖	✖	✖	See the Arrays Guide
long[]	✖	✖	✖	See the Arrays Guide
short[]	✖	✖	✖	See the Arrays Guide
java.lang.Boolean[]	✖	✖	✖	See the Arrays Guide
java.lang.Byte[]	✖	✖	✖	See the Arrays Guide
java.lang.Character[]	✖	✖	✖	See the Arrays Guide
java.lang.Double[]	✖	✖	✖	See the Arrays Guide
java.lang.Float[]	✖	✖	✖	See the Arrays Guide
java.lang.Integer[]	✖	✖	✖	See the Arrays Guide
java.lang.Long[]	✖	✖	✖	See the Arrays Guide
java.lang.Short[]	✖	✖	✖	See the Arrays Guide
java.lang.String[]	✖	✖	✖	See the Arrays Guide
java.util.Date[]	✖	✖	✖	See the Arrays Guide
java.math.BigDecimal[]	✖	✖	✖	See the Arrays Guide
java.math.BigInteger[]	✖	✖	✖	See the Arrays Guide
java.lang.Enum[]	✖	✖	✖	See the Arrays Guide
java.util.Locale[]	✖	✖	✖	See the Arrays Guide
Entity[]	✖	✖	✖	See the Arrays Guide

Generic Type Variables

JPA does not explicitly require support for generic type variables. DataNucleus does support some situations with generic type variables.

The first example that is largely supported is where you have an abstract base class with a generic TypeVariable and then you specify the type in the (concrete) subclass(es).

```
@MappedSuperclass
public abstract class Base<T>
{
    private T id;
}

@Entity
public class Sub1 extends Base<Long>
{
    ...
}

@Entity
public class Sub2 extends Base<Integer>
{
    ...
}
```

Similarly you use TypeVariables to form relations, like this

```
@MappedSuperclass
public abstract class Ownable<T extends Serializable> implements Serializable
{
    @ManyToOne(optional = false)
    private T owner;
}

@Entity
public class Document extends Ownable<Person>
{
    ...
}
```

Clearly there are many combinations of where TypeVariables can be used and DataNucleus supports a subset of these currently. Try it and see.

JPA Attribute Converters

JPA2.1 introduces an API for conversion of an attribute of an Entity to its datastore value. You can define a "converter" that will convert to the datastore value and back from it, implementing this interface.

```
public interface AttributeConverter<X,Y>
{
    public Y convertToDatabaseColumn (X attributeObject);

    public X convertToEntityAttribute (Y dbData);
}
```

so if we have a simple converter to allow us to persist fields of type URL in a String form in the datastore, like this

```
public class URLStringConverter implements AttributeConverter<URL, String>
{
    public URL convertToEntityAttribute(String str)
    {
        if (str == null)
        {
            return null;
        }

        URL url = null;
        try
        {
            url = new java.net.URL(str.trim());
        }
        catch (MalformedURLException mue)
        {
            throw new IllegalStateException("Error converting the URL", mue);
        }
        return url;
    }

    public String convertToDatabaseColumn(URL url)
    {
        return url != null ? url.toString() : null;
    }
}
```

and now in our Entity class we mark any URL field as being converted using this converter

```
@Entity
public class MyClass
{
    @Id
    long id;

    @Basic
    @Convert(converter=URLStringConverter.class)
    URL url;

    ...
}
```

Note that in strict JPA 2.1 you have to mark all converters with the @Converter annotation. In DataNucleus if you specify the converter class name in the @Convert then we know its a converter so don't really see why we need a user to annotate the converter too. We only require annotation as @Converter if you want the converter to always be applied to fields of a particular type. i.e if you want all URL fields to be persisted using the above converter (without needing to put @Convert on each field of that type) then you would add the annotation

```
@Converter(autoApply=true)
public class URLStringConverter implements AttributeConverter<URL, String>
{
    ...
}
```

Note that if you have some java type with a @Converter registered to "autoApply", you can turn it off on a field-by-field basis with

```
    @Convert(disableConversion=true)
    URL url;
```

A further use of AttributeConverter is where you want to apply type conversion to the key/value of a Map field, or to the element of a Collection field. The Collection element case is simple, you just specify the @Convert against the field and it will be applied to the element. If you want to apply type conversion to a key/value of a map do this.

```
    @Convert(attributeName="key", converter=URLStringConverter.class)
    Map<URL, OtherEntity> myMap;
```

So we specify the *attributeName* to be **key**, and to use it on the value we would set it to **value**.

Types extending Collection/Map

Say you have your own type that extends Collection/Map. By default DataNucleus will not know

how to persist this. You could declare the type in your class as Collection/Map, but often you want to refer to your own type. If you have your type and want to just persist it into a single column then you should do as follows

```
public class MyCollectionType extends Collection
{
    ...
}

@Entity
public class MyClass
{
    MyCollectionType myField;

    ...
}
```

We now define a simple converter to allow us to persist fields of this type in String form in the datastore, like this

```
public class MyCollectionTypeStringConverter implements AttributeConverter
<MyCollectionType, String>
{
    public MyCollectionType convertToEntityAttribute(String str)
    {
        if (str == null)
        {
            return null;
        }

        ...
        return myType;
    }

    public String convertToDatastoreColumn(MyCollectionType myType)
    {
        return myType != null ? myType.toString() : null;
    }
}
```

and now in our entity class we mark the *myField* as being converted using this converter

```
@Entity
public class MyClass
{
    @Convert(converter=MyCollectionTypeStringConverter.class)
    MyCollectionType myField;

    ...
}
```

If you want your extension of Collection/Map to be managed as a second class type then you will need to provide a *wrapper* class for it. Please refer to the java_type extension.

Identity

All JPA-enabled persistable classes need to have an "identity" to be able to identify an object for retrieval and relationships. In strict JPA there is only 1 type of identity - *application identity*, where you have a field or field(s) of the entity that are used to define the identity. With DataNucleus JPA we allow 2 additional types of identity. So your options are

- Application Identity : a field, or several fields of the persistable type are assigned as being (part of) the primary key.
- Datastore Identity : a surrogate column is added to the persistence of the persistable type, and objects of this type are identified by the class plus the value in this surrogate column. **DataNucleus Extension**
- Nondurable Identity : the persistable type has no identity as such, so the only way to lookup objects of this type would be via query for values of specific fields. This is useful for storing things like log messages etc. **DataNucleus Extension**

A further complication is where you use *application identity* but one of the fields forming the primary key is a relation field. This is known as Derived Identity.

When you have an inheritance hierarchy, you should specify the identity type in the *base instantiable* class for the inheritance tree. This is then used for all persistent classes in the tree. This means that you can have @MappedSuperclass without any identity fields/properties as superclass, and then the base instantiable class is the first persistable class which has the identity field(s).

Application Identity

Applicable to all datastores.

With **application identity** you are taking control of the specification of id's to DataNucleus. Application identity can require a primary key class *(when you have multiple identity fields)*, and each persistent capable class may define a different class for its primary key, and different persistent capable classes can use the same primary key class, as appropriate. With **application identity** the field(s) of the primary key will be present as field(s) of the class itself. To specify that a class is to use **application identity**, you add the following to the MetaData for the class.

```
<entity class="org.mydomain.MyClass">
    <attributes>
        <id name="myPrimaryKeyField"/>
    </attributes>
</entity>
```

or, if we are using annotations

```
@Entity
public class MyClass
{
    @Id
    private long myPrimaryKeyField;
}
```

When we have **multiple identity fields** we also require an **id-class**, using XML

```
<entity class="org.mydomain.MyClass">
    <id-class class="org.mydomain.MyIdClass"/>
    <attributes>
        <id name="myPrimaryKeyField1"/>
        <id name="myPrimaryKeyField2"/>
    </attributes>
</entity>
```

or, if we are using annotations

```
@Entity
@IdClass(class=MyIdClass.class)
public class MyClass
{
    @Id
    private long myPrimaryKeyField1;

    @Id
    private long myPrimaryKeyField2;

}
```

See also:-

- MetaData reference for <id> element
- Annotations reference for @Id

Application Identity : Generating identities

By choosing **application identity** you are controlling the process of identity generation for this class. This does not mean that you have a lot of work to do for this. JPA1 defines many ways of generating these identities and DataNucleus supports all of these and provides some more of its own besides.

See also:-

- Identity Generation Guide - strategies for generating ids

Application Identity : Changing Identities

JPA doesn't define what happens if you change the identity (an identity field) of an object once persistent. **DataNucleus doesn't currently support changes to identities.**

Application Identity : Accessing objects by Identity

You access an object from its object class name and identity "value" as follows

```
MyClass myObj = em.find(MyClass.class, mykey);
```

If you have defined your own "IdClass" then the *mykey* is the toString() form of the identity of your PK class.

Primary Key

When you choose application identity you are defining which fields of the class are part of the primary key, and you are taking control of the specification of id's to DataNucleus. Application identity requires a primary key (PK) class, and each persistent capable class may define a different class for its primary key, and different persistent capable classes can use the same primary key class, as appropriate. If you have only a single primary-key field then there are builtin PK classes so you can forget this section. Where you have more than 1 primary key field, you would define the PK class like this

```
<entity class="MyClass">
    <id-class class="MyIdClass"/>
    ...
</entity>
```

or using annotations

```
@Entity
@IdClass(class=MyIdClass.class)
public class MyClass
{
    ...
}
```

You now need to define the PK class to use. This is simplified for you because **if you have only one PK field then you dont need to define a PK class** and you only define it when you have a composite PK.

An important thing to note is that the PK can only be made up of fields of the following Java types

- Primitives : **boolean**, **byte**, **char**, **int**, **long**, **short**
- java.lang : **Boolean**, **Byte**, **Character**, **Integer**, **Long**, **Short**, **String**, **Enum**, StringBuffer

- java.math : **BigInteger**
- java.sql : **Date**, **Time**, **Timestamp**
- java.util : **Date**, Currency, Locale, TimeZone, UUID
- java.net : URI, URL
- *persistable*

Note that the types in **bold** are JPA standard types. Any others are DataNucleus extensions and, as always, check the specific datastore docs to see what is supported for your datastore.

Single PrimaryKey field

The simplest way of using **application identity** is where you have a single PK field, and in this case you use an inbuilt primary key class that DataNucleus provides, so you don't need to specify the *objectid-class*. Let's take an example

```
public class MyClass
{
    long id;
    ...
}
```

```
<entity class="MyClass">
    <attributes>
        <id name="id"/>
        ...
    </attributes>
</entity>
```

or using annotations

```
@Entity
public class MyClass
{
    @Id
    long id;
    ...
}
```

So we didnt specify the JPA "id-class". You will, of course, have to give the field a value before persisting the object, either by setting it yourself, or by using a value-strategy on that field.

PrimaryKey : Rules for User-Defined classes

If you wish to use **application identity** and don't want to use the "SingleFieldIdentity" builtin PK classes then you must define a Primary Key class of your own. You can't use classes like

java.lang.String, or java.lang.Long directly. You must follow these rules when defining your primary key class.

- the Primary Key class must be public
- the Primary Key class must implement Serializable
- the Primary Key class must have a public no-arg constructor, which might be the default constructor
- The PrimaryKey class can have a constructor taking the primary key fields, or can use Java bean setters/getters
- the field types of all non-static fields in the Primary Key class must be serializable, and are recommended to be primitive, String, Date, or Number types
- all serializable non-static fields in the Primary Key class can be public, but package/protected/private should also be fine
- the names of the non-static fields in the Primary Key class must include the names of the primary key fields in the Entity, and the types of the common fields must be identical
- the equals() and hashCode() methods of the Primary Key class must use the value(s) of all the fields corresponding to the primary key fields in the JPA entity
- if the Primary Key class is an inner class, it must be static
- the Primary Key class must override the toString() method defined in Object, and return a String that can be used as the parameter of a constructor
- the Primary Key class must provide a String constructor that returns an instance that compares equal to an instance that returned that String by the toString() method.
- the Primary Key class must be only used within a single inheritance tree.

Please note that if one of the fields that comprises the primary key is in itself an entity then you have Derived Identity and should consult the documentation for that feature which contains its own example.

Since there are many possible combinations of primary-key fields it is impossible for DataNucleus to provide a series of builtin composite primary key classes. However the DataNucleus enhancer provides a mechanism for auto-generating a primary-key class for a persistable class. It follows the rules listed above and should work for all cases. Obviously if you want to tailor the output of things like the PK toString() method then you ought to define your own. The enhancer generation of primary-key class is only enabled if you don't define your own class.

PrimaryKey Example - Multiple Field

Here's an example of a composite (multiple field) primary key class

```
@Entity
```

```
@IdClass(ComposedIdKey.class)
public class MyClass
{
    @Id
    String field1;

    @Id
    String field2;
    ...
}

public class ComposedIdKey implements Serializable
{
    public String field1;
    public String field2;

    /**
     *  Default constructor.
     */
    public ComposedIdKey ()
    {
    }

    /**
     * Constructor accepting same input as generated by toString().
     */
    public ComposedIdKey(String value)
    {
        StringTokenizer token = new StringTokenizer (value, "::");
        //field1
        this.field1 = token.nextToken ();
        //field2
        this.field2 = token.nextToken ();
    }

    public boolean equals(Object obj)
    {
        if (obj == this)
        {
            return true;
        }
        if (!(obj instanceof ComposedIdKey))
        {
            return false;
        }
        ComposedIdKey c = (ComposedIdKey)obj;

        return field1.equals(c.field1) && field2.equals(c.field2);
    }

    public int hashCode ()
```

```
    {
        return this.field1.hashCode() ^ this.field2.hashCode();
    }

    public String toString ()
    {
        // Give output expected by String constructor
        return "" + this.field1 + "::" + this.field2;
    }
}
```

Datastore Identity

Applicable to RDBMS, ODF, Excel, OOXML, XML, HBase, Cassandra, Neo4j, MongoDB, JSON

While JPA defines support for application identity only, DataNucleus also provides support for **datastore identity**. With **datastore identity** you are leaving the assignment of id's to DataNucleus and your class will **not** have a field for this identity - it will be added to the datastore representation by DataNucleus. It is, to all extents and purposes a *surrogate key* that will have its own column in the datastore. To specify that a class is to use **datastore identity** with JPA, you define the metadata as follows

```
<entity class="org.mydomain.MyClass">
    <datastore-id/>
    ...
</entity>
```

or using annotations, for example

```
@Entity
@org.datanucleus.api.jpa.annotations.DatastoreIdentity
public class MyClass
{
    ...
}
```

Please note that since the JPA XML metadata is poorly designed it is not possible to specify datastore identity using XML, you have to use the annotations.

Datastore Identity : Generating identities

By choosing **datastore identity** you are handing the process of identity generation to the DataNucleus. This does not mean that you haven't got any control over how it does this. JPA defines

many ways of generating these identities and DataNucleus supports all of these and provides some more of its own besides.

Defining which one to use is a simple matter of adding a MetaData element to your classes definition, like this

```
@Entity
@org.datanucleus.api.jpa.annotations.DatastoreIdentity(generationType=GenerationType.TABLE)
public class MyClass
{
    ...
}
```

See also:- * Identity Generation Guide - strategies for generating ids * Annotations reference for @DatastoreIdentity

Datastore Identity : Accessing the Identity

When using **datastore identity**, the class has no associated field so you can't just access a field of the class to see its identity - if you need a field to be able to access the identity then you should be using application identity. There are, however, ways to get the identity for the datastore identity case, if you have the object.

```
import org.datanucleus.api.jpa.NucleusJPAHelper;

Object idKey = NucleusJPAHelper.getDatastoreIdForEntity(obj);
```

From this you can use the "find" method to retrieve the object

```
MyClass myObj = em.find(MyClass.class, idKey);
```

Nondurable Identity

Applicable to RDBMS, ODF, Excel, OOXML, HBase, Neo4j, MongoDB

JPA requires that all objects have an identity. DataNucleus provides a vendor extension that allows objects of a class to not have a unique identity in the datastore. This type of identity is typically for log files, history files etc where you aren't going to access the object by key, but instead by a different parameter. In the datastore the table will typically not have a primary key. To specify that a class is to use **nondurable identity** with DataNucleus you would add the following to the MetaData for the class.

```
<entity class="org.mydomain.MyClass">
    <nondurable-id/>
    ...
</entity>
```

or using annotations, for example

```
@Entity
@org.datanucleus.api.jpa.annotations.NonDurableId
public class MyClass
{
    ...
}
```

What this means for something like RDBMS is that the table of the class will not have a primary-key.

Derived Identity Relationships

An derived identity relationship is a relationship between two objects of two classes in which the child object must coexist with the parent object and where the primary key of the child includes the Entity object of the parent. So effectively the key aspect of this type of relationship is that the primary key of one of the classes includes a Entity field (hence why is is referred to as *Derived Identity*). This type of relation is available in the following forms

- 1-1 unidirectional
- 1-N collection bidirectional using ForeignKey
- 1-N map bidirectional using ForeignKey (key stored in value)

In pure JPA, if the entity that is part of the id of the derived entity has a single long field then you can put a *long* field in the identity class of the derived entity. In DataNucleus you cannot do this currently, and should define the `@IdClass` of the entity being contained and use that type in the identity class of the derived entity.

The persistable class that is contained cannot be using *datastore identity*, and must be using *application identity* with an objectid-class

When using derived identity, it is best practice to define an *@IdClass* for any entity that is part of the primary key, and **not** rely on the built-in identity types.

