JDO Mapping Guide (v6.0)

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To implement a persistence layer with JDO you firstly need to map the classes and fields/properties that are involved in the persistence process to how they are represented in the datastore. This can be as simple as marking the classes as `@PersistenceCapable` and defaulting the datastore definition, 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 for using metadata to map your persistable classes.

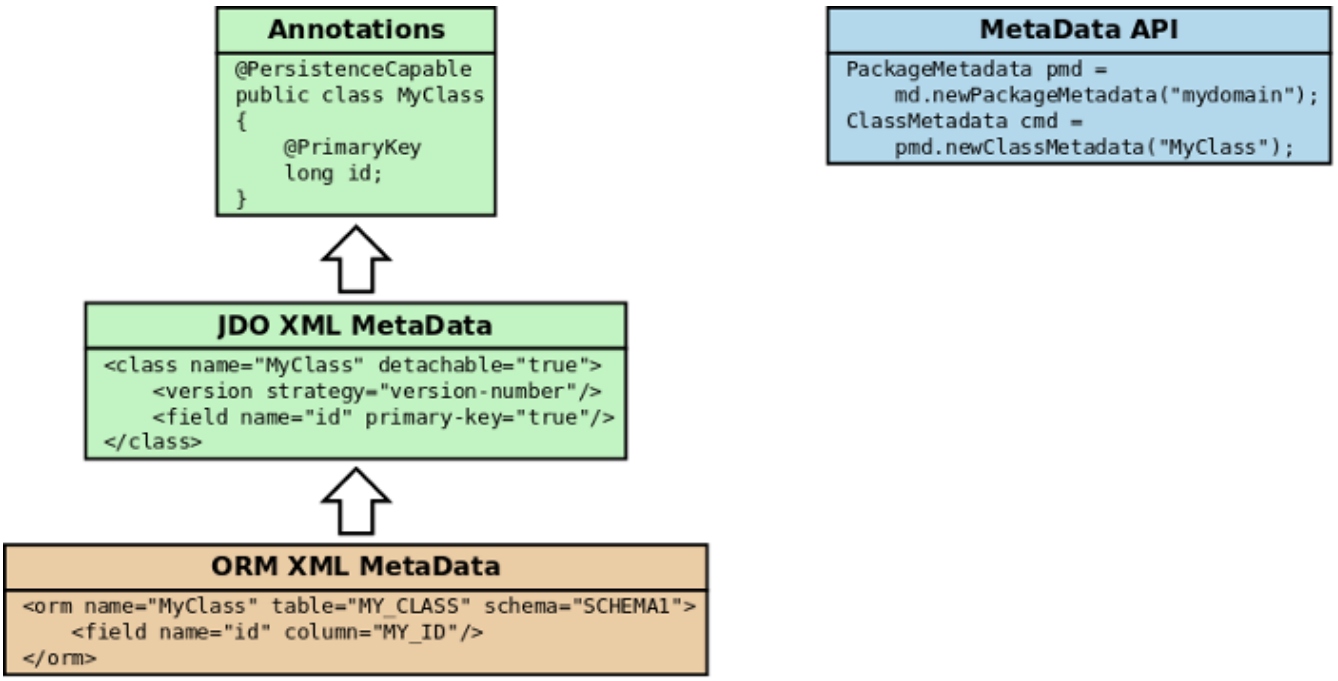
When mapping a class for JDO you make use of *metadata*, and this *metadata* can be Java annotations, or can be XML metadata, or a mixture of both, or you could even define it using a dynamic API. This is very much down to your own personal preference but we try to present both ways here.

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

You cannot use a Java (14+) "record" with JDO, since it does not meet the requirements for persistence, but you can use it as a DTO type object that is populated from a query.

In terms of the relative priority of annotations, JDO XML and ORM XML metadata, the following figure highlights the process



So you can provide the metadata via JDO annotations solely, or via JDO annotations plus ORM XML Metadata overrides, or via JDO XML Metadata solely, or via JDO XML Metadata plus ORM XML Metadata overrides, or finally via a Metadata API.

If you are using XML overrides for ORM, this definition will be merged in to the base definition (JDO annotations or JDO XML Metadata). Note that you can utilise JDO annotations for one class, and then JDO XML Metadata for another class should you so wish.

One further alternative is if you have annotations in your classes, you provide JDO XML Metadata (`package.jdo`), and also ORM XML Metadata (`package-{mapping}.orm`). In this case the annotations are the base representation, applying overrides from JDO XML Metadata, and then overrides from the ORM XML Metadata.

When not using the MetaData API we recommend that you use either XML or annotations for the basic persistence information, but always use XML for schema information. This is because it is liable to change at deployment time and hence is accessible when in XML form whereas in annotations you add an extra compile cycle (and also you may need to deploy to some other datastore at some point, hence needing a different deployment).

Classes

We have the following types of classes in DataNucleus JDO.

- PersistenceCapable - persistable class with full control over its persistence.
- PersistenceAware - a class that is not itself persisted, but that needs to access internals of persistable classes.

JDO imposes very little on classes used within the persistence process so, to a very large degree, you should design your classes as you would normally do and not design them to fit JDO.

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

If defining a method *toString* in a JDO persistable class, be aware that use of a persistable field will cause the load of that field if the object is managed and is not yet loaded.

If a JDO persistable class is an element of a Java collection in another entity, you are advised to define *hashCode* and *equals* methods for reliable handling by Java collections.

Persistence Capable Classes

The first thing to decide when implementing your persistence layer is which classes are to be persisted. 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. To achieve the above aim we do this

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

or using XML metadata

```
<class name="Hotel">
    ...
</class>
```

See also :-

- MetaData reference for <class> element
- Annotations reference for @PersistenceCapable

If any of your other classes **access the fields of these persistable classes directly** then these other classes should be defined as *PersistenceAware*.

Persistence-Aware Classes

If a class is not itself persistable but it interacts with *fields* of persistable classes then it should be marked as *Persistence Aware*. You do this as follows

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

or using XML metadata

```
<class name="MyClass" persistence-modifier="persistence-aware">
    ...
</class>
```

See also :-

- Annotations reference for @PersistenceAware

Read-Only Classes

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

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

@PersistenceCapable
@ReadOnly
public class MyClass
{
    ...
}
```

or using XML Metadata

```
<class name="MyClass">
    ...
    <extension vendor-name="datanucleus" key="read-only" value="true"/>
</class>
```

In practical terms this means that at runtime, if you try to persist an object of this type then an exception will be thrown. You can read objects of this type from the datastore just as you would for any persistable class

See also :-

- Annotations reference for @ReadOnly

Detachable Classes

One of the main things you need to decide for you persistable classes is whether you will be detaching them from the persistence process for use in a different layer of your application. If you do want to do this then you need to mark them as *detachable*, like this

```
@PersistenceCapable(detachable="true")
public class Hotel
{
    ...
}
```

or using XML metadata

```
<class name="Hotel" detachable="true">
    ...
</class>
```

SoftDelete

Applicable to RDBMS, MongoDB, Cassandra, *HBase, Neo4j*

With standard JDO when you delete an object from persistence it is deleted from the datastore. DataNucleus provides a useful ability to *soft delete* objects from persistence. In simple terms, any persistable types marked for soft deletion handling will have an extra column added to their datastore table to represent whether the record is soft-deleted. If it is soft deleted then it will not be visible at runtime thereafter, but will be present in the datastore.

You mark a persistable type for soft deletion handling like this, optionally specifying the column

details

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

@PersistenceCapable
@SoftDelete(columns={@Column(name="DELETE_FLAG")})
public class Hotel
{
    ...
}
```

If you instead wanted to define this in XML then do it like this

```
<class name="Hotel">
    <extension vendor-name="datanucleus" key="softdelete" value="true"/>
    <extension vendor-name="datanucleus" key="softdelete-column-name"
value="DELETE_FLAG"/>
    ...
</class>
```

Whenever any objects of type `Hotel` are deleted, like this

```
pm.deletePersistent(myHotel);
```

the *myHotel* object will be updated to set the *soft-delete* flag to *true*.

Any call to *pm.getObjectById* or query will not return the object since it is effectively deleted (though still present in the datastore).

If you want to view the object, you can specify the query extension **datanucleus.query.includeSoftDeletes** as *true* and the soft-deleted records will be visible.

This feature is still undergoing development, so not all aspects are feature complete.