1-1 Relationship

Lets take the same classes as we have in the 1-1 Relationships. In the 1-1 relationships guide we note that in the datastore representation of the **User** and **Account** the **ACCOUNT** table has a primary key as well as a foreign-key to **USER**. In our example here we want to just have a primary

key that is also a foreign-key to **USER**. To do this we need to modify the classes slightly and add primary-key fields and use "application-identity".

```
public class User
{
    long id;

    ...
}

public class Account
{
    User user;

    ...
}
```

In addition we need to define primary key classes for our **User** and **Account** classes

```
@Entity
public class User
{
    @Id
    long id;

    ... (remainder of User class)

    /**
     * Inner class representing Primary Key
     */
    public static class PK implements Serializable
    {
        public long id;

        public PK()
        {
        }

        public PK(String s)
        {
            this.id = Long.valueOf(s).longValue();
        }

        public String toString()
        {
            return "" + id;
        }

        public int hashCode()
```

```
        {
            return (int)id;
        }

        public boolean equals(Object other)
        {
            if (other != null && (other instanceof PK))
            {
                PK otherPK = (PK)other;
                return otherPK.id == this.id;
            }
            return false;
        }
    }
}

@Entity
public class Account
{
    @Id
    @OneToOne
    User user;

    ... (remainder of Account class)

    /**
     * Inner class representing Primary Key
     */
    public static class PK implements Serializable
    {
        public User.PK user; // Use same name as the real field above

        public PK()
        {
        }

        public PK(String s)
        {
            StringTokenizer token = new StringTokenizer(s,"::");

            this.user = new User.PK(token.nextToken());
        }

        public String toString()
        {
            return "" + this.user.toString();
        }

        public int hashCode()
        {
            return user.hashCode();
```

```
        }

        public boolean equals(Object other)
        {
            if (other != null && (other instanceof PK))
            {
                PK otherPK = (PK)other;
                return this.user.equals(otherPK.user);
            }
            return false;
        }
    }
}
```

To achieve what we want with the datastore schema we define the MetaData like this

```
<entity-mappings>
    <entity class="mydomain.User">
        <table name="USER"/>
        <id-class class="mydomain.User.PK"/>
        <attributes>
            <id name="id">
                <column name="USER_ID"/>
            </id>
            <basic name="login">
                <column name="LOGIN" length="20"/>
            </basic>
        </attributes>
    </entity>

    <entity class="mydomain.Account">
        <table name="ACCOUNT"/>
        <id-class class="mydomain.Account.PK"/>
        <attributes>
            <id name="user">
                <column name="USER_ID"/>
            </id>
            <basic name="firstName">
                <column name="FIRSTNAME" length="50"/>
            </basic>
            <basic name="secondName">
                <column name="LASTNAME" length="50"/>
            </basic>
            <one-to-one name="user"/>
        </attributes>
    </entity>
</entity-mappings>
```

So now we have the following datastore schema

Things to note:-

- In the child Primary Key class, you must have a field with the same name as the relationship in the child class, and the field in the child Primary Key class must be the same type as the Primary Key class of the parent
- See also the general instructions for Primary Key classes
- You can only have one "Account" object linked to a particular "User" object since the FK to the "User" is now the primary key of "Account". To remove this restriction you could also add a "long id" to "Account" and make the "Account.PK" a composite primary-key

1-N Collection Relationship

Lets take the same classes as we have in the 1-N Relationships (FK). In the 1-N relationships guide we note that in the datastore representation of the **Account** and **Address** classes the **ADDRESS** table has a primary key as well as a foreign-key to **ACCOUNT**. In our example here we want to have the primary-key to **ACCOUNT** to *include* the foreign-key. To do this we need to modify the classes slightly, adding primary-key fields to both classes, and use "application-identity" for both.

```
public class Account
{
    long id;

    Set<Address> addresses;

    ...
}

public class Address
{
    long id;

    Account account;

    ...
}
```

In addition we need to define primary key classes for our **Account** and **Address** classes

```
@Entity
public class Account
{
    @Id
```

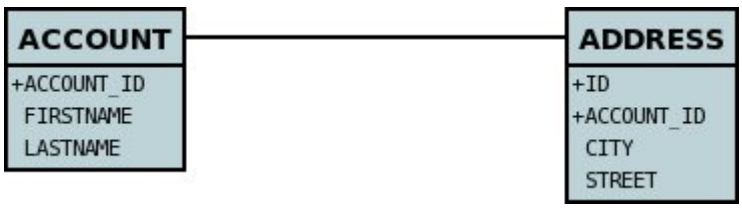
```
    long id;

    @OneToMany
    Set<Address> addresses = new HashSet<>();

    ... (remainder of Account class)

    /**
     * Inner class representing Primary Key
     */
    public static class PK implements Serializable
    {
        public long id;

        public PK()
        {
        }

        public PK(String s)
        {
            this.id = Long.valueOf(s).longValue();
        }

        public String toString()
        {
            return "" + id;
        }

        public int hashCode()
        {
            return (int)id;
        }

        public boolean equals(Object other)
        {
            if (other != null && (other instanceof PK))
            {
                PK otherPK = (PK)other;
                return otherPK.id == this.id;
            }
            return false;
        }
    }
}

@Entity
public class Address
{
    @Id
    long id;
```

```
    @Id
    @ManyToOne
    Account account;

    .. (remainder of Address class)

    /**
     * Inner class representing Primary Key
     */
    public static class PK implements Serializable
    {
        public long id; // Same name as real field above
        public Account.PK account; // Same name as the real field above

        public PK()
        {
        }

        public PK(String s)
        {
            StringTokenizer token = new StringTokenizer(s,"::");
            this.id = Long.valueOf(token.nextToken()).longValue();
            this.account = new Account.PK(token.nextToken());
        }

        public String toString()
        {
            return "" + id + "::" + this.account.toString();
        }

        public int hashCode()
        {
            return (int)id ^ account.hashCode();
        }

        public boolean equals(Object other)
        {
            if (other != null && (other instanceof PK))
            {
                PK otherPK = (PK)other;
                return otherPK.id == this.id && this.account.equals(otherPK.account);
            }
            return false;
        }
    }
}
```

To achieve what we want with the datastore schema we define the MetaData like this

```
<entity-mappings>
    <entity class="mydomain.Account">
        <table name="ACCOUNT"/>
        <id-class class="mydomain.Account.PK"/>
        <attributes>
            <id name="id">
                <column name="ACCOUNT_ID"/>
            </id>
            <basic name="firstName">
                <column name="FIRSTNAME" length="50"/>
            </basic>
            <basic name="secondName">
                <column name="LASTNAME" length="50"/>
            </basic>
            <one-to-many name="addresses" mapped-by="account"/>
        </attributes>
    </entity>

    <entity class="mydomain.Address">
        <table name="ADDRESS"/>
        <id-class class="mydomain.Address.PK"/>
        <attributes>
            <id name="id">
                <column name="ID"/>
            </id>
            <id name="account">
                <column name="ACCOUNT_ID"/>
            </id>
            <basic name="city">
                <column name="CITY"/>
            </basic>
            <basic name="street">
                <column name="STREET"/>
            </basic>
            <many-to-one name="account"/>
        </attributes>
    </entity>
</entity-mappings>
```

So now we have the following datastore schema



Things to note :-

- In the child Primary Key class, you must have a field with the same name as the relationship in

the child class, and the field in the child Primary Key class must be the same type as the Primary Key class of the parent

- See also the general instructions for Primary Key classes
- If we had omitted the "id" field from "Address" it would have only been possible to have one "Address" in the "Account" "addresses" collection due to PK constraints. For that reason we have the "id" field too.

1-N Map Relationship

Lets take the same classes as we have in the 1-N Relationships FK. In this guide we note that in the datastore representation of the **Account** and **Address** classes the **ADDRESS** table has a primary key as well as a foreign-key to **ACCOUNT**. In our example here we want to have the primary-key to **ACCOUNT** to *include* the foreign-key. To do this we need to modify the classes slightly, adding primary-key fields to both classes, and use "application-identity" for both.

```
public class Account
{
    long id;

    Map<String, Address> addresses;

    ...
}

public class Address
{
    long id;

    String alias;

    Account account;

    ...
}
```

In addition we need to define primary key classes for our **Account** and **Address** classes

```
@Entity
public class Account
{
    @Id
    long id;

    @OneToMany
    Map<String, Address> addresses;

    ... (remainder of Account class)
```

```
    /**
     * Inner class representing Primary Key
     */
    public static class PK implements Serializable
    {
        public long id;

        public PK()
        {
        }

        public PK(String s)
        {
            this.id = Long.valueOf(s).longValue();
        }

        public String toString()
        {
            return "" + id;
        }

        public int hashCode()
        {
            return (int)id;
        }

        public boolean equals(Object other)
        {
            if (other != null && (other instanceof PK))
            {
                PK otherPK = (PK)other;
                return otherPK.id == this.id;
            }
            return false;
        }
    }
}

@Entity
public class Address
{
    @Id
    String alias;

    @Id
    @ManyToOne
    Account account;

    .. (remainder of Address class)

    /**
```

```
     * Inner class representing Primary Key
     */
    public static class PK implements Serializable
    {
        public String alias; // Same name as real field above
        public Account.PK account; // Same name as the real field above

        public PK()
        {
        }

        public PK(String s)
        {
            StringTokenizer token = new StringTokenizer(s,"::");
            this.alias = Long.valueOf(token.nextToken()).longValue();
            this.account = new Account.PK(token.nextToken());
        }

        public String toString()
        {
            return alias + "::" + this.account.toString();
        }

        public int hashCode()
        {
            return alias.hashCode() ^ account.hashCode();
        }

        public boolean equals(Object other)
        {
            if (other != null && (other instanceof PK))
            {
                PK otherPK = (PK)other;
                return otherPK.alias.equals(this.alias) && this.account.equals(
otherPK.account);
            }
            return false;
        }
    }
}
```

To achieve what we want with the datastore schema we define the MetaData like this

```
<entity-mappings>
    <entity class="mydomain.Account">
        <table name="ACCOUNT"/>
        <id-class class="mydomain.Account.PK"/>
        <attributes>
            <id name="id">
                <column name="ACCOUNT_ID"/>
            </id>
            <basic name="firstName">
                <column name="FIRSTNAME" length="50"/>
            </basic>
            <basic name="secondName">
                <column name="LASTNAME" length="50"/>
            </basic>
            <one-to-many name="addresses" mapped-by="account">
                <map-key name="alias"/>
            </one-to-many>
        </attributes>
    </entity>

    <entity class="mydomain.Address">
        <table name="ADDRESS"/>
        <id-class class="mydomain.Address.PK"/>
        <attributes>
            <id name="account">
                <column name="ACCOUNT_ID"/>
            </id>
            <id name="alias">
                <column name="KEY"/>
            </id>
            <basic name="city">
                <column name="CITY"/>
            </basic>
            <basic name="street">
                <column name="STREET"/>
            </basic>
            <many-to-one name="account"/>
        </attributes>
    </entity>
</entity-mappings>
```

So now we have the following datastore schema

Things to note :-

- In the child Primary Key class, you must have a field with the same name as the relationship in the child class, and the field in the child Primary Key class must be the same type as the Primary Key class of the parent
- See also the general instructions for Primary Key classes
- If we had omitted the "alias" field from "Address" it would have only been possible to have one "Address" in the "Account" "addresses" collection due to PK constraints. For that reason we have the "alias" field too as part of the PK.

Versioning

JPA allows objects of classes to be versioned. The version is typically used as a way of detecting if the object has been updated by another thread or EntityManager since retrieval using the current EntityManager - for use by Optimistic Transactions.

Version Field/Property

The standard JPA mechanism for versioning of objects is to mark a field of the class to store the version. The field must be Integer/Long based. With JPA you can specify the details of this **version field** as follows

```
@Entity
public class User
{
    ...

    @Version
    int version;

    ...
}
```

or using XML metadata

```
<entity name="mydomain.User">
    <attributes>
        ...
        <version name="version"/>
        ...
    </attributes>
</entity>
```

The specification above will use the "version" field for storing the version of the object. DataNucleus will use a "version-number" strategy for populating the value.

Surrogate Version for Class

While the above mechanism should always be used for portability, DataNucleus also supports a surrogate version for objects of a class. With this you don't have a particular field that stores the version and instead DataNucleus persists the version in the datastore with the field values in its own "column". You do this as follows.

```
import org.datanucleus.api.jpa.annotations.SurrogateVersion;

@Entity
@SurrogateVersion
public class User
{
    ...
}
```

or using XML metadata

```
<entity name="mydomain.User">
    <surrogate-version column="version"/>
    ...
</entity>
```

To access the "surrogate" version, you can make use of the following method

```
import org.datanucleus.api.jpa.NucleusJPAHelper;

Object version = NucleusJPAHelper.getSurrogateVersionForEntity(obj);
```

Value Generation

Fields of a class can either have the values set by you the user, or you can set DataNucleus to generate them for you. This is of particular importance with identity fields where you want unique identities. You can use this value generation process with the identity field(s) in JPA. There are many different "strategies" for generating values, as defined by the JPA specification. Some strategies are specific to a particular datastore, and some are generic. You should choose the strategy that best suits your target datastore. The available strategies are :-

- AUTO - this is the default and allows DataNucleus to choose the most suitable for the datastore
- SEQUENCE - this uses a datastore sequence (if supported by the datastore)
- IDENTITY - these use autoincrement/identity/serial features in the datastore (if supported by the datastore)
- TABLE - this is datastore neutral and increments a sequence value using a table.
- Custom generators - these are beyond the scope of the JPA spec but provided by DataNucleus

See also:-

- JPA MetaData reference for <generated-value>
- JPA Annotation reference for @GeneratedValue

the JPA spec only requires the ability to generate values for identity fields. DataNucleus allows you to do it for any field. Please bear this in mind when considering portability

By defining a value-strategy for a field then it will, by default, always generate a value for that field on persist. If the field can store nulls and you only want it to generate the value at persist when it is null (i.e you haven't assigned a value yourself) then you can add the extension *"strategy-when-notnull"* as *false*

ValueGeneration Strategy AUTO

With this strategy DataNucleus will choose the most appropriate strategy for the datastore being used. If you define the field as String-based then it will choose uuid-hex. Otherwise the field is numeric in which case it chooses identity if supported, otherwise sequence if supported, otherwise table if supported otherwise throws an exception.

On RDBMS you can get the behaviour used up until DN v3.0 by specifying the persistence property **datanucleus.rdbms.useLegacyNativeValueStrategy** as *true*. For a class using **application identity** you need to set the *value-strategy* attribute on the primary key field. You can configure the Meta-Data for the class something like this

```
<entity class="MyClass">
    <attributes>
        <id name="myId">
            <generated-value strategy="AUTO"/>
        </id>
    </attributes>
</entity>
```

or using annotations

```
@Entity
public class MyClass
{
    @Id
    @GeneratedValue(strategy=GenerationType.AUTO)
    private long myId;
    ...
}
```

To configure a class to use this generation using **datastore identity** you need to look at the @DatastoreId extension annotation or the XML <datastore-id> tag

ValueGeneration Strategy SEQUENCE

Applicable to RDBMS (Oracle, PostgreSQL, SAPDB, DB2, Firebird, HSQLDB, H2, Derby, SQLServer, NuoDB)

A sequence is a user-defined database function that generates a sequence of unique numeric ids. The unique identifier value returned from the database is translated to a java type: java.lang.Long To configure a class to use this strategy using **application identity** you would add the following to the class' Meta-Data

```
<sequence-generator name="SEQ1" sequence-name="MY_SEQ" initial-value="5" allocation-
size="10"/>
<entity class="MyClass">
    <attributes>
        <id name="myId">
            <generated-value strategy="SEQUENCE" generator="SEQ1"/>
        </id>
    </attributes>
</entity>
```

or using annotations

```
@Entity
@SequenceGenerator(name="SEQ1", sequenceName="MY_SEQ", initialValue=5, allocationSize
=10)
public class MyClass
{
    @Id
    @GeneratedValue(strategy=GenerationType.SEQUENCE, generator="SEQ1")
    private long myId;
    ...
}
```

If the sequence does not yet exist in the database at the time DataNucleus needs a new unique identifier, a new sequence is created in the database based on the JPA Meta-Data configuration.

Extension properties for configuring sequences can be set in the JPA Meta-Data (via @Extension or <extension>), see the available properties below. Unsupported properties by a database are silently ignored by DataNucleus.

Property	Description	Required
key-database-cache-size	specifies how many sequence numbers are to be preallocated and stored in memory for faster access. This is an optimization feature provided by the database	No

To configure a class to use this generation using **datastore identity** you need to look at the @DatastoreId extension annotation or the XML <datastore-id> tag.

This value generator will generate values unique across different JVMs

Values generated using this generator are available in @PrePersist.

See also:-

- JPA MetaData reference for <sequence-generator>
- JPA Annotation reference for @SequenceGenerator

ValueGeneration Strategy IDENTITY

Applicable to RDBMS (IDENTITY (DB2, SQLServer, Sybase, HSQLDB, H2, Derby, NuoDB), AUTOINCREMENT (MySQL, MariaDB) SERIAL (PostgreSQL)), MongoDB (String), Neo4j (long)

Auto-increment/identity/serial are primary key columns that are populated when a row is inserted in the table. These use the databases own keywords on table creation and so rely on having the table structure either created by DataNucleus or having the column with the necessary keyword.

This generation strategy should only be used if there is a single "root" table for the inheritance tree. If you have more than 1 root table (e.g using subclass-table inheritance) then you should choose a different generation strategy

For a class using **application identity** you need to set the *value-strategy* attribute on the primary key field. You can configure the Meta-Data for the class something like this

```
<entity class="MyClass">
    <attributes>
        <id name="myId">
            <generated-value strategy="IDENTITY"/>
        </id>
    </attributes>
</entity>
```

or using annotations

```
@Entity
public class MyClass
{
    @Id
    @GeneratedValue(strategy=GenerationType.IDENTITY)
    private long myId;
    ...
}
```

Please be aware that if you have an inheritance tree with the base class defined as using "identity" then the column definition for the PK of the base table will be defined as "AUTO_INCREMENT" or "IDENTITY" or "SERIAL" (dependent on the RDBMS) and all subtables will NOT have this identifier added to their PK column definitions. This is because the identities are assigned in the base table (since all objects will have an entry in the base table).

Please note that if using optimistic transactions, this strategy will mean that the value is only set when the object is actually persisted (i.e at flush() or commit())

To configure a class to use this generation using **datastore identity** you need to look at the @DatastoreId extension annotation or the XML <datastore-id> tag

This value generator will generate values unique across different JVMs.

Values generated using this generator are NOT available in @PrePersist, being generated at persist only.

ValueGeneration Strategy TABLE

Applies to all datastores

This method is database neutral and uses a sequence table that holds an incrementing sequence value. The unique identifier value returned from the database is translated to a java type: java.lang.Long. This method require a sequence table in the database and creates one if doesn't exist.

To configure an **application identity** class to use this generation method you simply add this to the class' Meta-Data. If your class is in an inheritance tree you should define this for the base class only.

```
<entity class="MyClass">
    <table-generator name="myGenerator" table="TABLE_VALUE_GEN" pkColumnName="GEN_KEY"
valueColumnName="GEN_VALUE" pkColumnValue="MyClass"/>
    <attributes>
        <id name="myId">
            <generated-value strategy="TABLE"/>
        </id>
    </attributes>
</entity>
```

or using annotations

```
@Entity
@TableGenerator(name="myGenerator", table="TABLE_VALUE_GEN", pkColumnName="GEN_KEY",
valueColumnName="GEN_VALUE", pkColumnValue="MyClass")
public class MyClass
{
    @Id
    @GeneratedValue(strategy=GenerationType.TABLE, generator="myGenerator")
    private long myId;
    ...
}
```

This will create a table in the datastore called "TABLE_VALUE_GEN" with columns "GEN_KEY", "GEN_VALUE" with the key for the row for this class being "MyClass".

Extension properties for configuring sequences can be set in the JPA Meta-Data (via @Extension or <extension>), see the available properties below. Unsupported properties by a database are silently ignored by DataNucleus.

Property	Description	Required
sequence-table-basis	Whether to define uniqueness on the base class name or the base table name. Since there is no "base table name" when the root class has "subclass-table" this should be set to "class" when the root class has "subclass-table" inheritance	No. Defaults to *class*, but the other option is *table*

Property	Description	Required
table-name	Name of the table whose column we are generating the value for (used when we have no previous sequence value and want a start point).	No.
column-name	Name of the column we are generating the value for (used when we have no previous sequence value and want a start point).	No.

To configure a class to use this generation using **datastore identity** you need to look at the @DatastoreId extension annotation or the XML <datastore-id> tag

This value generator will generate values unique across different JVMs

Values generated using this generator are available in @PrePersist.

See also:-

- JPA MetaData reference for <table-generator>
- JPA Annotation reference for @TableGenerator

ValueGeneration Strategy "Custom"

JPA only provides a very restricted set of value generators. DataNucleus provides various others internally. To access these you need to use a custom annotation as follows

```
<entity class="MyClass">
    <attributes>
        <id name="myId">
            <generated-value strategy="uuid"/>
        </id>
    </attributes>
</entity>
```

or using annotations

```
@Entity
public class MyClass
{
    @Id
    @ValueGenerator(strategy="uuid")
    private String myId;
    ...
}
```

This will generate java UUID Strings in the "myId" field. You can also set the "strategy" to "timestamp", "auid", "uuid-string", "uuid-hex", "uuid-object" and "timestamp_value".

Values generated using these generators are available in @PrePersist.

1-1 Relations

You have a 1-to-1 relationship when an object of a class has an associated object of another class (only one associated object). It could also be between an object of a class and another object of the same class (obviously). You can create the relationship in 2 ways depending on whether the 2 classes know about each other (bidirectional), or whether only one of the classes knows about the other class (unidirectional). These are described below.

For RDBMS a 1-1 relation is stored as a foreign-key column(s). For non-RDBMS it is stored as a String "column" storing the 'id' (possibly with the class-name included in the string) of the related object.

DataNucleus does not support a 1-1 relation using a join table. It is not a use-case that is very common. You could look at N-1 unidirectional using join table if you really want to do this

Unidirectional

For this case you could have 2 classes, **User** and **Account**, as below.

```
public class Account
{
    User user;
}

public class User
{
    ...
}
```

so the **Account** class knows about the **User** class, but not vice-versa. If you define the annotations for these classes as follows

```
@Entity
public class Account
{
    ...

    @OneToOne
    @JoinColumn(name="USER_ID")
    User user;
}

@Entity
public class User
{
    ...
}
```

or using XML metadata

```
<entity-mappings>
    <entity class="User">
        <table name="USER"/>
        <attributes>
            <id name="id">
                <column name="USER_ID"/>
            </id>
            ...
    </entity>

    <entity class="Account">
        <table name="ACCOUNT"/>
        <attributes>
            <id name="id">
                <column name="ACCOUNT_ID"/>
            </id>
            ...
            <one-to-one name="user">
                <join-column name="USER_ID"/>
            </one-to-one>
        </attributes>
    </entity>
</entity-mappings>
```

This will create 2 tables in the database, one for **User** (with name *USER*), and one for **Account** (with name *ACCOUNT* and a column *USER_ID*), as shown below.

Account has the object reference to **User** (and so is the "owner" of the relation) and so its table holds the foreign-key

If you call *EntityManager.remove()* on the end of a 1-1 unidirectional relation without the relation and that object is related to another object, an exception will typically be thrown (assuming the datastore supports foreign keys). To delete this record you should remove the other objects association first.

Bidirectional

For this case you could have 2 classes, **User** and **Account** again, but this time as below. Here the **Account** class knows about the **User** class, and also vice-versa.

```
public class Account
{
    User user;

    ...
}

public class User
{
    Account account;

    ...
}
```

We create the 1-1 relationship with a single foreign-key. To do this you define the annotations as

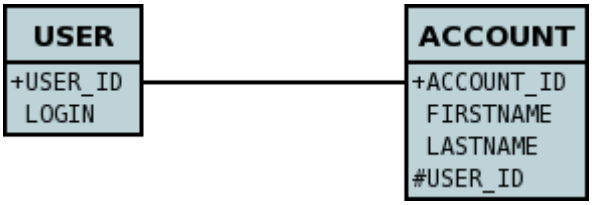
```
@Entity
public class Account
{
    ...

    @OneToOne
    @JoinColumn(name="USER_ID")
    User user;
}

@Entity
public class User
{
    ...

    @OneToOne(mappedBy="user")
    Account account;

    ...
}
```

or using XML metadata

```
<entity-mappings>
    <entity class="User">
        <table name="USER"/>
        <attributes>
            <id name="id">
                <column name="USER_ID"/>
            </id>
            ...
            <one-to-one name="account" mapped-by="user"/>
        </attributes>
    </entity>

    <entity class="Account">
        <table name="ACCOUNT"/>
        <attributes>
            <id name="id">
                <column name="ACCOUNT_ID"/>
            </id>
            ...
            <one-to-one name="user">
                <join-column name="USER_ID"/>
            </one-to-one>
        </attributes>
    </entity>
</entity-mappings>
```

The difference is that we added *mapped-by* to the field of **User** making it bidirectional (and putting the FK at the other side for RDBMS)

This will create 2 tables in the database, one for **User** (with name *USER*), and one for **Account** (with name *ACCOUNT*). For RDBMS it includes a *USER_ID* column in the *ACCOUNT* table, like this



For other types of datastore it will have a *USER_ID* column in the *ACCOUNT* table and a *ACCOUNT* column in the *USER* table.

When forming the relation please make sure that **you set the relation at BOTH sides** since DataNucleus would have no way of knowing which end is correct if you only set one end.

1-N Relations

You have a 1-N (one to many) when you have one object of a class that has a Collection of objects of another class.

Please note that Collections allow duplicates, and so the persistence process reflects this with the choice of primary keys. There are two principal ways in which you can represent this in a datastore : **Join Table** (where a join table is used to provide the relationship mapping between the objects), and **Foreign-Key** (where a foreign key is placed in the table of the object contained in the Collection.

The various possible relationships are described below.

- Collection<Entity> - Unidirectional using join table
- Collection<Entity> - Unidirectional using foreign-key
- Collection<Entity> - Bidirectional using join table
- Collection<Entity> - Bidirectional using foreign-key
- List<Entity>
- Collection<Simple> using join table
- Collection<Simple> using AttributeConverter into single column
- Collection<Entity> using shared join table (DataNucleus Extension)
- Collection<Entity> using shared foreign key (DataNucleus Extension)
- Map<Simple, Entity> using join table
- Map<Entity, Entity> using join table
- Map<Simple, Simple> using join table
- Map<Simple, Simple> using AttributeConverter into single column
- Map<Entity, Simple> using join table
- Map<Simple,Entity> - Unidirectional using foreign-key (key stored in the value class)
- Map<Simple,Entity> - Bidirectional using foreign-key (key stored in the value class)

RDBMS supports the full range of options on this page, whereas other datastores (ODF, Excel, HBase, MongoDB, etc) persist the Collection in a column in the owner object (as well as a column in the non-owner object when bidirectional) rather than using join-tables or foreign-keys since those concepts are RDBMS-only.

equals() and hashCode()

Important : The element of a Collection ought to define the methods *equals* and *hashCode* so that updates are detected correctly. This is because any Java Collection will use these to determine equality and whether an element is *contained* in the Collection. Note also that the hashCode() should be consistent throughout the lifetime of a persistable object. By that we mean

that it should **not** use some basis before persistence and then use some other basis (such as the object identity) after persistence in the equals/hashCode methods.

Collection<Entity> Unidirectional JoinTable

We have 2 sample classes **Account** and **Address**. These are related in such a way as **Account** contains a *Collection* of objects of type **Address**, yet each **Address** knows nothing about the **Account** objects that it relates to. Like this

```
public class Account
{
    Collection<Address> addresses

    ...
}

public class Address
{
    ...
}
```

If you define the annotations of the classes like this

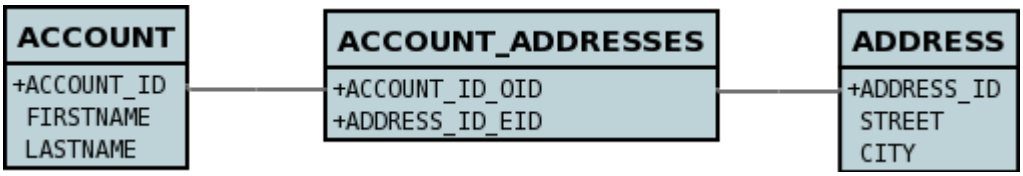
```
public class Account
{
    ...

    @OneToMany
    @JoinTable(name="ACCOUNT_ADDRESSES",
        joinColumns={@JoinColumn(name="ACCOUNT_ID_OID")},
        inverseJoinColumns={@JoinColumn(name="ADDRESS_ID_EID")})
    Collection<Address> addresses
}

public class Address
{
    ...
}
```

or using XML

```
<entity-mappings>
    <entity class="Account">
        <table name="ACCOUNT"/>
        <attributes>
            ...
            <one-to-many name="addresses">
                <join-table name="ACCOUNT_ADDRESSES">
                    <join-column name="ACCOUNT_ID_OID"/>
                    <inverse-join-column name="ADDRESS_ID_EID"/>
                </join-table>
            </one-to-many>
        </attributes>
    </entity>

    <entity class="Address">
        <table name="ADDRESS"/>
         ...
    </entity>
</entity-mappings>
```

The crucial part is the *join-table* element on the field element (@JoinTable annotation) - this signals to JPA to use a join table.

This will create 3 tables in the database, one for **Address**, one for **Account**, and a join table, as shown below.



The join table is used to link the 2 classes via foreign keys to their primary key. This is useful where you want to retain the independence of one class from the other class.

If you wish to fully define the schema table and column names etc, follow these tips

- To specify the name of the table where a class is stored, specify the *table* element below the **class** element
- To specify the names of the columns where the fields of a class are stored, specify the *column* attribute on the **basic** element.
- To specify the name of the join table, specify the *join-table* element below the **one-to-many** element with the collection.
- To specify the names of the join table columns, use the *join-column* and *inverse-join-column* elements below the *join-table* element.
- If the field type is Set then the join table will be given a primary key (since a Set cannot have duplicates), whereas for other Collection types it will not have a primary key (since duplicates are allowed).

Collection<Entity> Unidirectional FK

We have the same classes **Account** and **Address** as above for the join table case, but this time we will store the "relation" as a *foreign key* in the **Address** class. So we define the annotations like this

```
public class Account
{
    ...

    @OneToMany
    @JoinColumn(name="ACCOUNT_ID")
    Collection<Address> addresses
}

public class Address
{
    ...
}
```

or using XML metadata

```
<entity-mappings>
    <entity class="Account">
        <table name="ACCOUNT"/>
        <attributes>
            ...
            <one-to-many name="addresses">
                <join-column name="ACCOUNT_ID"/>
            </one-to-many>
        </attributes>
    </entity>

    <entity class="Address">
        <table name="ADDRESS"/>
        ...
    </entity>
</entity-mappings>
```

you MUST specify the join-column here otherwise it defaults to a join table with JPA!

There will be 2 tables, one for **Address**, and one for **Account**. If you wish to specify the names of the column(s) used in the schema for the foreign key in the **Address** table you should use the *join-column* element within the field of the collection.

In terms of operation within your classes of assigning the objects in the relationship. You have to take your **Account** object and add the **Address** to the **Account** collection field since the **Address** knows nothing about the **Account**.

If you wish to fully define the schema table and column names etc, follow these tips

- To specify the name of the table where a class is stored, specify the *table* element below the **class** element
- To specify the names of the columns where the fields of a class are stored, specify the *column* attribute on the **basic** element.

Since each Address object can have at most one owner (due to the "Foreign Key") this mode of persistence will not allow duplicate values in the Collection. If you want to allow duplicate Collection entries, then use the "Join Table" variant above.

Collection<Entity> Bidirectional JoinTable

We have our 2 sample classes **Account** and **Address**. These are related in such a way as **Account** contains a *Collection* of objects of type **Address**, and now each **Address** has a reference to the **Account** object that it relates to. Like this

```
public class Account
{
    Collection<Address> addresses;

    ...
}

public class Address
{
    Account account;

    ...
}
```

If you define the annotations for these classes as follows

```
public class Account
{
    ...

    @OneToMany(mappedBy="account")
    @JoinTable(name="ACCOUNT_ADDRESSES",
        joinColumns={@JoinColumn(name="ACCOUNT_ID_OID")},
        inverseJoinColumns={@JoinColumn(name="ADDRESS_ID_EID")})
    Collection<Address> addresses;
}

public class Address
{
    ...

    @ManyToOne
    Account account;
}
```

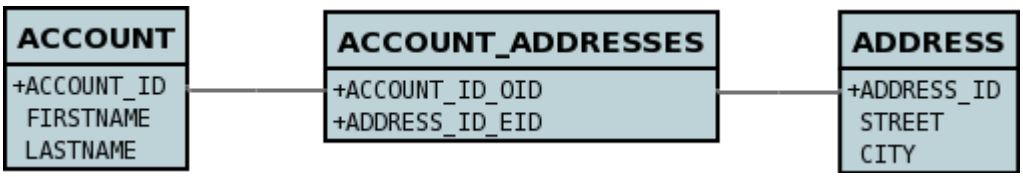
or alternatively using XML

```
<entity-mappings>
    <entity class="Account">
        <table name="ACCOUNT"/>
        <attributes>
            ...
            <one-to-many name="addresses" mapped-by="account">
                <join-table name="ACCOUNT_ADDRESSES">
                    <join-column name="ACCOUNT_ID_OID"/>
                    <inverse-join-column name="ADDRESS_ID_EID"/>
                </join-table>
            </one-to-many>
        </attributes>
    </entity>

    <entity class="Address">
        <table name="ADDRESS"/>
        <attributes>
            ...
            <many-to-one name="account"/>
        </attributes>
    </entity>
</entity-mappings>
```

The crucial part is the *join-table* element on the field element (or @JoinTable annotation) - this signals to JPA to use a join table.

This will create 3 tables in the database, one for **Address**, one for **Account**, and a join table, as

shown below.



The join table is used to link the 2 classes via foreign keys to their primary key. This is useful where you want to retain the independence of one class from the other class.

If you wish to fully define the schema table and column names etc, follow these tips

- To specify the name of the table where a class is stored, specify the *table* element below the **class** element
- To specify the names of the columns where the fields of a class are stored, specify the *column* attribute on the **basic** element.
- To specify the name of the join table, specify the *join-table* element below the **one-to-many** element with the collection.
- To specify the names of the join table columns, use the *join-column* and *inverse-join-column* elements below the *join-table* element.
- If the field type is a Set then the join table will be given a primary key (since a Set cannot have duplicates), whereas for other Collection types no primary key is assigned.
- When forming the relation please make sure that **you set the relation at BOTH sides** since DataNucleus would have no way of knowing which end is correct if you only set one end.

Collection<Entity> Bidirectional FK

We have the same classes **Account** and **Address** as above for the join table case, but this time we will store the "relation" as a *foreign key* in the **Address** class. If you define the annotations for these classes as follows

```
public class Account
{
    ...

    @OneToMany(mappedBy="account")
    @JoinColumn(name="ACCOUNT_ID")
    Collection<Address> addresses
}

public class Address
{
    ...

    @ManyToOne
    Account account;
}
```

or alternatively using XML metadata

```
<entity-mappings>
    <entity class="Account">
        <table name="ACCOUNT"/>
        <attributes>
            ...
            <one-to-many name="addresses" mapped-by="account">
                <join-column name="ACCOUNT_ID"/>
            </one-to-many>
        </attributes>
    </entity>

    <entity class="Address">
        <table name="ADDRESS"/>
        <attributes>
            ...
            <many-to-one name="account"/>
        </attributes>
    </entity>
</entity-mappings>
```

The crucial part is the *mapped-by* attribute of the field on the "1" side of the relationship. This tells the JPA implementation to look for a field called *account* on the **Address** class.

This will create 2 tables in the database, one for **Address** (including an *ACCOUNT_ID* to link to the *ACCOUNT* table), and one for **Account**. Notice the subtle difference to this set-up to that of the **Join Table** relationship earlier.

If you wish to fully define the schema table and column names etc, follow these tips

- To specify the name of the table where a class is stored, specify the *table* element below the *class*element
- To specify the names of the columns where the fields of a class are stored, specify the *column* attribute on the **basic** element.
- When forming the relation please make sure that **you set the relation at BOTH sides** since DataNucleus would have no way of knowing which end is correct if you only set one end.

Since each Address object can have at most one owner (due to the "Foreign Key") this mode of persistence will not allow duplicate values in the Collection. If you want to allow duplicate Collection entries, then use the "Join Table" variant above.

Using a List

In the case of the relation field being a List (i.e ordered), you define the relation just like you would for a Collection (above) but then define whether you want the relation to be either *ordered* or *indexed*.

In the case of *ordered* you would add the following to the metadata of the field

```
@OrderBy("city")
```

or using XML

```
<order-by>city</order-by>
```

This means that when the elements of the List are retrieved then they will be ordered according to the *city* field of the element.

If instead you want an *indexed* list then the elements will have an index stored against them, hence preserving the order in which they were in the original List. This adds a surrogate column to either the table of the element (when using *foreign key*) or to the join table.

```
@OrderColumn("ORDERING")
```

or using XML

```
<order-column>ORDERING</order-column>
```

Collection<Simple> via JoinTable

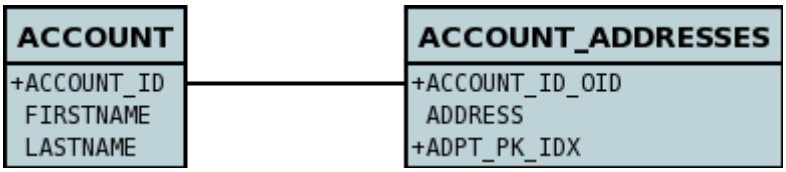
All of the examples above show a 1-N relationship between 2 entities. If you want the element to be primitive or Object types then follow this section. For example, when you have a Collection of Strings. This will be persisted in the same way as the "Join Table" examples above. A join table is created to hold the collection elements. Let's take our example. We have an **Account** that stores a Collection of addresses. These addresses are simply Strings. We define the annotations like this

```
@Entity
public class Account
{
    ...

    @ElementCollection
    @CollectionTable(name="ACCOUNT_ADDRESSES")
    Collection<String> addresses;
}
```

or using XML metadata

```
<entity class="mydomain.Account">
    <attributes>
        ...
        <element-collection name="addresses">
            <collection-table name="ACCOUNT_ADDRESSES"/>
        </element-collection>
    </attributes>
</entity>
```

In the datastore the following is created



The ACCOUNT table is as before, but this time we only have the "join table". Use @Column on the field/method to define the column details of the element in the join table.