See also :-

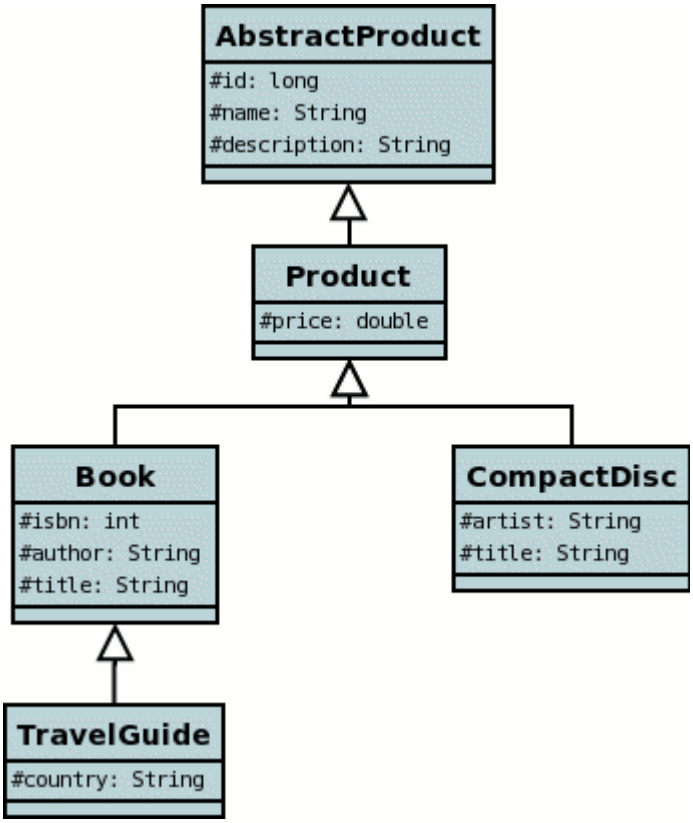
- Annotations reference for @SoftDelete

Inheritance

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

- The first and simplest to understand option is where each class has its own table in the datastore. In JDO this is referred to as **new-table**.
- The second way is to select a class to have its fields persisted in the table of its subclass. In JDO this is referred to as **subclass-table**
- The third way is to select a class to have its fields persisted in the table of its superclass. In JDO this is known as **superclass-table**
- The final way is for all classes in an inheritance tree to have their own table containing all fields. This is known as **complete-table** and is enabled by setting the inheritance strategy of the root class to use this.

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 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.



JDO imposes a "default" inheritance strategy if none is specified for a class. If the class is a base class and no inheritance strategy is specified then it will be set to **new-table** for that class. If the class has a superclass and no inheritance strategy is specified then it will be set to **superclass-table**. This means that, when no strategy is set for the classes in an inheritance tree, they will default to

using a single table managed by the base class.

You can control the "default" strategy chosen by way of the persistence property **datanucleus.defaultInheritanceStrategy**. The default is *JDO2* which will give the above default behaviour for all classes that have no strategy specified. The other option is *TABLE_PER_CLASS* which will use "new-table" for all classes which have no strategy specified

At runtime, when you start up your PersistenceManagerFactory, JDO will only *know about* the classes that the persistence API has been introduced to via method calls. To alleviate this, particularly for subclasses of classes in an inheritance relationship, you should make use of one of the many available Auto Start Mechanisms

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> element
- Annotations reference for @Inheritance
- Annotations reference for @Discriminator

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. There are two types of discriminator supported by JDO

- **class-name** : where the actual name of the class is stored as the discriminator
- **value-map** : where a (typically numeric) value is stored for each class in question, allowing simple look-up of the class it equates to

You specify a discriminator as follows

```
<class name="Product">
    <inheritance>
        <discriminator strategy="class-name"/>
    </inheritance>
    ...
</class>
```

or with annotations

```
@PersistenceCapable
@Discriminator(strategy=DiscriminatorStrategy.CLASS_NAME)
public class Product {...}
```

Alternatively if using *value-map* strategy then you need to provide the value map for all classes in the inheritance tree that will be persisted in their own right.

```
@PersistenceCapable
@Discriminator(strategy=DiscriminatorStrategy.VALUE_MAP, value="PRODUCT")
public class Product {...}

@PersistenceCapable
@Discriminator(value="BOOK")
public class Book {...}

...
```

New Table

Applicable to RDBMS

Here we want to have a separate table for each class. 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 **new-table**. 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

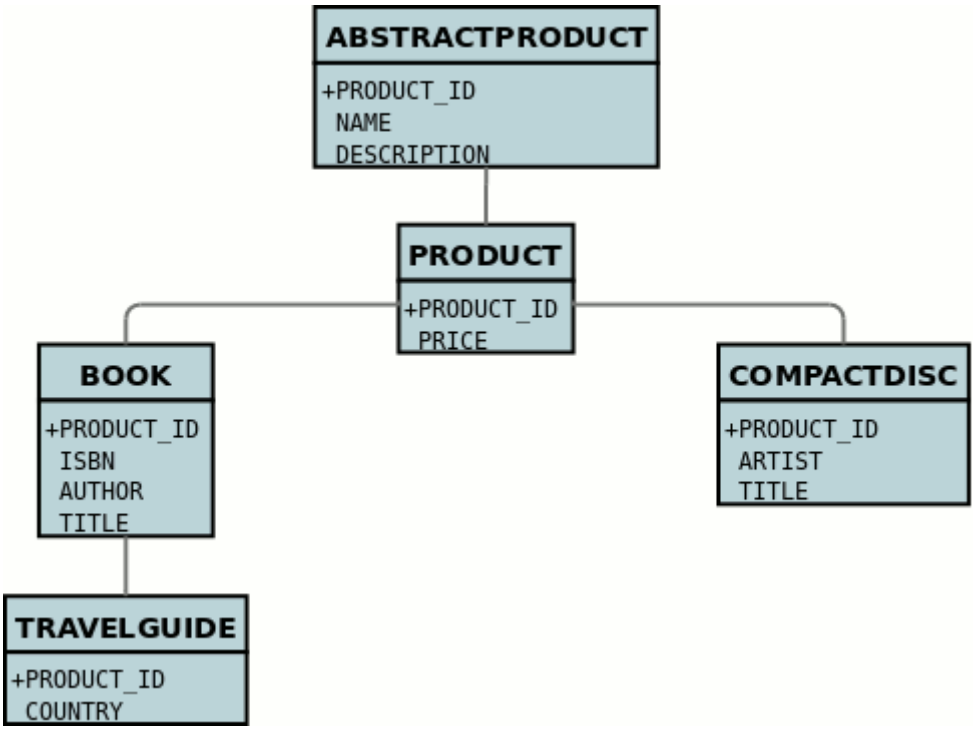
```
<class name="AbstractProduct">
    <inheritance strategy="new-table"/>
    <field name="id" primary-key="true">
        <column name="PRODUCT_ID"/>
    </field>
    ...
</class>
<class name="Product">
    <inheritance strategy="new-table"/>
    ...
</class>
<class name="Book">
    <inheritance strategy="new-table"/>
    ...
</class>
<class name="TravelGuide">
    <inheritance strategy="new-table"/>
    ...
</class>
<class name="CompactDisc">
    <inheritance strategy="new-table"/>
    ...
</class>
```

or with annotations

```
@PersistenceCapable
@Inheritance(strategy=InheritanceStrategy.NEW_TABLE)
public abstract class AbstractProduct {...}

@PersistenceCapable
@Inheritance(strategy=InheritanceStrategy.NEW_TABLE)
public class Product {...}

@PersistenceCapable
@Inheritance(strategy=InheritanceStrategy.NEW_TABLE)
public class Book {...}

@PersistenceCapable
@Inheritance(strategy=InheritanceStrategy.NEW_TABLE)
public class TravelGuide {...}

@PersistenceCapable
@Inheritance(strategy=InheritanceStrategy.NEW_TABLE)
public class CompactDisc {...}
```

We use the *inheritance* element to define the persistence of the inherited classes.

In the datastore, each class in an inheritance tree is represented in its own datastore table (tables ABSTRACTPRODUCT, PRODUCT, BOOK, TRAVELGUIDE, and COMPACTDISC), with the subclasses tables' having foreign keys between the primary key and the primary key of the superclass' table.