Collection<Simple> using AttributeConverter via column

Just like in the above example, here we have a Collection of simple types. In this case we are

wanting to store this Collection into a single column in the owning table. We do this by using a JPA AttributeConverter.

```
public class Account
{
    ...

    @ElementCollection
    @Convert(CollectionStringToStringConverter.class)
    @Column(name="ADDRESSES")
    Collection<String> addresses;
}
```

and then define our converter. You can clearly define your conversion process how you want it. You could, for example, convert the Collection into comma-separated strings, or could use JSON, or XML, or some other format.

```
public class CollectionStringToStringConverter implements AttributeConverter
<Collection<String>, String>
{
    public String convertToDatabaseColumn(Collection<String> attribute)
    {
        if (attribute == null)
        {
            return null;
        }

        StringBuilder str = new StringBuilder();
        ... convert Collection to String
        return str.toString();
    }

    public Collection<String> convertToEntityAttribute(String columnValue)
    {
        if (columnValue == null)
        {
            return null;
        }

        Collection<String> coll = new HashSet<String>();
        ... convert String to Collection
        return coll;
    }
}
```

Collection<Entity> via Shared JoinTable

The relationships using join tables shown above rely on the join table relating to the relation in question. DataNucleus allows the possibility of sharing a join table between relations. The example below demonstrates this. We take the example as show above (1-N Unidirectional Join table relation), and extend **Account** to have 2 collections of **Address** records. One for home addresses and one for work addresses, like this

```
public class Account
{
    Collection<Address> workAddresses;

    Collection<Address> homeAddresses;

    ...
}
```

We now change the metadata we had earlier to allow for 2 collections, but sharing the join table

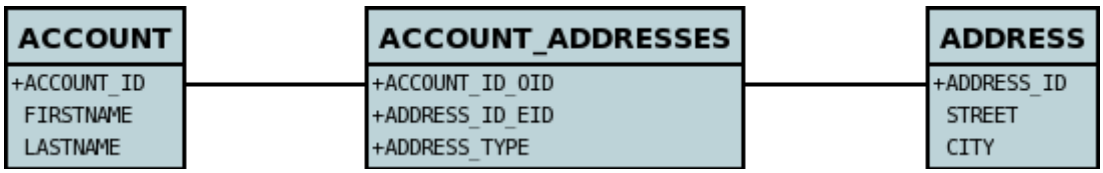
```
import org.datanucleus.api.jpa.annotations.SharedRelation;

public class Account
{
    @OneToMany
    @JoinTable(name="ACCOUNT_ADDRESSES",
        joinColumns={@JoinColumn(name="ACCOUNT_ID_OID")},
        inverseJoinColumns={@JoinColumn(name="ADDRESS_ID_EID")})
    @SharedRelation(column="ADDRESS_TYPE", value="work")
    Collection<Address> workAddresses;

    @OneToMany
    @JoinTable(name="ACCOUNT_ADDRESSES",
        joinColumns={@JoinColumn(name="ACCOUNT_ID_OID")},
        inverseJoinColumns={@JoinColumn(name="ADDRESS_ID_EID")})
    @SharedRelation(column="ADDRESS_TYPE", value="home")
    Collection<Address> homeAddresses;

    ...
}
```

or using XML metadata

```
<entity-mappings>
    <entity class="Account">
        <table name="ACCOUNT"/>
        <attributes>
            ...
            <one-to-many name="workAddresses">
                <join-table name="ACCOUNT_ADDRESSES">
                    <join-column name="ACCOUNT_ID_OID"/>
                    <inverse-join-column name="ADDRESS_ID_EID"/>
                </join-table>
                <extension key="relation-discriminator-column" value="ADDRESS_TYPE"/>
                <extension key="relation-discriminator-value" value="work"/>
                <!--extension key="relation-discriminator-pk" value="true"/-->
            </one-to-many>
            <one-to-many name="homeAddresses">
                <join-table name="ACCOUNT_ADDRESSES">
                    <join-column name="ACCOUNT_ID_OID"/>
                    <inverse-join-column name="ADDRESS_ID_EID"/>
                </join-table>
                <extension key="relation-discriminator-column" value="ADDRESS_TYPE"/>
                <extension key="relation-discriminator-value" value="home"/>
                <!--extension key="relation-discriminator-pk" value="true"/-->
            </one-to-many>
        </attributes>
    </entity>

    <entity class="Address">
        <table name="ADDRESS"/>
         ...
    </entity>
</entity-mappings>
```

So we have defined the same join table for the 2 collections "ACCOUNT_ADDRESSES", and the same columns in the join table, meaning that we will be sharing the same join table to represent both relations. The important step is then to define the 3 DataNucleus *extension* tags. These define a column in the join table (the same for both relations), and the value that will be populated when a row of that collection is inserted into the join table. In our case, all "home" addresses will have a value of "home" inserted into this column, and all "work" addresses will have "work" inserted. This means we can now identify easily which join table entry represents which relation field.

This results in the following database schema



Collection<Entity> via Shared FK

The relationships using foreign keys shown above rely on the foreign key relating to the relation in question. DataNucleus allows the possibility of sharing a foreign key between relations between the same classes. The example below demonstrates this. We take the example as show above (1-N Unidirectional Foreign Key relation), and extend **Account** to have 2 collections of **Address** records. One for home addresses and one for work addresses, like this

```
public class Account
{
    Collection<Address> workAddresses;

    Collection<Address> homeAddresses;

    ...
}
```

We now change the metadata we had earlier to allow for 2 collections, but sharing the join table

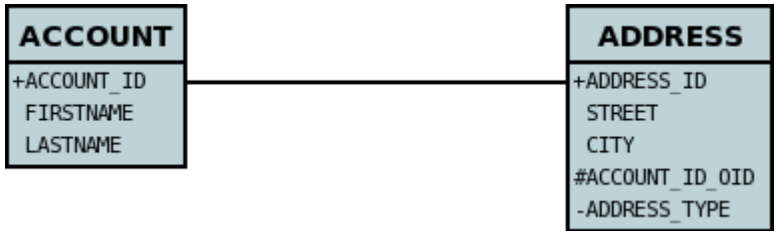
```
import org.datanucleus.api.jpa.annotations.SharedRelation;

public class Account
{
    ...

    @OneToMany
    @SharedRelation(column="ADDRESS_TYPE", value="work")
    Collection<Address> workAddresses;

    @OneToMany
    @SharedRelation(column="ADDRESS_TYPE", value="home")
    Collection<Address> homeAddresses;

    ...
}
```

or using XML metadata

```
<entity-mappings>
    <entity class="Account">
        <table name="ACCOUNT"/>
        <attributes>
            ...
            <one-to-many name="workAddresses">
                <join-column name="ACCOUNT_ID_OID"/>
                <extension key="relation-discriminator-column" value="ADDRESS_TYPE"/>
                <extension key="relation-discriminator-value" value="work"/>
            </one-to-many>
            <one-to-many name="homeAddresses">
                <join-column name="ACCOUNT_ID_OID"/>
                <extension key="relation-discriminator-column" value="ADDRESS_TYPE"/>
                <extension key="relation-discriminator-value" value="home"/>
            </one-to-many>
        </attributes>
    </entity>

    <entity class="Address">
        <table name="ADDRESS"/>
        ...
    </entity>
</entity-mappings>
```

So we have defined the same foreign key for the 2 collections "ACCOUNT_ID_OID", The important step is then to define the 2 DataNucleus *extension* tags (@SharedRelation annotation). These define a column in the element table (the same for both relations), and the value that will be populated when a row of that collection is inserted into the element table. In our case, all "home" addresses will have a value of "home" inserted into this column, and all "work" addresses will have "work" inserted. This means we can now identify easily which element table entry represents which relation field.

This results in the following database schema



Map<Simple, Entity> via JoinTable

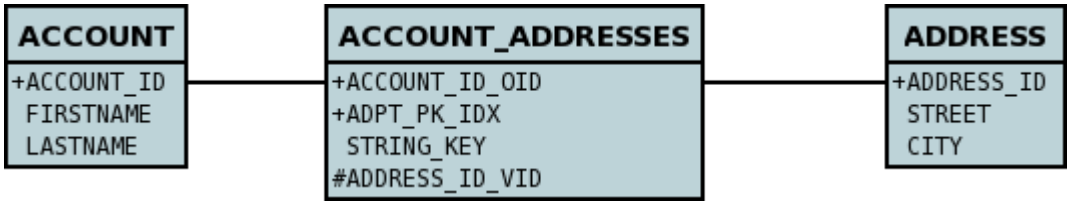
We have a class **Account** that contains a Map of Address objects. Here our key is a simple type (in this case a String) and the values are entities. Like this

```
public class Account
{
    Map<String, Address> addresses;

    ...
}

public class Address {...}
```

If you define the annotations for these classes as follows

```
@Entity
public class Account
{
    @OneToMany
    @JoinTable
    Map<String, Address> addresses;

    ...
}

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

This will create 3 tables in the datastore, one for **Account**, one for **Address** and a join table also containing the key.



You can configure the names of the key column(s) in the join table using the *joinColumns* attribute of @CollectionTable, or the names of the value column(s) using @Column for the field/method.

The column ADPT_PK_IDX is added by DataNucleus when the column type of the key is not valid to be part of a primary key (with the RDBMS being used). If the column type of your key is acceptable for use as part of a primary key then you will not have this "ADPT_PK_IDX" column.

Map<Simple, Simple> via JoinTable

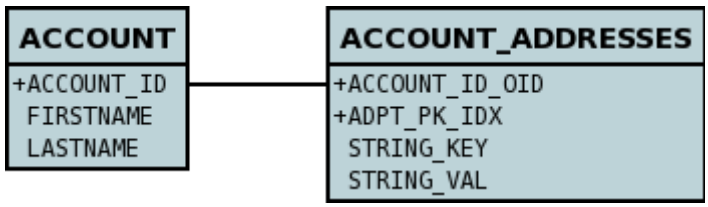
Here our keys and values are of simple types (in this case a String). Like this

```
public class Account
{
    Map<String, String> addresses;

    ...
}
```

If you define the annotations for these classes as follows

```
@Entity
public class Account
{
    @ElementCollection
    @CollectionTable
    Map<String, String> addresses;

    ...
}
```

This results in just 2 tables. The "join" table contains both the key AND the value.



You can configure the names of the key column(s) in the join table using the *joinColumns* attribute of @CollectionTable, or the names of the value column(s) using @Column for the field/method.

Please note that the column ADPT_PK_IDX is added by DataNucleus when the column type of the key is not valid to be part of a primary key (with the RDBMS being used). If the column type of your key is acceptable for use as part of a primary key then you will not have this "ADPT_PK_IDX" column.

Map<Simple, Simple> using AttributeConverter via column

Just like in the above example, here we have a Map of simple keys/values. In this case we are wanting to store this Map into a single column in the owning table. We do this by using a JPA AttributeConverter.

```
public class Account
{
    ...

    @ElementCollection
    @Convert(MapStringStringToStringConverter.class)
    @Column(name="ADDRESSES")
    Map<String, String> addresses;
}
```

and then define our converter. You can clearly define your conversion process how you want it. You could, for example, convert the Map into comma-separated strings, or could use JSON, or XML, or some other format.

```
public class MapStringStringToStringConverter implements AttributeConverter<Map<
String, String>, String>
{
    public String convertToDatabaseColumn(Map<String, String> attribute)
    {
        if (attribute == null)
        {
            return null;
        }

        StringBuilder str = new StringBuilder();
        ... convert Map to String
        return str.toString();
    }

    public Map<String, String> convertToEntityAttribute(String columnValue)
    {
        if (columnValue == null)
        {
            return null;
        }

        Map<String, String> map = new HashMap<String, String>();
        ... convert String to Map
        return map;
    }
}
```

Map<Entity, Entity> via JoinTable

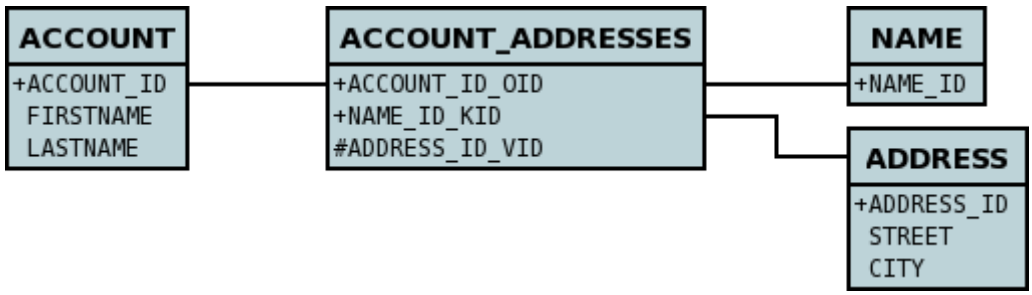
We have a class **Account** that contains a Map of Address objects. Here our key is an entity type and the values is an entity type also. Like this

```
public class Account
{
    Map<Name, Address> addresses;

    ...
}

public class Name {...}

public class Address {...}
```

If you define the annotations for these classes as follows

```
@Entity
public class Account
{
    @OneToMany
    @JoinTable
    Map<Name, Address> addresses;

    ...
}

@Entity
public class Name {...}

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

This will create 4 tables in the datastore, one for **Account**, one for **Name**, one for **Address** and a join table to link them.



You can configure the names of the key column(s) in the join table using the *joinColumns* attribute of @JoinTable, or the names of the value column(s) using @Column for the field/method.

The column ADPT_PK_IDX is added by DataNucleus when the column type of the key is not valid to be part of a primary key (with the RDBMS being used). If the column type of your key is acceptable for use as part of a primary key then you will not have this "ADPT_PK_IDX" column.

Map<Entity, Simple> via JoinTable

Here our key is an entity type and the value is a simple type (in this case a String).

JPA does NOT properly allow for this in its specification. Other implementations introduced the following hack so we also provide it. Note that there is no @OneToMany annotation here so this is seemingly not a *relation* to JPA (hence our description of this as a hack). Anyway use it to workaround JPA's lack of feature.

If you define the Meta-Data for these classes as follows

```
@Entity
public class Account
{
    @ElementCollection
    @JoinTable
    Map<Address, String> addressLookup;

    ...
}

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

This will create 3 tables in the datastore, one for **Account**, one for **Address** and a join table also containing the value.

You can configure the names of the columns in the join table using the *joinColumns* attributes of the various annotations.

Map<Simple,Entity> Unidirectional FK (key stored in value)

In this case we have an object with a Map of objects and we're associating the objects using a foreign-key in the table of the value. We're using a field (*alias*) in the Address class as the key of the map.

```
public class Account
{
    Map<String, Address> addresses;

    ...
}

public class Address
{
    String alias;

    ...
}
```

In this relationship, the **Account** class has a Map of **Address** objects, yet the **Address** knows nothing about the **Account**. In this case we don't have a field in the Address to link back to the Account and so DataNucleus has to use columns in the datastore representation of the **Address** class. So we define the annotations like this

```
@Entity
public class Account
{
    @OneToMany
    @MapKey(name="alias")
    @JoinColumn(name="ACCOUNT_ID_OID")
    Map<String, Address> addresses;

    ...
}

@Entity
public class Address
{
    String alias;

    ...
}
```

or using XML metadata

```
<entity-mappings>
    <entity class="Account">
        <table name="ACCOUNT"/>
        <attributes>
            ...
            <one-to-many name="addresses">
                <map-key name="alias"/>
                <join-column name="ACCOUNT_ID_OID"/>
            </one-to-many>
        </attributes>
    </entity>

    <entity class="Address">
        <table name="ADDRESS"/>
        <attributes>
            ...
            <basic name="alias">
                <column name="KEY" length="20"/>
            </basic>
        </attributes>
    </entity>
</entity-mappings>
```

Again there will be 2 tables, one for **Address**, and one for **Account**. If you wish to specify the names of the columns used in the schema for the foreign key in the **Address** table you should use the *join-column* element within the field of the map.

In terms of operation within your classes of assigning the objects in the relationship. You have to take your **Account** object and add the **Address** to the **Account** map field since the **Address** knows nothing about the **Account**. Also be aware that each **Address** object can have only one owner, since it has a single foreign key to the **Account**.

Map<Simple,Entity> Bidirectional FK (key stored in value)

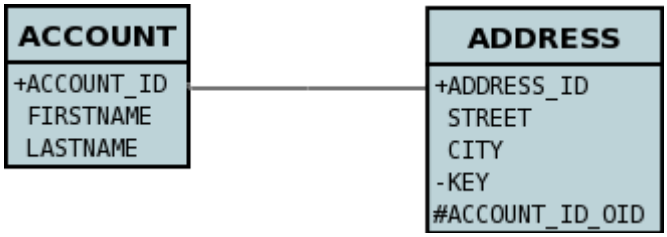
In this case we have an object with a Map of objects and we're associating the objects using a foreign-key in the table of the value.

```
public class Account
{
    long id;

    Map<String, Address> addresses;

    ...
}

public class Address
{
    long id;

    String alias;

    Account account;

    ...
}
```

With these classes we want to store a foreign-key in the value table (ADDRESS), and we want to use the "alias" field in the Address class as the key to the map. If you define the Meta-Data for these classes as follows

```
<entity-mappings>
    <entity class="Account">
        <table name="ACCOUNT"/>
        <attributes>
            ...
            <one-to-many name="addresses" mapped-by="account">
                <map-key name="alias"/>
            </one-to-many>
        </attributes>
    </entity>

    <entity class="Address">
        <table name="ADDRESS"/>
        <attributes>
            ...
            <basic name="alias">
                <column name="KEY" length="20"/>
            </basic>
            <many-to-one name="account">
                <join-column name="ACCOUNT_ID_OID"/>
            </many-to-one>
        </attributes>
    </entity>
</entity-mappings>
```

This will create 2 tables in the datastore. One for **Account**, and one for **Address**. The table for **Address** will contain the key field as well as an index to the **Account** record (notated by the *mapped-by* tag).



N-1 Relations

You have a N-to-1 relationship when an object of a class has an associated object of another class (only one associated object) and several of this type of object can be linked to the same associated object. From the other end of the relationship it is effectively a 1-N, but from the point of view of the object in question, it is N-1. You can create the relationship in 2 ways depending on whether the 2 classes know about each other (bidirectional), or whether only the "N" side knows about the other class (unidirectional). These are described below.

For RDBMS a N-1 relation is stored as a foreign-key column(s). For non-RDBMS it is stored as a String "column" storing the 'id' (possibly with the class-name included in the string) of the related object.

Unidirectional with ForeignKey

For this case you could have 2 classes, **User** and **Account**, as below.

```
public class Account
{
    User user;

    ...
}

public class User
{
    ...
}
```

so the **Account** class ("N" side) knows about the **User** class ("1" side), but not vice-versa. A particular user could be related to several accounts. If you define the annotations for these classes as follows

```
@Entity
public class Account
{
    ...

    @ManyToOne
    User user;
}
```

or using XML metadata

```
<entity-mappings>
    <entity class="User">
        <table name="USER"/>
        <attributes>
            <id name="id">
                <column name="USER_ID"/>
            </id>
            ...
        </attributes>
    </entity>

    <entity class="Account">
        <table name="ACCOUNT"/>
        <attributes>
            <id name="id">
                <column name="ACCOUNT_ID"/>
            </id>
            ...
            <many-to-one name="user"/>
        </attributes>
    </entity>
</entity-mappings>
```

This will create 2 tables in the database, one for **User** (with name *USER*), and one for **Account** (with name *ACCOUNT*), and a foreign-key in the *ACCOUNT* table, just like for the case of a @OneToOne relation.

Note that in the case of non-RDBMS datastores there is simply a "column" in the *ACCOUNT* "table", storing the "id" of the related object*

Unidirectional with JoinTable

For this case we have the same 2 classes, **User** and **Account**, as before.

```
public class Account
{
    User user;

    ...
}

public class User
{
    ...
}
```

so the **Account** class ("N" side) knows about the **User** class ("1" side), but not vice-versa, and are using a join table. A particular user could be related to several accounts. If you define the

annotations for these classes as follows

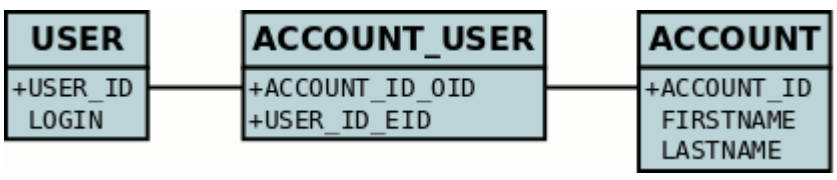
```
@Entity
public class Account
{
    @ManyToOne
    @JoinTable(name="ACCOUNT_USER")
    User user;

    ....
}
```

or using XML metadata

```
<entity-mappings>
    <entity class="User">
        <table name="USER"/>
        <attributes>
            <id name="id">
                <column name="USER_ID"/>
            </id>
            ...
        </attributes>
    </entity>

    <entity class="Account">
        <table name="ACCOUNT"/>
        <attributes>
            <id name="id">
                <column name="ACCOUNT_ID"/>
            </id>
            ...
            <many-to-one name="user">
                <join-table name="ACCOUNT_USER"/>
            </many-to-one>
        </attributes>
    </entity>
</entity-mappings>
```

alternatively using annotations

This will create 3 tables in the database, one for **User** (with name *USER*), one for **Account** (with name *ACCOUNT*), and a join table (with name *ACCOUNT_USER*), as shown below.



Note that in the case of non-RDBMS datastores there is no join-table, simply a "column" in the *ACCOUNT* "table", storing the "id" of the related object

Bidirectional

This relationship is described in the guide for 1-N relationships. In particular there are 2 ways to define the relationship for RDBMS : the first uses a Join Table to hold the relationship, whilst the second uses a Foreign Key in the "N" object to hold the relationship. For non-RDBMS datastores each side will have a "column" (or equivalent) in the "table" of the N side storing the "id" of the related (owning) object. Please refer to the 1-N relationships bidirectional relations since they show this exact relationship.

M-N Relations

You have a M-to-N (or Many-to-Many) relationship if an object of a class A has associated objects of class B, and class B has associated objects of class A. This relationship may be achieved through Java Collection, Set, List or subclasses of these, although the only one that supports a true M-N is Set.

With DataNucleus this can be set up as described in this section, using what is called a *Join Table* relationship. Let's take the following example and describe how to model it with the different types of collection classes. We have 2 classes, **Product** and **Supplier** as below.

```
public class Product
{
    Set<Supplier> suppliers;

    ...
}

public class Supplier
{
    Set<Product> products;

    ...
}
```

Here the **Product** class knows about the **Supplier** class. In addition the **Supplier** knows about the **Product** class, however with these relationships are really independent.

Please note that RDBMS supports the full range of options on this page, whereas other datastores (ODF, Excel, HBase, MongoDB, etc) persist the Collection in a column in the owner object (as well as a column in the non-owner object when bidirectional) rather than using join-tables or foreign-keys since those concepts are RDBMS-only.

when adding objects to an M-N relation, you MUST add to the owner side as a minimum, and optionally also add to the non-owner side. Just adding to the non-owner side will not add the relation.

If you want to delete an object from one end of a M-N relationship you will have to remove it first from the other objects relationship. If you don't you will get an error message that the object to be deleted has links to other objects and so cannot be deleted.

The various possible relationships are described below.

- M-N Set relation

equals() and hashCode()

Important : The element of a Collection ought to define the methods *equals* and *hashCode* so that updates are detected correctly. This is because any Java Collection will use these to determine equality and whether an element is *contained* in the Collection. Note also that the *hashCode()* should be consistent throughout the lifetime of a persistable object. By that we mean that it should **not** use some basis before persistence and then use some other basis (such as the object identity) after persistence in the equals/hashCode methods.

Using Set

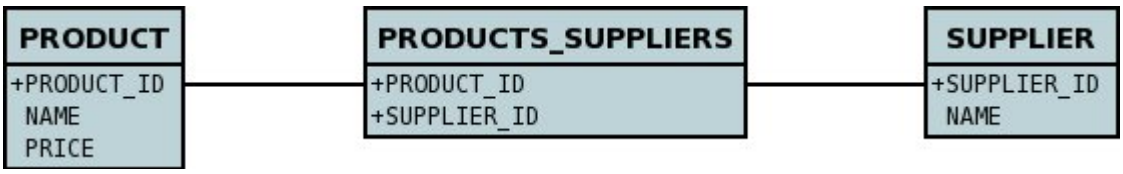
If you define the Meta-Data for these classes as follows

```
public class Product
{
    ...

    @ManyToMany(mappedBy="products")
    @JoinTable(name="PRODUCTS_SUPPLIERS",
        joinColumns={@JoinColumn(name="PRODUCT_ID")},
        inverseJoinColumns={@JoinColumn(name="SUPPLIER_ID")})
    Set<Supplier> suppliers
}

public class Supplier
{
    ...

    @ManyToMany
    Set<Product> products;

    ...
}
```

or using XML metadata

```
<entity-mappings>
    <entity class="mydomain.Product">
        <table name="PRODUCT"/>
        <attributes>
            <id name="id">
                <column name="PRODUCT_ID"/>
            </id>
            ...
            <many-to-many name="suppliers" mapped-by="products">
                <join-table name="PRODUCTS_SUPPLIERS">
                    <join-column name="PRODUCT_ID"/>
                    <inverse-join-column name="SUPPLIER_ID"/>
                </join-table>
            </many-to-many>
        </attributes>
    </entity>

    <entity class="mydomain.Supplier">
        <table name="SUPPLIER"/>
        <attributes>
            <id name="id">
                <column name="SUPPLIER_ID"/>
            </id>
            ...
            <many-to-many name="products"/>
        </attributes>
    </entity>
</entity-mappings>
```

Note how we have specified the information only once regarding join table name, and join column names as well as the <join-table>. This is the JPA standard way of specification, and results in a single join table. The "mapped-by" ties the two fields together.



Using Ordered Lists

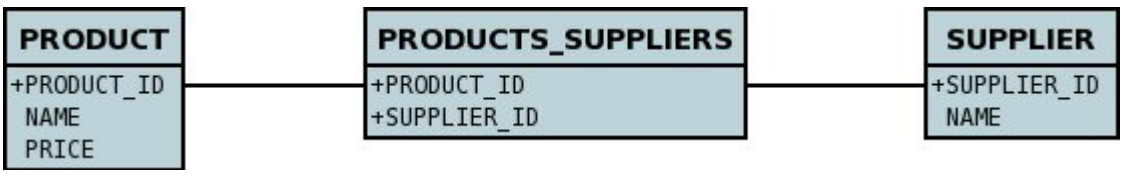
In this case our fields are of type List instead of Set used above. If you define the annotations for these classes as follows

```
public class Product
{
    ...

    @ManyToMany
    @JoinTable(name="PRODUCTS_SUPPLIERS",
        joinColumns={@JoinColumn(name="PRODUCT_ID")},
        inverseJoinColumns={@JoinColumn(name="SUPPLIER_ID")})
    @OrderBy("id")
    List<Supplier> suppliers
}

public class Supplier
{
    ...

    @ManyToMany
    @OrderBy("id")
    List<Product> products
}
```

or using XML metadata

```
<entity-mappings>
    <entity class="mydomain.Product">
        <table name="PRODUCT"/>
        <attributes>
            <id name="id">
                <column name="PRODUCT_ID"/>
            </id>
            ...
            <many-to-many name="suppliers" mapped-by="products">
                <order-by>name</order-by>
                <join-table name="PRODUCTS_SUPPLIERS">
                    <join-column name="PRODUCT_ID"/>
                    <inverse-join-column name="SUPPLIER_ID"/>
                </join-table>
            </many-to-many>
        </attributes>
    </entity>

    <entity class="mydomain.Supplier">
        <table name="SUPPLIER"/>
        <attributes>
            <id name="id">
                <column name="SUPPLIER_ID"/>
            </id>
            ...
            <many-to-many name="products">
                <order-by>name</order-by>
            </many-to-many>
        </attributes>
    </entity>
</entity-mappings>
```

There will be 3 tables, one for **Product**, one for **Supplier**, and the join table. The difference from the Set example is that we now have <order-by> at both sides of the relation. This has no effect in the datastore schema but when the Lists are retrieved they are ordered using the specified *order-by*.



You cannot have a many-to-many relation using indexed lists since both sides would need its own index.

Arrays

JPA defines support the persistence of arrays but only arrays of byte, Byte, char, Character. DataNucleus supports all types of arrays, as follows

- Single Column - the array is byte-streamed into a single column in the table of the containing object.
- Simple array stored in JoinTable - the array is stored in a "join" table, with a column in that table storing each element of the array
- Entity array via JoinTable - the array is stored via a "join" table, with FK across to the element Entity.
- Entity array via ForeignKey - the array is stored via a FK in the element Entity.

Single Column Arrays (serialised)

Let's suppose you have a class something like this

```
public class Account
{
    byte[] permissions;

    ...
}
```

So we have an **Account** and it has a number of permissions, each expressed as a byte. We want to persist the permissions in a single-column into the table of the account. We then define MetaData something like this

```
<entity class="Account">
    <table name="ACCOUNT"/>
    <attributes>
        ...
        <basic name="permissions">
            <column name="PERMISSIONS"/>
            <lob/>
        </basic>
        ...
    </attributes>
</entity>
```

This results in a datastore schema as follows

See also :-

- MetaData reference for <basic> element
- Annotations reference for @Basic

Simple array stored in join table

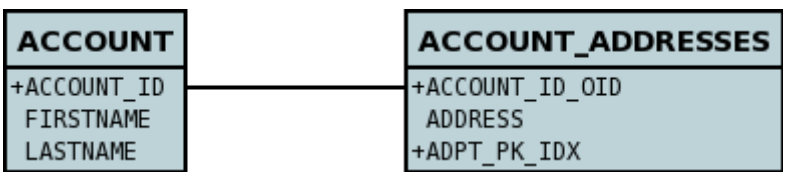
If you want an array of non-entity objects be stored in a "join" table, you can follow this example. We have an **Account** that stores a Collection of addresses. These addresses are simply Strings. We define the annotations like this

```
@Entity
public class Account
{
    ...

    @ElementCollection
    @CollectionTable(name="ACCOUNT_ADDRESSES")
    String[] addresses;
}
```

or using XML metadata

```
<entity class="mydomain.Account">
    <attributes>
        ...
        <element-collection name="addresses">
            <collection-table name="ACCOUNT_ADDRESSES"/>
        </element-collection>
    </attributes>
</entity>
```

In the datastore the following is created



Use @Column on the field/method to define the column details of the element in the join table.

Entity array persisted into Join Tables

DataNucleus will support arrays persisted into a join table. Let's take the example of a class Account with an array of Permission objects, so we have

```
public class Account
{
    ...

    Permission[] permissions;
}

public class Permission
{
    ...
}
```

So an **Account** has an array of *Permission*s, and both of these objects are entities. We want to persist the relationship using a join table. We define the MetaData as follows

```
@Entity
public class Account
{
    ...

    @OneToMany
    @JoinTable(name="ACCOUNT_PERMISSIONS", joinColumns={@Column(name="ACCOUNT_ID")},
inverseJoinColumns={@Column(name="PERMISSION_ID")})
    @OrderColumn(name="PERMISSION_ORDER_IDX")
    Permission[] permissions;
}

@Entity
public class Permission
{
    ...
}
```

or using XML metadata

```
<entity class="mydomain.Account">
    <attributes>
        ...
        <one-to-many name="permissions">
            <join-table name="ACCOUNT_PERMISSIONS">
                <join-column name="ACCOUNT_ID"/>
                <inverse-join-column name="PERMISSION_ID"/>
            </join-table>
            <order-column name="PERMISSION_ORDER_IDX"/>
        </one-to-many>
    </attributes>
</entity>
<entity name="Permission" table="PERMISSION">
</entity>
```

This results in a datastore schema as follows

Entity array persisted using Foreign-Keys

DataNucleus will support arrays persisted via a foreign-key in the element table. This is only applicable when the array is an entity. Let's take the same example above. So we have

```
public class Account
{
    ...

    Permission[] permissions;
}

public class Permission
{
    ...
}
```

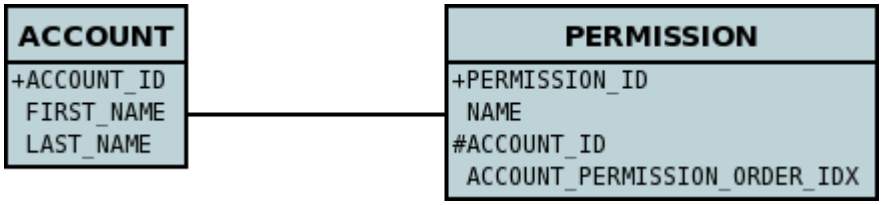
So an **Account** has an array of *Permission*s, and both of these objects are entities. We want to persist the relationship using a foreign-key in the table for the Permission class. We define the MetaData as follows

```
@Entity
public class Account
{
    @OneToMany
    @JoinColumn(name="ACCOUNT_ID")
    @OrderColumn(name="PERMISSION_ORDER_IDX")
    Permission[] permissions;

    ....
}

@Entity
public class Permission
{
    ...
}
```

or using XML metadata

```
<entity class="mydomain.Account">
    <attributes>
        ...
        <one-to-many name="permissions">
            <join-column name="ACCOUNT_ID"/>
            <order-column name="PERMISSION_ORDER_IDX"/>
        </one-to-many>
    </attributes>
</entity>
<entity name="Permission" table="PERMISSION">
</entity>
```

This results in a datastore schema as follows



Interfaces

JPA doesn't define support for persisting fields of type interface, but DataNucleus provides an extension whereby the implementations of the interface are entities. It follows the same general process as for java.lang.Object since both interfaces and java.lang.Object are basically *references* to some entity.

To demonstrate interface handling let's introduce some classes. Suppose you have an interface with a selection of classes implementing the interface something like this

```
public interface Shape
{
    double getArea();
}

public class Circle implements Shape
{
    double radius;
    ...
}

public class Square implements Shape
{
    double length;
    ...
}

public Rectange implements Shape
{
    double width;
    double length;
    ...
}
```

You then have a class that contains an object of this interface type

```
public class ShapeHolder
{
    protected Shape shape=null;
    ...
}
```

DataNucleus allows the following strategies for mapping this field

- **per-implementation** : a FK is created for each implementation so that the datastore can provide referential integrity. The other advantage is that since there are FKs then querying can

be performed. The disadvantage is that if there are many implementations then the table can become large with many columns not used

- **identity** : a single column is added and this stores the class name of the implementation stored, as well as the identity of the object. The advantage is that if you have large numbers of implementations then this can cope with no schema change. The disadvantages are that no querying can be performed, and that there is no referential integrity.
- **xcalia** : a slight variation on "identity" whereby there is a single column yet the contents of that column are consistent with what Xcalia XIC JDO implementation stored there.

The user controls which one of these is to be used by specifying the *extension* **mapping-strategy** on the field containing the interface. The default is "per-implementation"

In terms of the implementations of the interface, you can either leave the field to accept any *known about* implementation, or you can restrict it to only accept some implementations (see "implementation-classes" metadata extension). If you are leaving it to accept any persistable implementation class, then you need to be careful that such implementations are known to DataNucleus at the point of encountering the interface field. By this we mean, DataNucleus has to have encountered the metadata for the implementation so that it can allow for the implementation when handling the field. You can force DataNucleus to know about a persistable class by using an autostart mechanism, or using `persistence.xml`.

1-1 Interface Relation

To allow persistence of this interface field with DataNucleus you have 2 levels of control. The first level is global control. Since all of our *Square*, *Circle*, *Rectangle* classes implement *Shape* then we just define them in the MetaData as we would normally.

```
@Entity
public class Square implement Shape
{
    ...
}
@Entity
public class Circle implement Shape
{
    ...
}
@Entity
public class Rectangle implement Shape
{
    ...
}
```

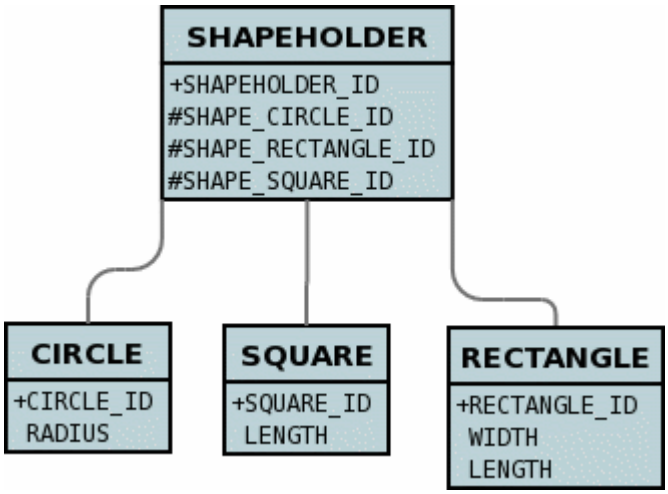
The global way means that when mapping that field DataNucleus will look at all Entities it knows about that implement the specified interface.

DataNucleus also allows users to specify a list of classes implementing the interface on a field-by-

field basis, defining which of these implementations are accepted for a particular interface field. To do this you define the Meta-Data like this

```
@Entity
public class ShapeHolder
{
    @OneToOne
    @Extension(key="implementation-classes",
        value="mydomain.Circle,mydomain.Rectangle,mydomain.Square")
    Shape shape;

    ...
}
```

That is, for any interface object in a class to be persisted, you define the possible implementation classes that can be stored there. DataNucleus interprets this information and will map the above example classes to the following in the database

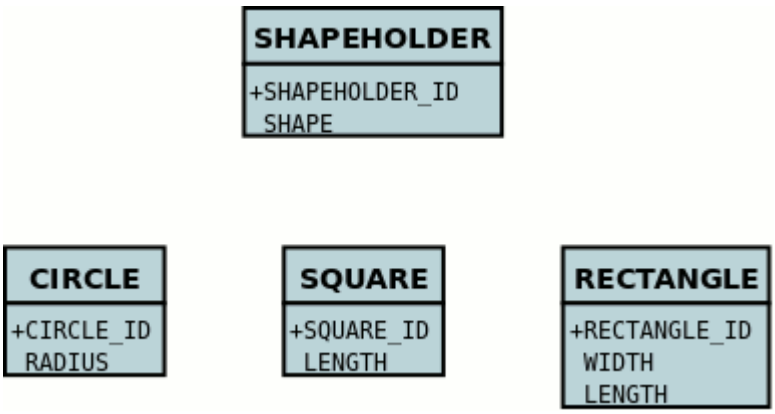


So DataNucleus adds foreign keys from the containers table to all of the possible implementation tables for the *shape* field.

If we use **mapping-strategy** of "identity" then we get a different datastore schema.