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

Subclass table

Applicable to RDBMS

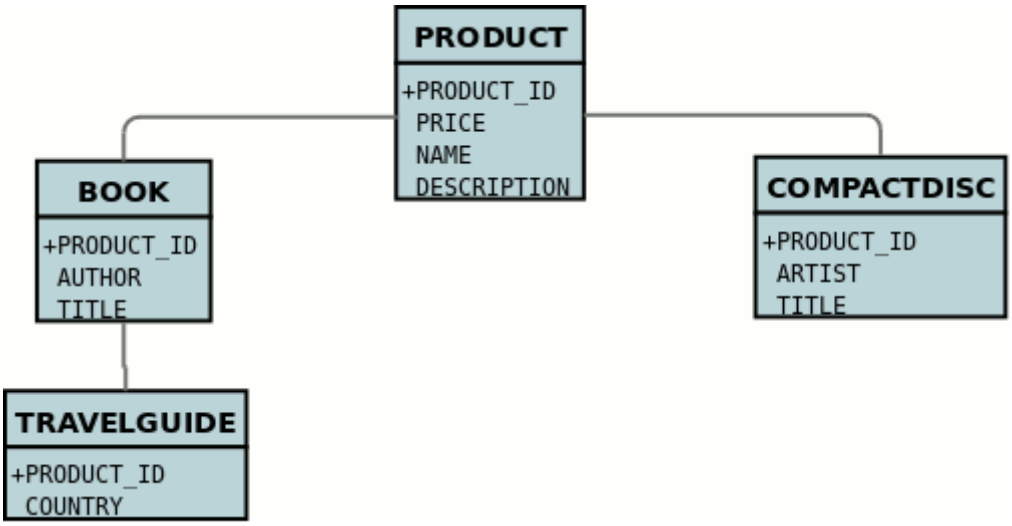
DataNucleus supports persistence of classes in the tables of subclasses where this is required. This is typically used where you have an abstract base class and it doesn't make sense having a separate table for that class. In our example we have no real interest in having a separate table for the **AbstractProduct** class. So in this case we change one thing in the Meta-Data quoted above. We now change the definition of **AbstractProduct** as follows

```
<class name="AbstractProduct">
    <inheritance strategy="subclass-table"/>
    <field name="id" primary-key="true">
        <column name="PRODUCT_ID"/>
    </field>
    ...
</class>
```

or with annotations

```
@PersistenceCapable
@Inheritance(strategy=InheritanceStrategy.SUBCLASS_TABLE)
public abstract class AbstractProduct {...}
```

This subtle change of use the **inheritance** element has the effect of using the PRODUCT table for both the **Product** and **AbstractProduct** classes, containing the fields of both classes.



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

DataNucleus doesn't currently fully support the use of classes defined with *subclass-table* strategy as having relationships where there are more than a single subclass that has a table. If the class has a single subclass with its own table then there should be no problem.

Superclass table

Applicable to RDBMS

DataNucleus supports persistence of classes in the tables of superclasses where this is required. This has the advantage that retrieval of an object is a single SQL 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. In our example, lets ignore the **AbstractProduct** class for a moment and assume that **Product** is the base class. 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

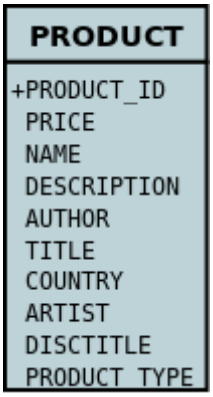
```
<class name="Product">
    <inheritance strategy="new-table">
        <discriminator strategy="class-name">
            <column name="PRODUCT_TYPE"/>
        </discriminator>
    </inheritance>
    <field name="id" primary-key="true">
        <column name="PRODUCT_ID"/>
    </field>
    ...
</class>
<class name="Book">
    <inheritance strategy="superclass-table"/>
    ...
</class>
<class name="TravelGuide">
    <inheritance strategy="superclass-table"/>
    ...
</class>
<class name="CompactDisc">
    <inheritance strategy="superclass-table"/>
    ...
</class>
```

or with annotations

```
@PersistenceCapable
@Inheritance(strategy=InheritanceStrategy.NEW_TABLE)
public abstract class AbstractProduct {...}

@PersistenceCapable
@Inheritance(strategy=InheritanceStrategy.SUPERCLASS_TABLE)
public class Product {...}

@PersistenceCapable
@Inheritance(strategy=InheritanceStrategy.SUPERCLASS_TABLE)
public class Book {...}

@PersistenceCapable
@Inheritance(strategy=InheritanceStrategy.SUPERCLASS_TABLE)
public class TravelGuide {...}

@PersistenceCapable
@Inheritance(strategy=InheritanceStrategy.SUPERCLASS_TABLE)
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* 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 class name of the object stored. So for a Book it will have "com.mydomain.samples.store.Book" in that column. 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.

JDO allows two types of discriminators. The example above used a discriminator strategy of *class-name*. This inserts the class name into the discriminator column so that we know what the class of the object really is. The second option is to use a discriminator strategy of *value-map*. With this we will define a "value" to be stored in this column for each of our classes. The only thing here is that we have to define the "value" in the MetaData for ALL classes that use that strategy. So to give the equivalent example :-

```
<class name="Product">
    <inheritance strategy="new-table">
        <discriminator strategy="value-map" value="PRODUCT">
            <column name="PRODUCT_TYPE"/>
        </discriminator>
    </inheritance>
    <field name="id" primary-key="true">
        <column name="PRODUCT_ID"/>
    </field>
    ...
</class>
<class name="Book">
    <inheritance strategy="superclass-table">
        <discriminator value="BOOK"/>
    </inheritance>
    ...
</class>
<class name="TravelGuide">
    <inheritance strategy="superclass-table">
        <discriminator value="TRAVELGUIDE"/>
    </inheritance>
    ...
</class>
<class name="CompactDisc">
    <inheritance strategy="superclass-table">
        <discriminator value="COMPACTDISC"/>
    </inheritance>
    ...
</class>
```

As you can see from the MetaData DTD it is possible to specify the column details for the *discriminator*. DataNucleus supports this, but only currently supports the following values of *jdbc-type* : VARCHAR, CHAR, INTEGER, BIGINT, NUMERIC. The default column type will be a VARCHAR.

Complete table

Applicable to RDBMS, Neo4j, NeoDatis, Excel, OOXML, ODF, HBase, JSON, AmazonS3, GoogleStorage, MongoDB, LDAP

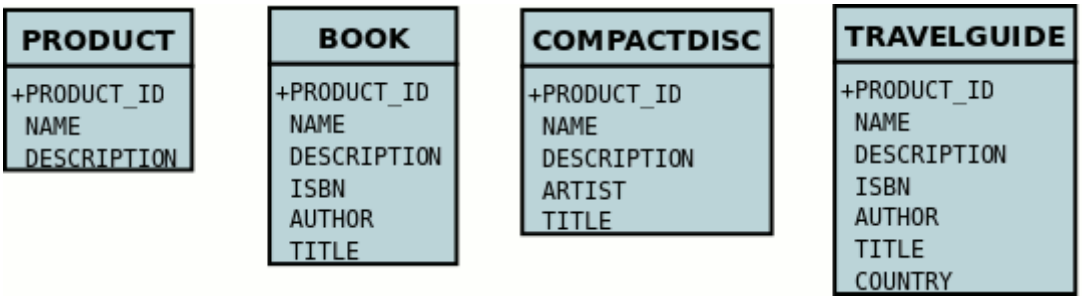
With "complete-table" we define the strategy on the root class of the inheritance tree and it applies to all subclasses. Each class is persisted into its own table, having columns for all fields (of the class in question plus all fields of superclasses). So taking the same classes as used above

```
<class name="Product">
    <inheritance strategy="complete-table"/>
    <field name="id" primary-key="true">
        <column name="PRODUCT_ID"/>
    </field>
    ...
</class>
<class name="Book">
    ...
</class>
<class name="TravelGuide">
    ...
</class>
<class name="CompactDisc">
    ...
</class>
```

or with annotations

```
@PersistenceCapable
@Inheritance(strategy=InheritanceStrategy.COMPLETE_TABLE)
public abstract class AbstractProduct {...}
```

So the key thing is the specification of inheritance strategy at the root only. 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`. 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.**

Retrieval of inherited objects

JDO provides particular mechanisms for retrieving inheritance trees. These are accessed via the Extent/Query interface. Taking our example above, we can then do