```
@Entity
public class ShapeHolder
{
    @OneToOne
    @Extension(key="implementation-classes", value
="mydomain.Circle,mydomain.Rectangle,mydomain.Square")
    @Extension(key="mapping-strategy", value="identity")
    Shape shape;

    ...
}
```

and the datastore schema becomes



and the column "SHAPE" will contain strings such as *mydomain.Circle:1* allowing retrieval of the related implementation object.

1-N Interface Relation

You can have a Collection/Map containing elements of an interface type. You specify this in the same way as you would any Collection/Map. **You can have a Collection of interfaces as long as you use a join table relation and it is unidirectional.** The "unidirectional" restriction is that the interface is not persistent on its own and so cannot store the reference back to the owner object. Use the 1-N relationship guides for the metadata definition to use.

You need to use a DataNucleus extension tag "implementation-classes" if you want to restrict the collection to only contain particular implementations of an interface. For example

```
@Entity
public class ShapeHolder
{
    @OneToMany
    @JoinTable
    @Extension(key="implementation-classes", value
="mydomain.Circle,mydomain.Rectangle,mydomain.Square")
    @Extension(key="mapping-strategy", value="identity")
    Collection<Shape> shapes;

    ...
}
```

So the *shapes* field is a Collection of *mydomain.Shape* and it will accept the implementations of type **Circle**, **Rectangle**, **Square** and **Triangle**. If you omit the implementation-classes tag then you have to give DataNucleus a way of finding the metadata for the implementations prior to encountering this field.

Dynamic Schema Updates (RDBMS)

The default mapping strategy for interface fields and collections of interfaces is to have separate FK

column(s) for each possible implementation of the interface. Obviously if you have an application where new implementations are added over time the schema will need new FK column(s) adding to match. This is possible if you enable the persistence property **datanucleus.rdbms.dynamicSchemaUpdates**, setting it to *true*. With this set, any insert/update operation of an interface related field will do a check if the implementation being stored is known about in the schema and, if not, will update the schema accordingly.

java.lang.Object

JPA doesn't specify support for persisting fields of type java.lang.Object, however DataNucleus does support this where the values of that field are entities themselves. This follows the same general process as for Interfaces since both interfaces and java.lang.Object are basically *references* to some entity.

java.lang.Object cannot be used to persist non-entities with fixed schema datastore (e.g RDBMS). Think of how you would expect it to be stored if you think it ought to

DataNucleus allows the following ways of persisting Object fields :-

- **per-implementation** : a FK is created for each "implementation" so that the datastore can provide referential integrity. The other advantage is that since there are FKs then querying can be performed. The disadvantage is that if there are many implementations then the table can become large with many columns not used
- **identity** : a single column is added and this stores the class name of the "implementation" stored, as well as the identity of the object. The disadvantages are that no querying can be performed, and that there is no referential integrity.
- **xcalia** : a slight variation on "identity" whereby there is a single column yet the contents of that column are consistent with what Xcalia XIC JDO implementation stored there.

The user controls which one of these is to be used by specifying the *extension* **mapping-strategy** on the field containing the interface. The default is "per-implementation"

1-1/N-1 Object Relation

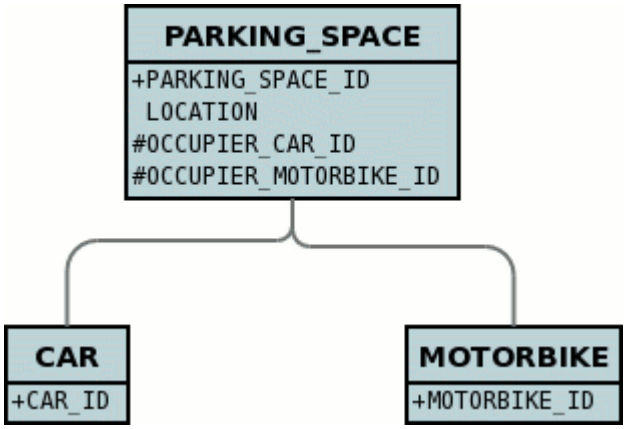
Let's suppose you have a field in a class and you have a selection of possible persistable class that could be stored there, so you decide to make the field a *java.lang.Object*. So let's take an example. We have the following class

```
public class ParkingSpace
{
    String location;
    Object occupier;
}
```

So we have a space in a car park, and in that space we have an occupier of the space. We have some legacy data and so can't make the type of this "occupier" an interface type, so we just use *java.lang.Object*. Now we know that we can only have particular types of objects stored there (since there are only a few types of vehicle that can enter the car park). So we define our annotations like this

```
@Entity
public class ParkingSpace
{
    String location;

    @OneToOne
    @Extension(key="implementation-classes", value
="mydomain.samples.vehicles.Car,mydomain.samples.vehicles.Motorbike")
    Object occupier;
}
```

This will result in the following database schema.



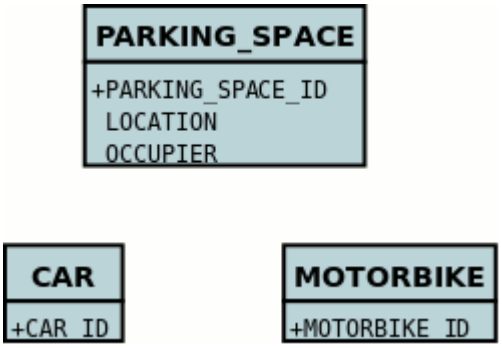
So DataNucleus adds foreign keys from the ParkingSpace table to all of the possible implementation tables for the *occupier* field.

In conclusion, when using "per-implementation" mapping for any java.lang.Object field in a class to be persisted (as non-serialised), you **must** define the possible "implementation" classes that can be stored there.

If we use **mapping-strategy** of "identity" then we get a different datastore schema.

```
public class ParkingSpace
{
    String location;

    @OneToOne
    @Extension(key="implementation-classes", value
="mydomain.samples.vehicles.Car,mydomain.samples.vehicles.Motorbike")
    @Extension(key="mapping-strategy", value="identity")
    Object occupier;
}
```

and the datastore schema becomes



and the column "OCCUPIER" will contain strings such as *com.mydomain.samples.object.Car:1* allowing retrieval of the related implementation object.

1-N Object Relation

You can have a Collection/Map containing elements of java.lang.Object. You specify this in the same way as you would any Collection/Map. DataNucleus supports having a Collection of references with multiple implementation types as long as you use a join table relation.

Serialised Objects

By default a field of type *java.lang.Object* is stored as an instance of the underlying entity in the table of that object. If either your Object field represents non-entities or you simply wish to serialise the Object into the same table as the owning object, you need to specify it as "lob", like this

```
public class MyClass
{
    @Lob
    Object myObject;
}
```

Please refer to the serialised fields guide for more details of storing objects in this way.

Embedded Fields

The JPA persistence strategy typically involves persisting the fields of any class into its own table, and representing any relationships from the fields of that class across to other tables. There are occasions when this is undesirable, maybe due to an existing datastore schema, or because a more convenient datastore model is required. JPA allows the persistence of fields as *embedded* typically into the same table as the "owning" class.

One important decision when defining objects of a type to be embedded into another type is whether objects of that type will ever be persisted in their own right into their own table, and have an identity. JPA allows you to mark a class as `@Embeddable` (instead of `@Entity`) in this case.

```
@Embeddable
public class MyClass {}
```

or using XML metadata

```
<embeddable name="mydomain.MyClass">
    ...
</embeddable>
```

With the above MetaData (using the *embeddable* definition), in our application any objects of the class **MyClass** can be embedded into other objects.

JPA's definition of embedding encompasses several types of fields. These are described below

- Embedded Entities - where you have a 1-1 relationship and you want to embed the other Entity into the same table as the your object
- Embedded Nested Entities - like the first example except that the other object also has another Entity that also should be embedded
- Embedded Collection elements - where you want to embed the elements of a collection into a join table (instead of persisting them into their own table)
- Embedded Map keys/values - where you want to embed the keys/values of a map into a join table (instead of persisting them into their own table)

With respect to what types of fields you can have in an embedded class, DataNucleus supports all basic types, as well as 1-1/N-1 relations (where the *foreign-key* is at the embedded object side), and some 1-N/M-N relations.

whilst nested embedded members are supported, you **cannot use recursive embedded objects** since that would require potentially infinite columns in the owner table, or infinite embedded join tables.

Embedding entities (1-1)

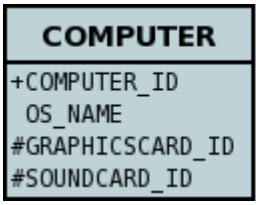
Applicable to RDBMS, Excel, OOXML, ODF, HBase, MongoDB, Neo4j, Cassandra, JSON

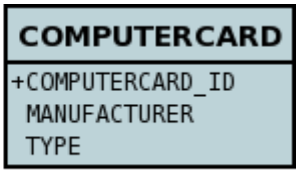
In a typical 1-1 relationship between 2 classes, the 2 classes in the relationship are persisted to their own table, and a foreign key is managed between them. With JPA and DataNucleus you can persist the related entity object as embedded into the same table. This results in a single table in the datastore rather than one for each of the 2 classes.

Let's take an example. We are modelling a **Computer**, and in our simple model our **Computer** has a graphics card and a sound card. So we model these cards using a **ComputerCard** class. So our classes become

```
public class Computer
{
    private String operatingSystem;

    private ComputerCard graphicsCard;

    private ComputerCard soundCard;

    public Computer(String osName, ComputerCard graphics, ComputerCard sound)
    {
        this.operatingSystem = osName;
        this.graphicsCard = graphics;
        this.soundCard = sound;
    }

    ...
}

public class ComputerCard
{
    public static final int ISA_CARD = 0;
    public static final int PCI_CARD = 1;
    public static final int AGP_CARD = 2;

    private String manufacturer;

    private int type;

    public ComputerCard(String manufacturer, int type)
    {
        this.manufacturer = manufacturer;
        this.type = type;
    }

    ...
}
```

The traditional (default) way of persisting these classes would be to have a table to represent each class. So our datastore will look like this

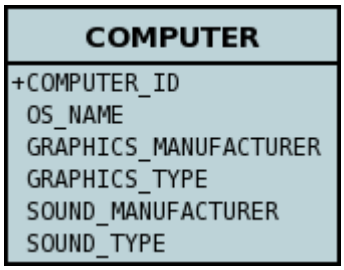




However we decide that we want to persist **Computer** objects into a table called COMPUTER and we also want to persist the PC cards into the *same table*. We define our MetaData like this

```
<entity name="mydomain.Computer">
    <attributes>
        <basic name="operatingSystem">
            <column="OS_NAME"/>
        </basic>
        <embedded name="graphicsCard">
            <attribute-override name="manufacturer">
                <column="GRAPHICS_MANUFACTURER"/>
            </attribute-override>
            <attribute-override name="type">
                <column="GRAPHICS_TYPE"/>
            </attribute-override>
        </embedded>
        <embedded name="soundCard">
            <attribute-override name="manufacturer">
                <column="SOUND_MANUFACTURER"/>
            </attribute-override>
            <attribute-override name="type">
                <column="SOUND_TYPE"/>
            </attribute-override>
        </embedded>
    </attributes>
</entity>
<embeddable name="mydomain.ComputerCard">
    <attributes>
        <basic name="manufacturer"/>
        <basic name="type"/>
    </attributes>
</embeddable>
-----
```

So here we will end up with a TABLE called "COMPUTER" with columns "COMPUTER_ID", "OS_NAME", "GRAPHICS_MANUFACTURER", "GRAPHICS_TYPE", "SOUND_MANUFACTURER", "SOUND_TYPE". If we call persist() on any objects of type **Computer**, they will be persisted into this table.



You can represent inheritance of embedded objects using a discriminator (you must define it in the metadata of the embedded type). This is a DataNucleus extension since JPA doesn't define any support for embedded inherited persistable objects

Null embedded objects

DataNucleus supports persistence of null embedded objects using the following metadata

```
@Extension(key="null-indicator-column", value"MY_COL")
@Extension(key="null-indicator-value", value="SomeValue")
```

and these will be used when persisting and retrieving the embedded object.

See also :-

- MetaData reference for <embedded> element
- Annotations reference for @Embeddable
- Annotations reference for @Embedded

Embedding Nested Entities

Applicable to RDBMS, Excel, OOXML, ODF, HBase, MongoDB, Neo4j, Cassandra, JSON

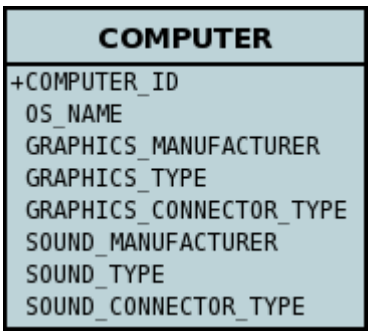
In the above example we had an embeddable entity within an entity. What if our embeddable object also contain another embeddable entity? Using the above example, what if **ComputerCard** contains an object of type **Connector** ?

```
@Embeddable
public class ComputerCard
{
    @Embedded
    Connector connector;

    public ComputerCard(String manufacturer, int type, Connector conn)
    {
        this.manufacturer = manufacturer;
        this.type = type;
        this.connector = conn;
    }

    ...
}

@Embeddable
public class Connector
{
    int type;
}
```

We want to store all of these objects into the same record in the COMPUTER table.

```
<entity name="mydomain.Computer">
    <attributes>
        <basic name="operatingSystem">
            <column="OS_NAME"/>
        </basic>
        <embedded name="graphicsCard">
            <attribute-override name="manufacturer">
                <column="GRAPHICS_MANUFACTURER"/>
            </attribute-override>
            <attribute-override name="type">
                <column="GRAPHICS_TYPE"/>
            </attribute-override>
            <attribute-override name="connector.type">
                <column="GRAPHICS_CONNECTOR_TYPE"/>
            </attribute-override>
        </embedded>
        <embedded name="soundCard">
            <attribute-override name="manufacturer">
                <column="SOUND_MANUFACTURER"/>
            </attribute-override>
            <attribute-override name="type">
                <column="SOUND_TYPE"/>
            </attribute-override>
            <attribute-override name="connector.type">
                <column="SOUND_CONNECTOR_TYPE"/>
            </attribute-override>
        </embedded>
    </attributes>
</entity>
<embeddable name="mydomain.ComputerCard">
    <attributes>
        <basic name="manufacturer"/>
        <basic name="type"/>
    </attributes>
</embeddable>
<embeddable name="mydomain.Connector">
    <attributes>
        <basic name="type"/>
    </attributes>
</embeddable>
```

So we simply nest the embedded definition of the **Connector** objects within the embedded definition of the **ComputerCard** definitions for **Computer**. JPA supports this to as many levels as you require! The **Connector** objects will be persisted into the GRAPHICS_CONNECTOR_TYPE, and SOUND_CONNECTOR_TYPE columns in the COMPUTER table.



Embedding Collection Elements

Applicable to RDBMS, MongoDB

In a typical 1-N relationship between 2 classes, the 2 classes in the relationship are persisted to their own table, and either a join table or a foreign key is used to relate them. With JPA and DataNucleus you have a variation on the join table relation where you can persist the objects of the "N" side into the join table itself so that they don't have their own identity, and aren't stored in the table for that class. **This is supported in DataNucleus with the following provisos**

- You can have inheritance in embedded keys/values and a discriminator is added (you must define the discriminator in the metadata of the embedded type).
- When retrieving embedded elements, all fields are retrieved in one call. That is, fetch plans are not utilised. This is because the embedded element has no identity so we have to retrieve all initially.

It should be noted that where the collection "element" is not an entity or of a "reference" type (Interface or Object) it will **always** be embedded, and this functionality here applies to embeddable entity elements only. DataNucleus doesn't support the embedding of "reference type" objects currently.

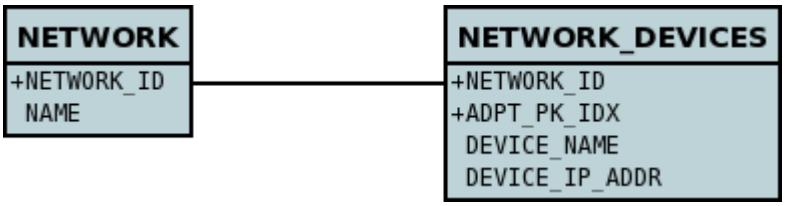
Let's take an example. We are modelling a **Network**, and in our simple model our **Network** has collection of *Device*s. So we define our classes as

```
@Entity
public class Network
{
    private String name;

    @Embedded
    @ElementCollection
    private Collection<Device> devices = new HashSet<>();

    public Network(String name)
    {
        this.name = name;
    }

    ...
}

@Embeddable
public class Device
{
    private String name;

    private String ipAddress;

    public Device(String name, String addr)
    {
        this.name = name;
        this.ipAddress = addr;
    }

    ...
}
```

We decide that instead of **Device** having its own table, we want to persist them into the join table of its relationship with the **Network** since they are only used by the network itself. We define our MetaData like this

```
<entity name="mydomain.Network">
    <attributes>
        <basic name="name">
            <column="NAME" length="40"/>
        </basic>
        <element-collection name="devices">
            <collection-table name="NETWORK_DEVICES">
                <join-column name="NETWORK_ID"/>
            </collection-table>
        </element-collection>
    </attributes>
</entity>
<embeddable name="mydomain.Device">
    <attributes>
        <basic name="name">
            <column="DEVICE_NAME"/>
        </basic>
        <basic name="ipAddress">
            <column="DEVICE_IP_ADDR"/>
        </basic>
    </attributes>
</embeddable>
```

So here we will end up with a table called "NETWORK" with columns "NETWORK_ID", and "NAME", and a table called "NETWORK_DEVICES" with columns "NETWORK_ID", "ADPT_PK_IDX", "DEVICE_NAME", "DEVICE_IP_ADDR". When we persist a **Network** object, any devices are persisted into the NETWORK_DEVICES table.



Note that if you want to override the name of the fields of the embedded element in the table of the owner, you should use @AttributeOverride (when using annotations) or <attribute-override> (when using XML).

See also :-

- MetaData reference for <embeddable> element
- MetaData reference for <embedded> element
- MetaData reference for <element-collection> element
- MetaData reference for <collection-table> element
- Annotations reference for @Embeddable
- Annotations reference for @Embedded
- Annotations reference for @ElementCollection

Embedding Map Keys/Values

Applicable to RDBMS, MongoDB

In a typical 1-N map relationship between classes, the classes in the relationship are persisted to their own table, and a join table forms the map linkage. With JPA and DataNucleus you have a variation on the join table relation where you can persist either the key class or the value class, or both key class and value class into the join table. **This is supported in DataNucleus with the following provisos**

- You can have inheritance in embedded keys/values and a discriminator is added (you must define the discriminator in the metadata of the embedded type).
- When retrieving embedded keys/values, all fields are retrieved in one call. That is, entity graphs and fetch specifications are not utilised. This is because the embedded key/value has no identity so we have to retrieve all initially.

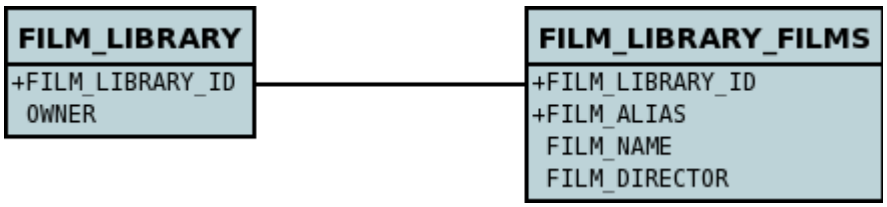
It should be noted that where the map "key"/"value" is not *persistable* or of a "reference" type (Interface or Object) it will **always** be embedded, and this functionality here applies to *persistable* keys/values only.

DataNucleus doesn't support embedding reference type elements currently.

Let's take an example. We are modelling a **FilmLibrary**, and in our simple model our **FilmLibrary** has map of *Film*s, keyed by a String alias. So we define our classes as

```
@Entity
public class FilmLibrary
{
    private String owner;

    @Embedded
    @ElementCollection
    @CollectionTable(name="FILM_LIBRARY_FILMS")
    @MapKeyColumn(name="FILM_ALIAS")
    private Map<String, Film> films = new HashMap<>();

    public FilmLibrary(String owner)
    {
        this.owner = owner;
    }

    ...
}

public class Film
{
    @Column(name="FILM_NAME")
    private String name;

    @Column(name="FILM_DIRECTOR")
    private String director;

    public Film(String name, String director)
    {
        this.name = name;
        this.director = director;
    }

    ...
}
```

So here we will end up with a table called "FILM_LIBRARY" with columns "FILM_LIBRARY_ID", and "OWNER", and a table called "FILM_LIBRARY_FILMS" with columns "FILM_LIBRARY_ID", "FILM_ALIAS", "FILM_NAME", "FILM_DIRECTOR". When we persist a **FilmLibrary** object, any films are persisted into the FILM_LIBRARY_FILMS table.



Note that if you want to override the name of the fields of the embedded key/value in the table of the owner, you should use @AttributeOverride (when using annotations) or <attribute-override>

(when using XML). In the case of fields of an embedded key you should set the name as "key.{fieldName}" and in the case of fields of an embedded value you should set the name as "value.{fieldName}".

Serialised Fields

JPA provides a way for users to specify that a field will be persisted *serialised*. This is of use, for example, to collections/maps/arrays which typically are stored using join tables or foreign-keys to other records. By specifying that a field is serialised a column will be added to store that field and the field will be serialised into it.

JPA's definition of serialising applies to any field and all in the same way, unlike the situation with JDO which provides much more flexibility. Perhaps the most important thing to bear in mind when deciding to serialise a field is that that object in the field being serialised must implement *java.io.Serializable*.

Serialised Fields

Applicable to RDBMS, HBase, MongoDB

If you wish to serialise a particular field into a single column (in the table of the class), you need to simply mark the field as a "lob" (large object). Let's take an example. We have the following classes

```
public class Farm
{
    Collection<Animal> animals;

    ...
}

public class Animal
{
    ...
}
```

and we want the *animals* collection to be serialised into a single column in the table storing the **Farm** class, so we define our MetaData like this

```
@Entity
public class Farm
{
    @Lob
    Collection<Animal> animals;

    ...
}
```

or using XML metadata

```
<entity class="Farm">
    <table name="FARM"/>
    <attributes>
        ...
        <basic name="animals">
            <column name="ANIMALS"/>
            <lob/>
        </basic>
        ...
    </attributes>
</entity>
```

So we make use of the *lob* element / @Lob annotation. This specification results in a table like this

Queries cannot be performed on collections stored as serialised.

If the field that we want to serialise is of type String, byte array, char array, Byte array or Character array then the field will be serialised into a CLOB column rather than BLOB.

See also :-

- MetaData reference for <basic> element
- Annotations reference for @Lob

Serialise to File

Applicable to RDBMS

Note this is not part of the JPA spec, but is available in DataNucleus to ease your usage. If you have a non-relation field that implements Serializable you have the option of serialising it into a file on the local disk. This could be useful where you have a large file and don't want to persist very large objects into your RDBMS. Obviously this will mean that the field is no longer queryable, but then if its a large file you likely don't care about that. So let's give an example

```
@Entity
public class Person
{
    @Id
    long id;

    @Basic
    @Lob
    @Extension(vendorName="datanucleus", key="serializeToFileLocation", value
="person_avatars")
    AvatarImage image;
}
```

or using XML metadata

```
<entity class="Person">
    <attributes>
        ...
        <basic name="image">
            <lob/>
            <extension key="serializeToFileLocation" value="person_avatars"
        </basic>
        ...
    </attributes>
</entity>
```

So this will now persist a file into a folder /person_avatars_ with filename as the String form of the identity of the owning object. In a real world example you likely will specify the extension value as an absolute path name, so you can place it anywhere in the local disk.

Schema

We have shown earlier how you define a classes basic persistence, notating which fields are persisted. The next step is to define how it maps to the datastore. Fields of a class are mapped to *columns* of a *table* (note that with some datastores it is not called a 'table' or 'column', but the concept is similar and we use 'table' and 'column' here to represent the mapping). If you don't specify the table and column names, then DataNucleus will generate table and column names for you, according to the JPA specs rules.

You should specify your table and column names if you have an existing schema. Failure to do so will mean that DataNucleus uses its own names and these will almost certainly not match what you have in the datastore.

There are several aspects to cover here

- Table and column names
- Column nullability and default value
- Column Types
- Position of a column in a table
- RDBMS : Mapping a class to an RDBMS View
- RDBMS : Supported types for a field

Tables and Column names

The main thing that developers want to do when they set up the persistence of their data is to control the names of the tables and columns used for storing the classes and fields. This is an essential step when mapping to an existing schema, because it is necessary to map the classes onto the existing database entities. Let's take an example

```
public class Hotel
{
    private String name;
    private String address;
    private String telephoneNumber;
    private int numberOfRooms;
    ...
}
```

In our case we want to map this class to a table called **ESTABLISHMENT**, and has columns *NAME*, *DIRECTION*, *PHONE* and *NUMBER_OF_ROOMS* (amongst other things). So we define our Meta-Data like this

```
<entity class="Hotel">
    <table name="ESTABLISHMENT"/>
    <attributes>
        <basic name="name">
            <column name="NAME"/>
        </basic>
        <basic name="address">
            <column name="DIRECTION"/>
        </basic>
        <basic name="telephoneNumber">
            <column name="PHONE"/>
        </basic>
        <basic name="numberOfRooms">
            <column name="NUMBER_OF_ROOMS"/>
        </basic>
    </attributes>
</entity>
```

Alternatively, if you really want to embody schema info in your class, you can use annotations

```
@Table(name="ESTABLISHMENT")
public class Hotel
{
    @Column(name="NAME")
    private String name;
    @Column(name="DIRECTION")
    private String address;
    @Column(name="PHONE")
    private String telephoneNumber;
    @Column(name="NUMBER_OF_ROOMS")
    private int numberOfRooms;

    ...
}
```

So we have defined the table and the column names. It should be mentioned that if you don't specify the table and column names then DataNucleus will generate names for the datastore identifiers consistent with the JPA specification. The table name will be based on the class name, and the column names will be based on the field names and the role of the field (if part of a relationship).

See also :-

- Identifier Guide - defining the identifiers to use for table/column names
- MetaData reference for <column> element

Column nullability and default values

So we've seen how to specify the basic structure of a table, naming the table and its columns, and how to control the types of the columns. We can extend this further to control whether the columns are allowed to contain nulls. Let's take a related class for our hotel. Here we have a class to model the payments made to the hotel.

```
public class Payment
{
    Customer customer;
    String bankTransferReference;
    String currency;
    double amount;
}
```

In this class we can model payments from a customer of an amount. Where the customer pays by bank transfer we can save the reference number. Since the bank transfer reference is optional we want that column to be nullable. So let's specify the MetaData for the class.

```
<entity class="Payment">
    <attributes>
        <one-to-one name="customer">
            <primary-key-join-column name="CUSTOMER_ID"/>
        </one-to-one>
        <basic name="bankTransferReference">
            <column name="TRANSFER_REF" nullable="true"/>
        </basic>
        <basic name="currency">
            <column name="CURRENCY" default-value="GBP"/>
        </basic>
        <basic name="amount">
            <column name="AMOUNT"/>
        </basic>
    </attributes>
</entity>
```

Alternatively, you can specify these using annotations should you so wish.

So we make use of the *nullable* attribute. The table, when created by DataNucleus, will then provide the nullability that we require. Unfortunately with JPA there is no way to specify a default value for a field when it hasn't been set (unlike JDO where you can do that).

See also :-

- MetaData reference for <column> element

Column types

DataNucleus will provide a default type for any columns that it creates, but it will allow users to override this default. The default that DataNucleus chooses is always based on the Java type for the field being mapped. For example a Java field of type "int" will be mapped to a column type of INTEGER in RDBMS datastores. Similarly String will be mapped to VARCHAR.

JPA provides 2 ways of influencing the column DDL generated.

- You can specify the *columnDefinition* of @Column/<column> but you have to provide the complete DDL for that column (without the column name), and hence can lose database independence by using this route. e.g "VARCHAR(255)"
- Use @Column/<column> attributes and specify the *length*/*precision*/*scale* of the column, as well as whether it is unique etc. It will make use of the Java type to come up with a default datastore type for the column. Sadly JPA doesn't allow specification of the precise datastore type (except for BLOB/CLOB/TIME/TIMESTAMP cases). DataNucleus provides an extension to overcome this gap in the JPA spec. Here we make use of a DataNucleus extension annotation @JdbcType or "jdbc-type" extension attribute for <column>. Like this

```
<entity name="Payment">
    <attributes>
        <one-to-one name="customer">
            <primary-key-join-column name="CUSTOMER_ID"/>
        </one-to-one>
        <basic name="bankTransferReference">
            <column name="TRANSFER_REF" nullable="true" length="255"/>
        </basic>
        <basic name="currency">
            <column name="CURRENCY" default-value="GBP" length="3" jdbc-type="CHAR"/>
        </basic>
        <basic name="amount">
            <column name="AMOUNT" precision="10" scale="2"/>
        </basic>
    </attributes>
</entity>
```

You could alternatively specify these using annotations should you so wish. So we have defined TRANSFER_REF to use VARCHAR(255) column type, CURRENCY to use (VAR)CHAR(3) column type, and AMOUNT to use DECIMAL(10,2) column type.

See also :-

- Types Guide - defining mapping of Java types
- RDBMS Types Guide - defining mapping of Java types to JDBC/SQL types
- MetaData reference for <column> element

Column Position

With some datastores it is desirable to be able to specify the relative position of a column in the table schema. The default (for DataNucleus) is just to put them in ascending alphabetical order. DataNucleus allows an extension to JPA providing definition of this using the *position* of a **column**. See fields/properties positioning docs for details.

RDBMS : Views

The standard situation with an RDBMS datastore is to map classes to **Tables**. The majority of RDBMS also provide support for **Views**, providing the equivalent of a read-only SELECT across various tables. DataNucleus also provides support for querying such Views. This provides more flexibility to the user where they have data and need to display it in their application. Support for Views is described below.

When you want to access data according to a View, you are required to provide a class that will accept the values from the View when queried, and Meta-Data for the class that defines the View and how it maps onto the provided class. Let's take an example. We have a View SALEABLE_PRODUCT in our database as follows, defined based on data in a PRODUCT table.

```
CREATE VIEW SALEABLE_PRODUCT (ID, NAME, PRICE, CURRENCY) AS
    SELECT ID, NAME, CURRENT_PRICE AS PRICE, CURRENCY FROM PRODUCT
    WHERE PRODUCT.STATUS_ID = 1
```

So we define a class to receive the values from this **View**, and define how it is mapped to the view.

```
package mydomain.views;

@Entity
@Table("SALEABLE_PRODUCT")
@Extension(vendorName="datanucleus", key="view-definition", value="CREATE VIEW
SALEABLE_PRODUCT
(
    {this.id},
    {this.name},
    {this.price},
    {this.currency}
) AS
SELECT ID, NAME, CURRENT_PRICE AS PRICE, CURRENCY FROM PRODUCT
WHERE PRODUCT.STATUS_ID = 1")
public class SaleableProduct
{
    String id;
    String name;
    double price;
    String currency;