```
tx.begin();
Extent e = pm.getExtent(com.mydomain.samples.store.Product.class, true);
Query  q = pm.newQuery(e);
Collection c=(Collection)q.execute();
tx.commit();
```

The second parameter passed to *pm.getExtent* relates to whether to return subclasses. So if we pass in the root of the inheritance tree (Product in our case) we get all objects in this inheritance tree returned. You can, of course, use far more elaborate queries using JDOQL, but this is just to highlight the method of retrieval of subclasses.

Identity

All JDO-enabled persistable classes need to have an "identity" to be able to identify an object for retrieval and relationships. There are three types of identity defineable using JDO. These are

- 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.
- 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.
- Application Identity : a field, or several fields of the persistable type are assigned as being (part of) the primary key. 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 Compound 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 superclass(es) without any identity defined but using *subclass-table* inheritance, and then the base instantiable class is the first persistable class which has the identity.

The JDO *identity* is not the same as the type of the field(s) marked as the primary key. The *identity* will always have an identity class name. If you specify the object-id class then it will be this, otherwise will use a built-in type.

Nondurable Identity

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

With **nondurable identity** your objects will 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 JDO you would define metadata like this

```
@PersistenceCapable(identityType=IdentityType.NONDURABLE)
public class MyClass
{
    ...
}
```

or using XML metadata

```
<class name="MyClass" identity-type="nondurable">
...
</class>
```

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

Datastore Identity

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

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 JDO, you do it like this

```
@PersistenceCapable(identityType=IdentityType.DATASTORE)
public class MyClass
{
    ...
}
```

or using XML metadata

```
<class name="MyClass" identity-type="datastore">
...
</class>
```

So you are specifying the **identity-type** as *datastore*. You don't need to add this because *datastore* is the default, so in the absence of any value, it will be assumed to be 'datastore'.

Datastore Identity : Generating identities

By choosing **datastore identity** you are handing the process of identity generation to the JDO implementation. This does not mean that you haven't got any control over how it does this. JDO 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 specifying its metadata, like this

```
@PersistenceCapable
@DatastoreIdentity(strategy="sequence", sequence="MY_SEQUENCE")
public class MyClass
{
    ...
}
```

or using XML metadata

```
<class name="MyClass" identity-type="datastore">
    <datastore-identity strategy="sequence" sequence="MY_SEQUENCE"/>
    ...
</class>
```

Some of the datastore identity strategies require additional attributes, but the specification is straightforward.

See also :-

- Value Generation - strategies for generating ids
- MetaData reference for <datastore-identity> element
- 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.

```
// Via the PersistenceManager
Object id = pm.getObjectId(obj);

// Via JDOHelper
Object id = JDOHelper.getObjectId(obj);
```

You should be aware however that the "identity" is in a complicated form, and is not available as a simple integer value for example. Again, if you want an identity of that form then you should use application identity

Datastore Identity : Implementation

When implementing **datastore identity** all JDO implementations have to provide a public class that represents this identity. If you call *pm.getObjectId(...)* for a class using datastore identity you will be passed an object which, in the case of DataNucleus will be of type *org.datanucleus.identity.OIDImpl*. If you were to call "toString()" on this object you would get

something like

```
1[OID]mydomain.MyClass
This is made up of :-
    1 = identity number of this object
    class-name
```

The definition of this datastore identity is JDO implementation dependent. As a result you should not use the *org.datanucleus.identity.OID* class in your application if you want to remain implementation independent.

DataNucleus allows you the luxury of being able to provide your own datastore identity class so you can have whatever formatting you want for identities. You can then specify the persistence property **datanucleus.datastoreIdentityType** to be such as *kodo* or *xcalia* which would replicate the types of datastore identity generated by former JDO implementations Solarmetric Kodo and Xcalia respectively.

Datastore Identity : Accessing objects by Identity

If you have the JDO identity then you can access the object with that identity like this

```
Object obj = pm.getObjectById(id);
```

You can also access the object from the object class name and the toString() form of the datastore identity (e.g "1[OID]mydomain.MyClass") like this

```
Object obj = pm.getObjectById(MyClass.class, mykey);
```

Application Identity

Applicable to all datastores.

With **application identity** you are taking control of the specification of id's to DataNucleus. Application identity requires a primary key class *(unless you have a single primary-key field in which case the PK class is provided for you)*, 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.

```
<class name="MyClass" objectid-class="MyIdClass">
    <field name="myPrimaryKeyField" primary-key="true"/>
    ...
</class>
```

For JDO we specify the **primary-key** and **objectid-class**. The **objectid-class** is optional, and is the class defining the identity for this class (again, if you have a single primary-key field then you can omit it). Alternatively, if we are using annotations

```
@PersistenceCapable(objectIdClass=MyIdClass.class)
public class MyClass
{
    @Persistent(primaryKey="true")
    private long myPrimaryKeyField;
}
```

See also :-

- MetaData reference for <field> element
- Annotations reference for @Persistent

Application Identity : PrimaryKey Classes

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 built-in PK classes so you can forget this section.

If you are thinking of using multiple primary key fields in a class we would urge you to consider using a single (maybe surrogate) primary key field instead for reasons of simplicity and performance. This also means that you can avoid the need to define your own primary key class.

Where you have more than 1 primary key field, you would map the persistable class like this

```
<class name="MyClass" identity-type="application" objectid-class="MyIdClass">
...
</class>
```

or using annotations

```
@PersistenceCapable(objectIdClass=MyIdClass.class)
public class MyClass
{
    ...
}
```

You now need to define the PK class to use (`MyIdClass`). This is simplified for you because **if you have only one PK field then you don't 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 JDO 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 **SingleFieldIdentity** Javadoc mechanism. This provides a PrimaryKey and you don't need to specify the *objectid-class*. Let's take an example

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

```
<class name="MyClass" identity-type="application">
    <field name="id" primary-key="true"/>
    ...
</class>
```

or using annotations

```
@PersistenceCapable
public class MyClass
{
    @PrimaryKey
    long id;
    ...
}
```

So we didn't specify the JDO "objectid-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.

If you need to create an identity of this form for use in querying via *pm.getObjectById()* then you can create the identities in the following way

```
// For a "long" type :
javax.jdo.identity.LongIdentity id = new javax.jdo.identity.LongIdentity(myClass,
101);

// For a "String" type :
javax.jdo.identity.StringIdentity id = new javax.jdo.identity.StringIdentity(myClass,
"ABCD");
```

We have shown an example above for type "long", but you can also use this for the following

```
short, Short       - javax.jdo.identity.ShortIdentity
int, Integer       - javax.jdo.identity.IntIdentity
long, Long         - javax.jdo.identity.LongIdentity
String             - javax.jdo.identity.StringIdentity
char, Character    - javax.jdo.identity.CharIdentity
byte, Byte         - javax.jdo.identity.ByteIdentity
java.util.Date     - javax.jdo.identity.ObjectIdentity
java.util.Currency - javax.jdo.identity.ObjectIdentity
java.util.Locale   - javax.jdo.identity.ObjectIdentity
```

It is however better **not** to make explicit use of these JDO classes and instead to just use the *pm.getObjectById* taking in the class and the value and then you have no dependency on these classes.

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 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 must be public
- the names of the non-static fields in the Primary Key class must include the names of the primary key fields in the JDO class, 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 JDO class
- 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 inheritence tree.

Please note that if one of the fields that comprises the primary key is in itself a persistable object then you have Compound 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 JDO 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 below 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.

Your "id" class can store the target class name of the persistable object that it represents. This is useful where you want to avoid lookups of a class in an inheritance tree. To do this, add a field to your id-class called *targetClassName* and make sure that it is part of the *toString()* and *String constructor* code.

PrimaryKey Example - Multiple Field

Again, if you are thinking of using multiple primary key fields in a class we would urge you to consider using a single (maybe surrogate) primary key field instead for reasons of simplicity and performance. This also means that you can avoid the need to define your own primary key class.

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

```
@PersistenceCapable(objectIdClass=ComposedIdKey.class)
public class MyClass
{
    @PrimaryKey
    String field1;

    @PrimaryKey
    String field2;
    ...
}

public class ComposedIdKey implements Serializable
{
    public String targetClassName; // DataNucleus extension, storing the class name of
the persistable object
    public String field1;
    public String field2;

    public ComposedIdKey ()
    {
    }

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

    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.targetClassName + "::"  + this.field1 + "::" + this.field2;
    }
}
```

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

See also :-

- Value Generation - strategies for generating ids

Application Identity : Accessing the Identity

When using **application identity**, the class has associated field(s) that equate to the identity. As a result you can simply access the values for these field(s). Alternatively you could use a JDO identity-independent way

```
// Using the PersistenceManager
Object id = pm.getObjectId(obj);