    public String getId()
    {
        return id;
    }

    public String getName()
    {
        return name;
    }

    public double getPrice()
    {
        return price;
    }

    public String getCurrency()
    {
        return currency;
    }
}
```

Please note the following

- We've defined our class as using "nondurable" identity (`@NonDurableId`). This was mandatory in all versions up to 5.0.7 but after that is optional and you can use application/datastore identity also.
- We've specified the "table", which in this case is the view name - otherwise DataNucleus would create a name for the view based on the class name.

- We've defined a DataNucleus extension *view-definition* that defines the view for this class. If the view doesn't already exist it doesn't matter since DataNucleus (when used with *autoCreateSchema*) will execute this construction definition.
- The *view-definition* can contain macros utilising the names of the fields in the class, and hence borrowing their column names (if we had defined column names for the fields of the class).
- You can also utilise other classes in the macros, and include them via a DataNucleus MetaData extension *view-imports* (not shown here)
- If your **View** already exists you are still required to provide a *view-definition* even though DataNucleus will not be utilising it, since it also uses this attribute as the flag for whether it is a **View** or a **Table** - just make sure that you specify the "table" also in the MetaData.
- If you have a relation to the class represented by a **View**, you cannot expect it to create an FK in the **View**. The **View** will map on to exactly the members defined in the class it represents. i.e cannot have a 1-N FK uni relation to the class with the **View**.

We can now utilise this class within normal DataNucleus JPA querying operation.

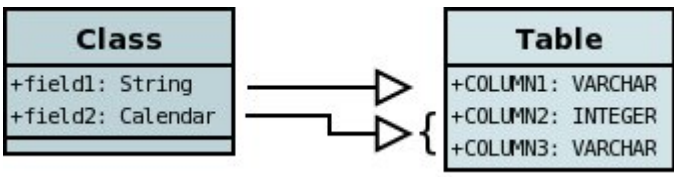
```
Query<MyViewClass> q = em.createQuery("SELECT p FROM SaleableProduct p",
SaleableProduct.class);
List<MyViewClass> results = q.getResultList();
```

Hopefully that has given enough detail on how to create and access views from with a DataNucleus-enabled application.

RDBMS : Datastore Types

As we saw in the Types Guide DataNucleus supports the persistence of a large range of Java field types. With RDBMS datastores, we have the notion of tables/columns in the datastore and so each Java type is mapped across to a column or a set of columns in a table. It is important to understand this mapping when mapping to an existing schema for example. In RDBMS datastores a java type is stored using JDBC types. DataNucleus supports the use of the vast majority of the available JDBC types.

When persisting a Java type in general it is persisted into a single column. For example a String will be persisted into a VARCHAR column by default. Some types (e.g Color) have more information to store than we can conveniently persist into a single column and so use multiple columns. Other types (e.g Collection) store their information in other ways, such as foreign keys.



This table shows the Java types we saw earlier and whether they can be queried using JPQL queries, and what JDBC types can be used to store them in your RDBMS datastore. Not all RDBMS datastores support all of these options. While DataNucleus always tries to provide a complete list sometimes this is impossible due to limitations in the underlying JDBC driver

Java Type	Number of Columns	Queryable	JDBC Type(s)
boolean	1	✔	**BIT**, CHAR ('Y','N'), BOOLEAN, TINYINT, SMALLINT, NUMERIC
byte	1	✔	**TINYINT**, SMALLINT, NUMERIC
char	1	✔	**CHAR**, INTEGER, NUMERIC
double	1	✔	**DOUBLE**, DECIMAL, FLOAT
float	1	✔	**FLOAT**, REAL, DOUBLE, DECIMAL
int	1	✔	**INTEGER**, BIGINT, NUMERIC
long	1	✔	**BIGINT**, NUMERIC, DOUBLE, DECIMAL, INTEGER
short	1	✔	**SMALLINT**, INTEGER, NUMERIC
boolean[]	1	✔ [5]	LONGVARBINARY, BLOB
byte[]	1	✔ [5]	LONGVARBINARY, BLOB
char[]	1	✔ [5]	LONGVARBINARY, BLOB
double[]	1	✔ [5]	LONGVARBINARY, BLOB
float[]	1	✔ [5]	LONGVARBINARY, BLOB
int[]	1	✔ [5]	LONGVARBINARY, BLOB
long[]	1	✔ [5]	LONGVARBINARY, BLOB
short[]	1	✔ [5]	LONGVARBINARY, BLOB
java.lang.Boolean	1	✔	**BIT**, CHAR('Y','N'), BOOLEAN, TINYINT, SMALLINT
java.lang.Byte	1	✔	**TINYINT**, SMALLINT, NUMERIC
java.lang.Character	1	✔	**CHAR**, INTEGER, NUMERIC
java.lang.Double	1	✔	**DOUBLE**, DECIMAL, FLOAT
java.lang.Float	1	✔	**FLOAT**, REAL, DOUBLE, DECIMAL
java.lang.Integer	1	✔	**INTEGER**, BIGINT, NUMERIC
java.lang.Long	1	✔	**BIGINT**, NUMERIC, DOUBLE, DECIMAL, INTEGER
java.lang.Short	1	✔	**SMALLINT**, INTEGER, NUMERIC
java.lang.Boolean[]	1	✔ [5]	LONGVARBINARY, BLOB
java.lang.Byte[]	1	✔ [5]	LONGVARBINARY, BLOB
java.lang.Character[]	1	✔ [5]	LONGVARBINARY, BLOB

Java Type	Number of Columns	Queryable	JDBC Type(s)
java.lang.Double[]	1	✔ [5]	LONGVARBINARY, BLOB
java.lang.Float[]	1	✔ [5]	LONGVARBINARY, BLOB
java.lang.Integer[]	1	✔ [5]	LONGVARBINARY, BLOB
java.lang.Long[]	1	✔ [5]	LONGVARBINARY, BLOB
java.lang.Short[]	1	✔ [5]	LONGVARBINARY, BLOB
java.lang.Number	1	✔	
java.lang.Object	1		LONGVARBINARY, BLOB
java.lang.String [8]	1	✔	**VARCHAR**, CHAR, LONGVARCHAR, CLOB, BLOB, DATALINK [6], UNIQUEIDENTIFIER [7], XMLTYPE [9]
java.lang.StringBuffer [8]	1	✔	**VARCHAR**, CHAR, LONGVARCHAR, CLOB, BLOB, DATALINK [6], UNIQUEIDENTIFIER [7], XMLTYPE [9]
java.lang.String[]	1	✔ [5]	LONGVARBINARY, BLOB
java.lang.Enum	1	✔	LONGVARBINARY, BLOB, VARCHAR, INTEGER
java.lang.Enum[]	1	✔ [5]	LONGVARBINARY, BLOB
java.math.BigDecimal	1	✔	**DECIMAL**, NUMERIC
java.math.BigInteger	1	✔	**NUMERIC**, DECIMAL
java.math.BigDecimal[]	1	✔ [5]	LONGVARBINARY, BLOB
java.math.BigInteger[]	1	✔ [5]	LONGVARBINARY, BLOB
java.sql.Date	1	✔	**DATE**, TIMESTAMP
java.sql.Time	1	✔	**TIME**, TIMESTAMP
java.sql.Timestamp	1	✔	**TIMESTAMP**
java.util.ArrayList	0	✔	
java.util.BitSet	0	✖	LONGVARBINARY, BLOB
java.util.Calendar [3]	1 or 2	✖	INTEGER, VARCHAR, CHAR
java.util.Collection	0	✔	
java.util.Currency	1	✔	**VARCHAR**, CHAR
java.util.Date	1	✔	**TIMESTAMP**, DATE, CHAR, BIGINT
java.util.Date[]	1	✔ [5]	LONGVARBINARY, BLOB
java.util.GregorianCalendar [2]	1 or 2	✖	INTEGER, VARCHAR, CHAR

Java Type	Number of Columns	Queryable	JDBC Type(s)
java.util.HashMap	0	✔	
java.util.HashSet	0	✔	
java.util.Hashtable	0	✔	
java.util.LinkedHashMap	0	✔	
java.util.LinkedHashSet	0	✔	
java.util.LinkedList	0	✔	
java.util.List	0	✔	
java.util.Locale [8]	1	✔	**VARCHAR**, CHAR, LONGVARCHAR, CLOB, BLOB, DATALINK [6], UNIQUEIDENTIFIER [7], XMLTYPE [9]
java.util.Locale[]	1	✔ [5]	LONGVARBINARY, BLOB
java.util.Map	0	✔	
java.util.Properties	0	✔	
java.util.PriorityQueue	0	✔	
java.util.Queue	0	✔	
java.util.Set	0	✔	
java.util.SortedMap	0	✔	
java.util.SortedSet	0	✔	
java.util.Stack	0	✔	
java.util.TimeZone [8]	1	✔	**VARCHAR**, CHAR, LONGVARCHAR, CLOB, BLOB, DATALINK [7], UNIQUEIDENTIFIER [8], XMLTYPE [9]
java.util.TreeMap	0	✔	
java.util.TreeSet	0	✔	
java.util.UUID [8]	1	✔	**VARCHAR**, CHAR, LONGVARCHAR, CLOB, BLOB, DATALINK [7], UNIQUEIDENTIFIER [8], XMLTYPE [9]
java.util.Vector	0	✔	
java.awt.Color [1]	4	✖	INTEGER
java.awt.Point [2]	2	✖	INTEGER
java.awt.image.BufferedImage [4]	1	✖	LONGVARBINARY, BLOB

Java Type	Number of Columns	Queryable	JDBC Type(s)
java.net.URI [8]	1	✔	**VARCHAR**, CHAR, LONGVARCHAR, CLOB, BLOB, DATALINK [7], UNIQUEIDENTIFIER [8], XMLTYPE [9]
java.net.URL [8]	1	✔	**VARCHAR**, CHAR, LONGVARCHAR, CLOB, BLOB, DATALINK [7], UNIQUEIDENTIFIER [8], XMLTYPE [9]
java.io.Serializable	1	✖	LONGVARBINARY, BLOB
Entity	1	✔	[embedded]
Entity[]	1	✔ [5]	

- **[1]** - *java.awt.Color* - stored in 4 columns (red, green, blue, alpha). ColorSpace is not persisted.
- **[2]** - *java.awt.Point* - stored in 2 columns (x and y).
- **[3]** - *java.util.Calendar* - stored in 2 columns (milliseconds and timezone).
- **[4]** - *java.awt.image.BufferedImage* is stored using JPG image format
- **[5]** - Array types are queryable if not serialised, but stored to many rows
- **[6]** - DATALINK JDBC type supported on DB2 only. Uses the SQL function DLURLCOMPLETEONLY to fetch from the datastore. You can override this using the select-function extension. See the MetaData reference.
- **[7]** - UNIQUEIDENTIFIER JDBC type supported on MSSQL only.
- **[8]** - Oracle treats an empty string as the same as NULL. To workaround this limitation DataNucleus replaces the empty string with the character \u0001.
- **[9]** - XMLTYPE JDBC type supported on Oracle only.

If you need to extend the provided DataNucleus capabilities in terms of its datastore types support you can utilise a plugin point.

DataNucleus provides support for the majority of the JDBC types with RDBMS. The support is shown below.

JDBC Type	Supported	Restrictions
ARRAY	✔	Only for PostgreSQL array type
BIGINT	✔	
BINARY	✔	Only for geospatial types on MySQL
BIT	✔	
BLOB	✔	
BOOLEAN	✔	

JDBC Type	Supported	Restrictions
CHAR	✔	
CLOB	✔	
DATALINK	✔	Only on DB2
DATE	✔	
DECIMAL	✔	
DISTINCT	✖	
DOUBLE	✔	
FLOAT	✔	
INTEGER	✔	
JAVA_OBJECT	✖	
LONGVARBINARY	✔	
LONGVARCHAR	✔	
NCHAR	✔	
NULL	✖	
NUMERIC	✔	
NVARCHAR	✔	
OTHER	✔	
REAL	✔	
REF	✖	
SMALLINT	✔	
STRUCT	✔	Only for geospatial types on Oracle
TIME	✔	
TIMESTAMP	✔	
TINYINT	✔	
VARBINARY	✔	
VARCHAR	✔	

Secondary Tables

Applicable to RDBMS

The standard JPA persistence strategy is to persist an object of a class into its own table. In some situations you may wish to map the class to a primary table as well as one or more secondary

tables. For example when you have a Java class that could have been split up into 2 separate classes yet, for whatever reason, has been written as a single class, however you have a legacy datastore and you need to map objects of this class into 2 tables. JPA allows persistence of fields of a class into *secondary* tables.

The process for managing this situation is best demonstrated with an example. Let's suppose we have a class that represents a **Printer**. The **Printer** class contains within it various attributes of the toner cartridge. So we have

```
package com.mydomain.samples.secondarytable;

public class Printer
{
    long id;
    String make;
    String model;

    String tonerModel;
    int tonerLifetime;

    ....
}
```

Now we have a database schema that has 2 tables (PRINTER and PRINTER_TONER) in which to store objects of this class. So we need to tell DataNucleus to perform this mapping. So we define the MetaData for the **Printer** class like this

```
@Entity
@Table(name="PRINTER")
@SecondaryTable(name="PRINTER_TONER", pkJoinColumns=@PrimaryKeyJoinColumn(name
="PRINTER_REFID"))
public class Printer
{
    ...

    @Column(name="MODEL", table="PRINTER_TONER")
    String tonerModel;

    @Column(name="LIFETIME", table="PRINTER_TONER")
    int tonerLifetime;
}
```

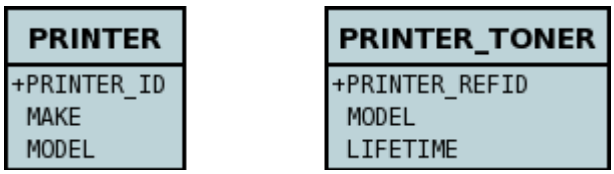
or using XML metadata

```
<entity class="Printer">
    <table name="PRINTER"/>
    <secondary-table name="PRINTER_TONER">
        <primary-key-join-column name="PRINTER_REFID"/>
    </secondary-table>

    <attributes>
        ...
        <basic name="tonerModel">
            <column name="MODEL" table="PRINTER_TONER"/>
        </basic>
        <basic name="tonerLifetime">
            <column name="LIFETIME" table="PRINTER_TONER"/>
        </basic>
    </attributes>
</entity>
```

Here we have defined that objects of the **Printer** class will be stored in the primary table PRINTER. In addition we have defined that some fields are stored in the table PRINTER_TONER.

- We declare the "secondary-table"(s) that we will be using at the start of the definition.
- We define *tonerModel* and *tonerLifetime* to use columns in the table PRINTER_TONER. This uses the "table" attribute of <column>
- Whilst defining the secondary table(s) we will be using, we also define the join column to be called "PRINTER_REFID".

This results in the following database tables :-



So we now have our primary and secondary database tables. The primary key of the PRINTER_TONER table serves as a foreign key to the primary class. Whenever we persist a **Printer** object a row will be inserted into **both** of these tables.

See also :-

- MetaData reference for <secondary-table> element
- MetaData reference for <column> element
- Annotations reference for @SecondaryTable
- Annotations reference for @Column

Constraints

A datastore often provides ways of constraining the storage of data to maintain relationships and improve performance. These are known as *constraints* and they come in various forms. These are :-

- Indexes - these are used to mark fields that are referenced often as indexes so that when they are used the performance is optimised.
- Unique constraints - these are placed on fields that should have a unique value. That is, only one object will have a particular value.
- Foreign-Keys - these are used to interrelate objects, and allow the datastore to keep the integrity of the data in the datastore.
- Primary-Keys - allow the PK to be set, and also to have a name.

Indexes

Applicable to RDBMS, NeoDatis, MongoDB

Many datastores provide the ability to have indexes defined to give performance benefits. With RDBMS the indexes are specified on the table and the indexes to the rows are stored separately. In the same way an ODBMS typically allows indexes to be specified on the fields of the class, and these are managed by the datastore. JPA 2.1 allows you to define the indexes on a table-by-table basis by metadata as in the following example (note that you cannot specify indexes on a field basis like in JDO)

```
import javax.persistence.Index;

@Entity
@Table(indexes={@Index(name="SOME_VAL_IDX", columnList="SOME_VALUE")})
public class MyClass
{
    @Column(name="SOME_VALUE")
    long someValue;

    ...
}
```

The JPA @Index annotation is only applicable at a class level. DataNucleus provides its own @Index annotation that you can specify on a field/method to signify that the column(s) for this field/method will be indexed. Like this

```
@Entity
public class MyClass
{
    @org.datanucleus.api.jpa.annotations.Index(name="VAL_IDX")
    long someValue;

    ...
}
```

Unique constraints

Applicable to RDBMS, NeoDatis, MongoDB

Some datastores provide the ability to have unique constraints defined on tables to give extra control over data integrity. JPA provides a mechanism for defining such unique constraints. Let's take an example class, and show how to specify this

```
public class Person
{
    String forename;
    String surname;
    String nickname;
    ...
}
```

and here we want to impose uniqueness on the "nickname" field, so there is only one Person known as "DataNucleus Guru" for example !

```
<entity class="Person">
    <table name="PEOPLE"/>
    <attributes>
        ...
        <basic name="nickname">
            <column name="SURNAME" unique="true"/>
        </basic>
        ...
    </attributes>
</entity>
```

The second use of unique constraints is where we want to impose uniqueness across composite columns. So we reuse the class above, and this time we want to impose a constraint that there is only one Person with a particular "forename+surname".

```
<entity class="Person">
    <table name="PEOPLE">
        <unique-constraint>
            <column-name>FORENAME</column-name>
            <column-name>SURNAME</column-name>
        </unique-constraint>
    </table>
    <attributes>
        ...
        <basic name="forename">
            <column name="FORENAME"/>
        </basic>
        <basic name="surname">
            <column name="SURNAME"/>
        </basic>
        ...
    </attributes>
</entity>
```

In the same way we can also impose unique constraints on <join-table> and <secondary-table>

See also :-

- MetaData reference for <column> element
- MetaData reference for <unique-constraint> element
- Annotations reference for @Column
- Annotations reference for @UniqueConstraint

Foreign Keys

Applicable to RDBMS

When objects have relationships with one object containing, for example, a Collection of another object, it is common to store a foreign key in the datastore representation to link the two associated tables. Moreover, it is common to define behaviour about what happens to the dependent object when the owning object is deleted. Should the deletion of the owner cause the deletion of the dependent object maybe ? JPA 2.1 adds support for defining the foreign key for relation fields as per the following example

```
public class MyClass
{
    ...

    @OneToOne
    @JoinColumn(name="OTHER_ID", foreignKey=@ForeignKey(name="OTHER_FK",
        foreignKeyDefinition="FOREIGN KEY (OTHER_ID) REFERENCES MY_OTHER_TBL
(MY_OTHER_ID) ]"))
    MyOtherClass other;

}
```

Note that when you don't specify any foreign key the JPA provider is free to add the foreign keys that it considers are necessary.

Primary Keys

Applicable to RDBMS

In RDBMS datastores, it is accepted as good practice to have a primary key on all tables. You specify in other parts of the MetaData which fields are part of the primary key (if using application identity). Unfortunately JPA doesnt allow specification of the name of the primary key constraint, nor of whether join tables are given a primary key constraint at all.

Datastore Identifiers

A datastore identifier is a simple name of a database object, such as a column, table, index, or view, and is composed of a sequence of letters, digits, and underscores (_) that represents it's name. DataNucleus allows users to specify the names of tables, columns, indexes etc but if the user doesn't specify these DataNucleus will generate names.

With RDBMS the generation of identifier names is controlled by an IdentifierFactory, and DataNucleus provides a default implementation for JPA. You can provide your own RDBMS IdentifierFactory plugin to give your own preferred naming if so desired. For RDBMS you set the *RDBMS IdentifierFactory* by setting the persistence property *datanucleus.identifierFactory*. Set it to the symbolic name of the factory you want to use.

- jpa RDBMS IdentifierFactory (default for JPA persistence for RDBMS)

With non-RDBMS the generation of identifier names is controlled by a NamingFactory and again a default implementation for JPA. You can provide your own NamingFactory plugin to give your own preferred naming if so desired. You set the *NamingFactory* by setting the persistence property *datanucleus.identifier.namingFactory* to give your own preferred naming if so desired. Set it to the symbolic name of the factory you want to use.

- jpa NamingFactory (default for JPA persistence for non-RDBMS)

In describing the different possible naming conventions available out of the box with DataNucleus

we'll use the following example

```
public class MyClass
{
    String myField1;
    Collection<MyElement> elements1; // Using join table
    Collection<MyElement> elements2; // Using foreign-key
}

class MyElement
{
    String myElementField;
    MyClass myClass2;
}
```

NamingFactory 'jpa'

The *NamingFactory* "jpa" aims at providing a naming policy consistent with the "JPA" specification.

Using the same example above, the rules in this *NamingFactory* mean that, assuming that the user doesn't specify any <column> elements :-

- *MyClass* will be persisted into a table named **MYCLASS**
- When using datastore identity **MYCLASS** will have a column called **MYCLASS_ID**
- *MyClass.myField1* will be persisted into a column called **MYFIELD1**
- *MyElement* will be persisted into a table named **MYELEMENT**
- *MyClass.elements1* will be persisted into a join table called **MYCLASS_MYELEMENT**
- **MYCLASS_ELEMENTS1** will have columns called **MYCLASS_MYCLASS_ID** (FK to owner table) and **ELEMENTS1_ELEMENT_ID** (FK to element table)
- **MyClass.elements2** will be persisted into a column **ELEMENTS2_MYCLASS_ID** (FK to owner) table
- Any discriminator column will be called **DTYPE**
- Any index column in a List for field *MyClass.myField1* will be called **MYFIELD1_ORDER**
- Any adapter column added to a join table to form part of the primary key will be called **IDX**
- Any version column for a table will be called **VERSION**

RDBMS IdentifierFactory 'jpa'

The *RDBMS IdentifierFactory* "jpa" aims at providing a naming policy consistent with the JPA specification.

Using the same example above, the rules in this *IdentifierFactory* mean that, assuming that the user doesnt specify any <column> elements :-

- *MyClass* will be persisted into a table named **MYCLASS**

- When using datastore identity **MYCLASS** will have a column called **MYCLASS_ID**
- *MyClass.myField1* will be persisted into a column called **MYFIELD1**
- *MyElement* will be persisted into a table named **MYELEMENT**
- *MyClass.elements1* will be persisted into a join table called **MYCLASS_MYELEMENT**
- **MYCLASS_ELEMENTS1** will have columns called **MYCLASS_MYCLASS_ID** (FK to owner table) and **ELEMENTS1_ELEMENT_ID** (FK to element table)
- **MyClass.elements2** will be persisted into a column **ELEMENTS2_MYCLASS_ID** (FK to owner) table
- Any discriminator column will be called **DTYPE**
- Any index column in a List for field *MyClass.myField1* will be called **MYFIELD1_ORDER**
- Any adapter column added to a join table to form part of the primary key will be called **IDX**
- Any version column for a table will be called **VERSION**

Controlling the Case

The underlying datastore will define what case of identifiers are accepted. By default, DataNucleus will capitalise names (assuming that the datastore supports it). You can however influence the case used for identifiers. This is specifiable with the persistence property *datanucleus.identifier.case*, having the following values

- UpperCase: identifiers are in upper case
- LowerCase: identifiers are in lower case
- MixedCase: No case changes are made to the name of the identifier provided by the user (class name or metadata).

NOTE : Some datastores only support UPPERCASE or lowercase identifiers and so setting this parameter may have no effect if your database doesn't support that option.

NOTE : This case control only applies to DataNucleus-generated identifiers. If you provide your own identifiers for things like schema/catalog etc then you need to specify those using the case you wish to use in the datastore (including quoting as necessary)