// Using JDOHelper
Object id = JDOHelper.getObjectId(obj);
```

Application Identity : Changing Identities

JDO allows implementations to support the changing of the identity of a persisted object. **This is an optional feature and DataNucleus doesn't currently support it.**

Application Identity : Accessing objects by Identity

If you have the JDO identity then you can access the object with that identity like this

```
Object obj = pm.getObjectById(id);
```

If you are using SingleField identity then you can access it from the object class name and the key

value like this

```
Object obj = pm.getObjectById(MyClass.class, mykey);
```

If you are using your own PK class then the *mykey* value is the toString() form of the identity of your PK class.

Compound Identity Relationships

A JDO "compound identity relationship" is a relationship between two classes in which the child object must coexist with the parent object and where the primary key of the child includes the persistable object of the parent. The key aspect of this type of relationship is that the primary key of one of the classes includes a persistable field (hence why is is referred to as *Compound 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 the identity class of the compound persistable class you should define the *object-idclass* of the persistable type being contained and use that type in the identity class of the compound persistable type.

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

When using compound identity, it is best practice to define an *object-idclass* for any persistable classes that are 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

```
public class User
{
    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;
        }
    }
}

public class Account
{
    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

```
<package name="mydomain">
    <class name="User" identity-type="application" objectid-class="User$PK">
        <field name="id" primary-key="true"/>
        <field name="login" persistence-modifier="persistent">
            <column length="20" jdbc-type="VARCHAR"/>
        </field>
    </class>

    <class name="Account" identity-type="application" objectid-class="Account$PK">
        <field name="user" persistence-modifier="persistent" primary-key="true">
            <column name="USER_ID"/>
        </field>
        <field name="firstName" persistence-modifier="persistent">
            <column length="50" jdbc-type="VARCHAR"/>
        </field>
        <field name="secondName" persistence-modifier="persistent">
            <column length="50" jdbc-type="VARCHAR"/>
        </field>
    </class>
</package>
```

So now we have the following datastore schema

Things to note :-

- You must use "application-identity" in both parent and child classes
- 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

```
public class Account
{
    long id; // PK field

    Set 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)
        {
```

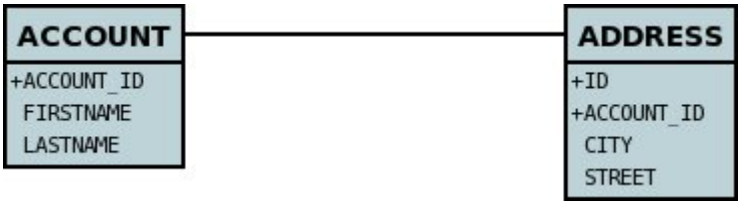
```
            this.id = Long.valueOf(s).longValue();
        }

        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;
        }
    }
}

public class Address
{
    long id;
    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

```
<package name="mydomain">
    <class name="Account" identity-type="application" objectid-class="Account$PK">
        <field name="id" primary-key="true"/>
        <field name="firstName" persistence-modifier="persistent">
            <column length="50" jdbc-type="VARCHAR"/>
        </field>
        <field name="secondName" persistence-modifier="persistent">
            <column length="50" jdbc-type="VARCHAR"/>
        </field>
        <field name="addresses" persistence-modifier="persistent" mapped-by="account">
            <collection element-type="Address"/>
        </field>
    </class>

    <class name="Address" identity-type="application" objectid-class="Address$PK">
        <field name="id" primary-key="true"/>
        <field name="account" persistence-modifier="persistent" primary-key="true">
            <column name="ACCOUNT_ID"/>
        </field>
        <field name="city" persistence-modifier="persistent">
            <column length="50" jdbc-type="VARCHAR"/>
        </field>
        <field name="street" persistence-modifier="persistent">
            <column length="50" jdbc-type="VARCHAR"/>
        </field>
    </class>
</package>
```

So now we have the following datastore schema



Things to note :-

- You must use "application-identity" in both parent and child classes
- 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

```
public class Account
{
    long id; // PK field

    Set addresses = new HashSet();

    ... (remainder of Account class)

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

        public PK()
        {
        }
```

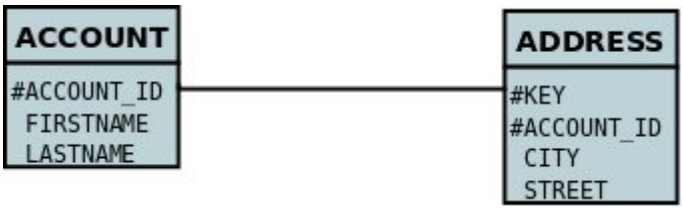
```
        public PK(String s)
        {
            this.id = Long.valueOf(s).longValue();
        }

        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;
        }
    }
}

public class Address
{
    String alias;
    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

```
<package name="com.mydomain">
    <class name="Account" objectid-class="Account$PK">
        <field name="id" primary-key="true"/>
        <field name="firstname" persistence-modifier="persistent">
            <column length="100" jdbc-type="VARCHAR"/>
        </field>
        <field name="lastname" persistence-modifier="persistent">
            <column length="100" jdbc-type="VARCHAR"/>
        </field>
        <field name="addresses" persistence-modifier="persistent" mapped-by="account">
            <map key-type="java.lang.String" value-type="com.mydomain.Address"/>
            <key mapped-by="alias"/>
        </field>
    </class>

    <class name="Address" objectid-class="Address$PK">
        <field name="account" persistence-modifier="persistent" primary-key="true"/>
        <field name="alias" null-value="exception" primary-key="true">
            <column name="KEY" length="20" jdbc-type="VARCHAR"/>
        </field>
        <field name="city" persistence-modifier="persistent">
            <column length="50" jdbc-type="VARCHAR"/>
        </field>
        <field name="street" persistence-modifier="persistent">
            <column length="50" jdbc-type="VARCHAR"/>
        </field>
    </class>
</package>
```

So now we have the following datastore schema



Things to note :-

- You must use "application-identity" in both parent and child classes
- 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

JDO 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 PersistenceManager since retrieval using the current PersistenceManager - for use by Optimistic Locking. JDO defines several "strategies" for generating the version of an object. The strategy has the following possible values

- **none** stores a number like the version-number but will not perform any optimistic checks.
- **version-number** stores a number (starting at 1) representing the version of the object.
- **date-time** stores a temporal representing the time at which the object was last updated. *Note that not all RDBMS store milliseconds in a Timestamp!*
- **state-image** stores a Long value being the hash code of all fields of the object. **DataNucleus doesnt currently support this option**

Versioning using a surrogate column

The default JDO mechanism for versioning of objects in RDBMS datastores is via a **surrogate column** in the table of the class. In the MetaData you specify the details of the surrogate column and the strategy to be used. For example

```
<package name="mydomain">
    <class name="User" table="USER">
        <version strategy="version-number" column="VERSION"/>
        <field name="name" column="NAME"/>
        ...
    </class>
</package>
```

alternatively using annotations

```
@PersistenceCapable
@Version(strategy=VersionStrategy.VERSION_NUMBER, column="VERSION")
public class MyClass
{
    ...
}
```

The specification above will create a table with an additional column called `VERSION` that will store the version of the object.

Versioning using a field/property of the class

DataNucleus provides a valuable extension to JDO whereby you can have a field of your class store the version of the object. This equates to JPA's default versioning process whereby you have to have a field present. To do this, lets take a class

```
public class User
{
    String name;
    ...
    long myVersion;

}
```

and we want to store the version of the object in the field "myVersion". So we specify the metadata as follows

```
<package name="mydomain">
    <class name="User" table="USER">
        <version strategy="version-number">
            <extension vendor-name="datanucleus" key="field-name" value="myVersion"/>
        </version>
        <field name="name" column="NAME"/>
        ...
        <field name="myVersion" column="VERSION"/>
    </class>
</package>
```

alternatively using annotations

```
@PersistenceCapable
@Version(strategy=VersionStrategy.VERSION_NUMBER, column="VERSION",
         extensions={@Extension(vendorName="datanucleus", key="field-name", value
="myVersion")})
public class MyClass
{
    protected long myVersion;
    ...
}
```

and so now objects of our class will have access to the version via the "myVersion" field.

A further improvement is possible when using the DataNucleus *javax.jdo* jar v3.2.0-release or later, where you can do this

```
@PersistenceCapable
public class MyClass
{
    @Version(strategy=VersionStrategy.VERSION_NUMBER, column="VERSION")
    protected long myVersion;
    ...
}
```

The field must be of one of the following types : int, long, short, *java.lang.Integer*, *java.lang.Long*, *java.lang.Short*, *java.sql.Timestamp*, *java.sql.Date*, *java.sql.Time*, *java.util.Date*, *java.util.Calendar*, *java.time.Instant*.

Auditing

Applicable to RDBMS

With standard JDO you have no annotations available to automatically add timestamps and user names 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.jdo.annotations.CreateTimestamp;
import org.datanucleus.api.jdo.annotations.CreateUser;
import org.datanucleus.api.jdo.annotations.UpdateTimestamp;
import org.datanucleus.api.jdo.annotations.UpdateUser;

@PersistenceCapable
public class Hotel
{
    @CreateTimestamp
    Timestamp createTimestamp;

    @CreateUser
    String createUser;

    @UpdateTimestamp
    Timestamp updateTimestamp;

    @UpdateUser
    String updateUser;

    ...
}
```

In the above example we have 4 fields in the class that will have columns in the datastore. The field *createTimestamp* and *createUser* will be persisted at INSERT with the Timestamp and current user for the insert. The field *updateTimestamp* and *updateUser* will be persisted whenever any update is made to the object in the datastore, with the Timestamp and current user for the update.

If you instead wanted to define this in XML then do it like this

```
<class name="Hotel">
    <field name="createTimestamp">
        <extension vendor-name="datanucleus" key="create-timestamp" value="true"/>
    </field>
    <field name="createUser">
        <extension vendor-name="datanucleus" key="create-user" value="true"/>
    </field>
    <field name="updateTimestamp">
        <extension vendor-name="datanucleus" key="update-timestamp" value="true"/>
    </field>
    <field name="updateUser">
        <extension vendor-name="datanucleus" key="update-user" value="true"/>
    </field>
</class>
```

Any field/property marked as `@CreateTimestamp` / `@UpdateTimestamp` needs to be of type *java.sql.Timestamp* or *java.time.Instant*.

You can only annotate a single field/property per class with each of these annotations (e.g a single `@CreateUser`)

Defining the Current User

The timestamp can be automatically generated for population here, but clearly the *current user* is not available as a standard, and so we have to provide a mechanism for setting it. You have 2 ways to do this; choose the one that is most appropriate to your situation

- Specify the persistence property **datanucleus.CurrentUser** on the PMF to be the current user to use. Optionally you can also specify the same persistence property on each PM if you have a particular user for each PM.
- Define an implementation of the DataNucleus interface *org.datanucleus.store.schema.CurrentUserProvider*, and specify it on PMF creation using the property **datanucleus.CurrentUserProvider**. This is defined as follows

```
public interface CurrentUserProvider
{
    /** Return the current user. */
    String currentUser();
}
```

So you could, for example, store the current user in a thread-local and return it via your implementation of this interface.

Full Traceability Auditing

DataNucleus doesn't currently provide a full traceability auditing capability, whereby you can track all changes to every relevant field. This would involve having a mirror table for each persistable class and, for each insert/update of an object, would require 2 SQL statements to be issued. The obvious consequence would be to slow down the persistence process.

Should your organisation require this, we could work with you to provide it. Please contact us if interested.

Multitenancy

On occasion you need to share a data model with other user-groups or other applications and where the model is persisted to the same structure of datastore. There are three ways of handling this with DataNucleus.

- **Separate Database per Tenant** - have a different database per user-group/application. In this case you will have a separate PMF for each database, and manage use of the appropriate PMF yourself.
- **Separate Schema per Tenant** - as the first option, except use different schemas. In this case you will have a separate PMF for each database schema, and manage use of the appropriate PMF yourself.
- **Same Database/Schema but with a Discriminator in affected Table(s)**. In this case you will have a single PMF, and DataNucleus will manage selecting appropriate data for the tenant in question. This is described below.

Multitenancy via Discriminator in Table

Applicable to RDBMS, HBase, MongoDB, Neo4j, Cassandra

To define that a class is to be "multi-tenant" and hence have a discriminator column added you need to do as follows.

```
<class name="MyClass">
     <extension vendor-name="datanucleus" key="multitenant" value="true"/>
     <extension vendor-name="datanucleus" key="multitenancy-column-name"
value="TENANT"/>
     <extension vendor-name="datanucleus" key="multitenancy-column-length" value=
"24"/>
     ...
</class>
```

or using annotations

```
@PersistenceCapable
@MultiTenant(columns={@Column(name="TENANT", length=24)})
public class MyClass
{
    ...
}
```

By default (without the specification of column name/length) this will add a column **TENANT_ID** to each primary table, of String-based (255) type.

In all DataNucleus prior to v6.0.0-m3 you enabled multitenancy globally (so the discriminator was always added, and you had to disable on a class-by-class basis). This is now changed so that you **explicitly** define which classes need a multitenancy discriminator.

Fields/Properties

Once we have defined a class to be persistable, 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.

Almost all Java field types are default persistent (if DataNucleus knows how to persist a type then it defaults to persistent) so there is no real need to specify `@Persistent` to make the field persistent.

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

```
@PersistenceCapable
public class MyClass
{
    @Persistent
    Date birthday;

    @NotPersistent
    String someOtherField;
}
```

So, using annotations, we have marked the field *birthday* as persistent, whereas field *someOtherField* is declared as *not* persisted. *Please note that in this particular case, Date is by default persistent so we could omit the* `@Persistent` *annotation* (with non-default-persistent types we would definitely need the annotation). Using XML MetaData we would have done

```
<class name="MyClass">
    <field name="birthday" persistence-modifier="persistent"/>
    <field name="someOtherField" persistence-modifier="none"/>
</class>
```

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.

The JavaBean specification is to have a getter method with signature *{type} getMyField()* and a setter method with signature *void setMyField({type} arg)*, where the property name is then *myField*, and the type is *{type}*.

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

```
@PersistenceCapable
public class MyClass
{
    @Persistent
    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 not persistent. Using XML MetaData we would have done

```
<class name="MyClass">
    <property name="birthday" persistence-modifier="persistent"/>
</class>
```

Overriding Superclass Field/Property MetaData

If you are using XML MetaData you can also override the MetaData for fields/properties of superclasses. You do this by adding an entry for *{class-name}.fieldName*, like this

```
<class name="Hotel" detachable="true">
    ...
    <field name="HotelSuperclass.someField" default-fetch-group="false"/>
</class>
```

so we have changed the field "someField" specified in the persistent superclass "HotelSuperclass" to not be part of the DFG.

Making a field/property non-persistent

If you have a field/property that you don't want to persist, just mark it's *persistence-modifier* as *none*, like this

```
    @NotPersistent
    String unimportantField;
```

or with XML

```
<class name="mydomain.MyClass">
    <field name="unimportantField" persistence-modifier="none"/>
</class>
```

Making a field/property read-only

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

```
<jdo>
    <package name="mydomain">
        <class name="MyClass">
            <field name="myField">
                <extension vendor-name="datanucleus" key="insertable" value="false"/>
                <extension vendor-name="datanucleus" key="updateable" value="false"/>
            </field>
        </class>
    </package>
</jdo>
```

and with annotations

```
@PersistenceCapable
public class MyClass
{
    @Extension(vendorName="datanucleus", key="insertable", value="false")
    @Extension(vendorName="datanucleus", key="updateable", value="false")
    String myField;

}
```

alternatively using a DataNucleus convenience annotation

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

@PersistenceCapable
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 JDO 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

- **First-Class (FCO) Types** : An object that can be *referred to* (object reference, providing a relation) and that has an "identity" is termed a **First Class Object (FCO)**. DataNucleus supports the following Java types as FCO :
  - **persistable** : any class marked for persistence can be persisted with its own identity in the datastore
  - **interface** where the field represents a *persistable* object
  - **java.lang.Object** where the field represents a *persistable* object
- **Second-Class (SCO) Types** : An object that does not have an "identity" is termed a **Second Class Object (SCO)**. This is something like a String or Date field in a class, or alternatively a Collection (that contains other objects). The sections below shows the currently supported SCO java types in DataNucleus. The tables in these sections show
  - **default-fetch-group (DFG)** : 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.
  - **primary-key** : whether the field can be used as part of the primary-key

First-Class Types (relation fields) are not present in the default fetch group.

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.

Where you have a secondary type that can be persisted in multiple possible ways you select which column type(s) by using the *jdbc-type* for the field, or alternatively you find the name of the internal DataNucleus *TypeConverter* and use that via the metadata extension "type-converter-name".

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 JDO AttributeConverter if you can easily convert the type into a String or Long.

You can add support for a Java type using the the Java Types 

.

You can also define more specific support for it with RDBMS datastores using the the RDBMS Java Types 

.

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.

When your field type is a type that is mutable it will be replaced by a "wrapper" when the owning object is managed. By default this wrapper type will be based on the *instantiated* type. You can change this to use the *declared* type by setting the persistence property **datanucleus.type.wrapper.basis** to *declared*.

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	DFG?	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 Type	DFG?	Proxy ?	PK?	Comments
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.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	DFG?	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.

CHECK constraints

Supported for RDBMS datastores.

If you want to constraint the column where a standard numeric/character field is stored to only have particular values you can put a CHECK constraint on the column contents in the datastore. You specify it like this

```
@Extension(vendorName="datanucleus", key="check-constraint-values", value="1,2,4")
int groupNumber;
```

This results in a column defined like

```
GRP_NUMBER INTEGER CHECK (GRP_NUMBER IN (1, 2, 4)),
```

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	DFG?	Proxy ?	PK?	Comments
java.sql.Date	✔	✔ (1)	✔	Persisted as **DATE**, String, DATETIME or Long.
java.sql.Time	✔	✔ (1)	✔	Persisted as **TIME**, String, DATETIME or Long.
java.sql.Timestamp	✔	✔ (1)	✔	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	✔	✔ (1)	✔	Persisted as **DATETIME**, String or Long.
java.util.TimeZone	✔	✘	✔	Persisted as **String**.
java.time.LocalDateTime	✔	✘	✘	Persisted as **Timestamp**, String, or DATETIME.
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 Type	DFG?	Proxy ?	PK?	Comments
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).
org.joda.time.Period	✔	✘	✘	Requires **datanucleus-jodatime** plugin. Persisted as **String**.

(1) By default the legacy Java temporal types (java.util.Date, java.sql.Date, java.sql.Time, java.sql.Timestamp) are treated as mutable even though most of their mutator methods are deprecated. If you never call the setTime() method on fields of these types you can get an efficiency benefit by setting persistence property **datanucleus.type.treatJavaUtilDateAsMutable** to *false* and they will not be wrapped by a proxy when handed back to you.

Collection/Map types

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

Java Type	DFG?	Proxy ?	PK?	Comments
java.util.Collection	✗	✓	✗	See the 1-N Mapping Guide
java.util.List	✗	✓	✗	See the 1-N Mapping Guide
java.util.Map	✗	✓	✗	See the 1-N Mapping Guide
java.util.Queue	✗	✓	✗	The comparator is specifiable via the metadata extension *comparator-name* (see below). See the 1-N Mapping Guide
java.util.Set	✗	✓	✗	See the 1-N Mapping Guide
java.util.SortedMap	✗	✓	✗	The comparator is specifiable via the metadata extension *comparator-name* (see below). See the 1-N Mapping Guide
java.util.SortedSet	✗	✓	✗	The comparator is specifiable via the metadata extension *comparator-name* (see below). See the 1-N Mapping Guide
java.util.ArrayList	✗	✓	✗	See the 1-N Mapping 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.HashMap	✗	✓	✗	See the 1-N Mapping Guide
java.util.HashSet	✗	✓	✗	See the 1-N Mapping Guide
java.util.Hashtable	✗	✓	✗	See the 1-N Mapping Guide
java.util.LinkedHashMap	✗	✓	✗	Persisted as a Map currently. No List-ordering is supported. See the 1-N Mapping Guide
java.util.LinkedHashSet	✗	✓	✗	Persisted as a Set currently. No List-ordering is supported. See the 1-N Mapping Guide
java.util.LinkedList	✗	✓	✗	See the 1-N Mapping Guide
java.util.Properties	✗	✓	✗	See the 1-N Mapping Guide
java.util.PriorityQueue	✗	✓	✗	The comparator is specifiable via the metadata extension *comparator-name* (see below). See the 1-N Mapping Guide
java.util.Stack	✗	✓	✗	See the 1-N Mapping Guide
java.util.TreeMap	✗	✓	✗	The comparator is specifiable via the metadata extension *comparator-name* (see below). See the 1-N Mapping Guide

Java Type	DFG?	Proxy?	PK?	Comments
java.util.TreeSet	✗	✓	✗	The comparator is specifiable via the metadata extension *comparator-name* (see below). See the 1-N Mapping Guide
java.util.Vector	✗	✓	✗	See the 1-N Mapping Guide
com.google.common.collect.Multiset	✗	✓	✗	Requires **datanucleus-guava** plugin. See the 1-N Mapping Guide

Collection Comparators

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

```
@Element
@Extension(vendorName="datanucleus", 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

DataNucleus supports persisting Enums, and they can be stored as either the *ordinal* (numeric column) or *name* (String column).

Java Type	DFG?	Proxy?	PK?	Comments
java.lang.Enum	✓	✗	✓	Persisted as String (name) or int (ordinal). Specified via *jdbc-type*.

Enum custom values

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 *jdbc-type* as INTEGER it would persist 0, 1, 2, 3 being the ordinal values. If you define the metadata as

```
@Extension(vendorName="datanucleus", 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.

Enum CHECK constraints

Supported for RDBMS datastores.

If you want to constraint the column where the Enum is stored to only have the values for that enum you can put a CHECK constraint on the column contents in the datastore. You specify it like this

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

This results in a column defined like

```
MY_COL VARCHAR(10) CHECK (MY_COL IN ('RED', 'GREEN', 'BLUE', 'YELLOW')),
```

This is the recommended way of constraining enum values in the datastore since it uses ANSI SQL, and it is a better more portable solution than using such as PostgreSQL enum type.

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. This plugin supports types from all of the most used geospatial libraries, see below. The implementation of many of these spatial types follows the OGC Simple Feature specification, but adds further types where the datastores support them.

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!

We do not currently support persisting to the PostGIS "geography" type, only the (most used) "geometry" type.

java.awt types

The JRE contains very limited support for some geometric types, largely under the *java.awt* package.

Java Type	DFG?	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 Type	DFG?	Proxy?	PK?	Comments
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.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.

JTS Topology Suite types

The JTS Topology Suite is a Java library for creating and manipulating vector geometry.

Java Type	DFG?	Proxy?	PK?	Comments
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).

Java Type	DFG?	Proxy ?	PK?	Comments
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).
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).

PostGIS types

PostGIS provides a series of geometric types for use in Java applications

Java Type	DFG?	Proxy ?	PK?	Comments
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).

Java Type	DFG?	Proxy?	PK?	Comments
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).
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).

Oracle JGeometry type

Oracle provides its own geometry type for use in Oracle databases.

Java Type	DFG?	Proxy ?	PK?	Comments
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)

Geospatial metadata extensions

`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.

```
<package name="mydomain.model.samples.jtsgeometry">
    <extension vendor-name="datanucleus" key="spatial-dimension" value="2"/> [1]
    <extension vendor-name="datanucleus" key="spatial-srid" value="4326"/> [1]

    <class name="SampleGeometry" detachable="true">
        <field name="id"/>
        <field name="name"/>
        <field name="geom" persistence-modifier="persistent">
            <extension vendor-name="datanucleus" key="mapping" value="no-userdata"/>
[2]
        </field>
    </class>

    <class name="SampleGeometryCollectionM" table="samplejtsgeometrycollectionm"
detachable="true">
        <extension vendor-name="datanucleus" key="postgis-hasMeasure" value="true"/>
[3]
        <field name="id"/>
        <field name="name"/>
        <field name="geom" persistence-modifier="persistent"/>
    </class>

    <class name="SampleGeometryCollection3D" table="samplejtsgeometrycollection3d"
detachable="true">
        <extension vendor-name="datanucleus" key="spatial-srid" value="-1"/> [1]
        <extension vendor-name="datanucleus" key="spatial-dimension" value="3"/> [1]
        <field name="id"/>
        <field name="name"/>
        <field name="geom" persistence-modifier="persistent"/>
    </class>
</package>
```

- **[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-userdata" 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	DFG?	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/H2/HSQLDB 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 SCO 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	DFG?	Proxy?	PK?	Comments
boolean[]	✗	✗	✗	See the Arrays Guide
byte[]	✗	✗	✗	See the Arrays Guide
char[]	✗	✗	✗	See the Arrays Guide
double[]	✗	✗	✗	See the Arrays Guide
float[]	✗	✗	✗	See the Arrays Guide
int[]	✗	✗	✗	See the Arrays Guide
long[]	✗	✗	✗	See the Arrays Guide

Java Type	DFG?	Proxy ?	PK?	Comments
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
Persistable[]	✗	✗	✗	See the Arrays Guide

Generic Type Variables

JDO does not explicitly require support for generic type variables. DataNucleus provides support for many situations with generic type variables.

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

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

public class Sub1 extends Base<Long>
{
    ...
}
public class Sub2 extends Base<Integer>
{
    ...
}
```

Similarly you could use TypeVariables to form relations, like this

```
public abstract class Ownable<T extends Serializable> implements Serializable
{
    @Persistent
    private T owner;
}

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

Similarly, if you use a type argument in a generic declaration for a field, like this

```
public class Owner
{
    private List<? extends Element> elements;
}

public class Element
{
    ...
}
```

Clearly there are many combinations of where generics and *TypeVariables* can be used, so let us know if your generics usage isn't supported.

JDO Attribute Converters

JDO3.2 introduces an API for conversion of an attribute of a *PersistenceCapable* object 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 convertToDatastore(X attributeValue);

    public X convertToAttribute (Y datastoreValue);
}
```

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 convertToAttribute(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 convertToDatastore(URL url)
    {
        return url != null ? url.toString() : null;
    }
}
```

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

```
@PersistenceCapable
public class MyClass
{
    @PrimaryKey
    long id;

    @Convert(URLStringConverter.class)
    URL url;

    ...
}
```

or using XML metadata

```
<field name="url" converter="mydomain.package.URLStringConverter"/>
```

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.

```
@Key(converter=URLStringConverter.class)
Map<URL, OtherEntity> myMap;
```

or using XML metadata

```
<field name="myMap">
    <key converter="mydomain.package.URLStringConverter"/>
</field>
```

You can register a *default* `AttributeConverter` for a java type when constructing the PMF via persistence properties. These properties should be of the form **javax.jdo.option.typeconverter.{javatype}** and the value is the class name of the `AttributeConverter`.

You CANNOT use an `AttributeConverter` for a *PersistenceCapable* type. This is because a *PersistenceCapable* type requires special treatment, such as attaching a StateManager etc.

The `AttributeConverter` objects shown here are **stateless**. DataNucleus allows for stateful `AttributeConverter` objects, with the state being CDI injectable, but you must be in a CDI environment for this to work. To provide CDI support for JDO, you should specify the persistence property **datanucleus.cdi.bean.manager** to be a CDI `BeanManager` object.

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
{
    ...
}

@PersistenceCapable
public class MyClass
{
    MyCollectionType myField;

    ...
}
```

We now define a simple `AttributeConverter` 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 convertToAttribute(String str)
    {
        if (str == null)
        {
            return null;
        }

        ...
        return myType;
    }

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

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

```
@PersistenceCapable
public class MyClass
{
    @Convert(MyCollectionTypeStringConverter.class)
    MyCollectionType myField;

    ...
}
```

or using XML metadata

```
<field name="myField" converter="mydomain.package.MyCollectionTypeStringConverter"/>
```

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

TypeConverters (DataNucleus Internals)

By default DataNucleus will store the value using its own **internal** configuration/default for the java type and for the datastore. The user can, however, change that internal handling by making use of a *TypeConverter*. You firstly need to define the *TypeConverter* class (assuming you aren't going to use an internal DataNucleus converter, and for this you should refer to the TypeConverter plugin-point. Once you have the converter defined, and registered in a `plugin.xml` under a name you then mark the field/property to use it

```
@Extension(vendorName="datanucleus", key="type-converter-name", value="kryo-
serialise")
String longString;
```

In this case we have a String field but we want to serialise it, not using normal Java serialisation but using the "Kryo" library. When it is stored it will be converted into a serialised form and when read back in will be deserialised. You can see the example Kryo TypeConverter over on GitHub.

You CANNOT use a TypeConverter for a *PersistenceCapable* type. This is because a *PersistenceCapable* type requires special treatment, such as attaching a StateManager etc.

Column Adapters

Supported for RDBMS.

By default, when inserting/updating into a column into an RDBMS datastore, the SQL will have a ? and the value replaced into it. We allow the use of adapter "functions" so that the inserted value can be modified during the insert/update. Like this

```
@Extension(vendorName="datanucleus", key="insert-function", value="TRIM(?)")
@Extension(vendorName="datanucleus", key="update-function", value="TRIM(?)")
String myStringField;
```

So when this field of this class is persisted the SQL generated will include `TRIM(?)` rather than `?`, and any leading/trailing whitespace will be removed.

Similarly on retrieval, we also allow the equivalent.

```
@Extension(vendorName="datanucleus", key="select-function", value="UPPER(?)")
String myStringField;
```

The `?` is replaced by the column name. So the stored datastore value will be converted to UPPERCASE before being set in the Java object retrieved.

You could use these *column adapters* to do things like encrypt/decrypt the value of a field when storing to/retrieving from the database, for example.

RDBMS Override of mapping

If you are using an RDBMS datastore a java type is mapped to type mapping, which is mapped to 1...N column mapping(s). You can override the **java type mapping** as well as the **column_mapping_class** for each column.

To override the mapping class used for a field/property add

```
<field name="myField">
    <extension vendor-name="datanucleus" key="mapping-class"
value="org.datanucleus.store.rdbms.mapping.java.IntegerMapping"/>
</field>
```

To override the column mapping class used for a column add

```
<column name="MYCOL">
    <extension vendor-name="datanucleus" key="column-mapping-class"
value="org.datanucleus.store.rdbms.mapping.column.ClobColumnMapping"/>
</column>
```

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 any field in JDO. There are many different "strategies" for generating values, as defined by the JDO specifications, and also some DataNucleus extensions. 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 for JDO are :-

- **native** - 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)
- **increment** - this is datastore neutral and increments a sequence value using a table.
- **uuid-string** - this is a UUID in string form
- **uuid-hex** - this is a UUID in hexadecimal form
- **uuid** - provides a pure UUID String utilising the JRE UUID class (DataNucleus extension)
- **uuid-object** - provides a pure UUID object utilising the JRE UUID class (DataNucleus extension)
- **auid** - provides a pure UUID following the OpenGroup standard (DataNucleus extension)
- **timestamp** - creates a java.sql.Timestamp of the current time (DataNucleus extension)
- **timestamp-value** - creates a long (millisecs) of the current time (DataNucleus extension)
- **max** - uses a max(column)+1 method (only in RDBMS) (DataNucleus extension)
- **datastore-uuid-hex** - UUID in hexadecimal form using datastore capabilities (only in RDBMS) (DataNucleus extension)
- user-supplied value generators - allows you to hook in your own identity generator (DataNucleus extension)

See also :-

- JDO MetaData reference for <class>
- JDO MetaData reference for <datastore-identity>
- JDO MetaData reference for <field>
- JDO Annotation reference for @DatastoreIdentity
- JDO Annotation reference for @Persistent

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*

native

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 increment 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*

Which generation strategy is used internally will be JDO provider dependent. If you want to be portable and independent of a JDO providers internals you should likely avoid use of `native`.

sequence

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. DataNucleus supports sequences for the following datastores:

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

To configure a class to use either of these generation methods with **datastore identity** you simply add this to the class' Meta-Data

```
<sequence name="yourseq" datastore-sequence="YOUR_SEQUENCE_NAME"
strategy="noncontiguous"/>
<class name="myclass" ... >
    <datastore-identity strategy="sequence" sequence="yourseq"/>
    ...
</class>
```

or using annotations

```
@PersistenceCapable
@DatastoreIdentity(strategy=IdGeneratorStrategy.SEQUENCE, sequence="yourseq")
@Sequence(name="yourseq", datastoreSequence="YOUR_SEQUENCE_NAME", strategy
=SequenceStrategy.NONCONTIGUOUS)
public class MyClass
```

You replace "YOUR_SEQUENCE_NAME" with your sequence name. To configure a class to use either of these generation methods using **application identity** you would add the following to the class' Meta-Data

```
<sequence name="yourseq" datastore-sequence="YOUR_SEQUENCE_NAME"
strategy="noncontiguous"/>
<class name="myclass" ... >
    <field name="myfield" primary-key="true" value-strategy="sequence"
sequence="yourseq"/>
    ...
</class>
```

or using annotations

```
@PersistenceCapable
@Sequence(name="yourseq", datastoreSequence="YOUR_SEQUENCE_NAME" strategy
=SequenceStrategy.NONCONTIGUOUS)
public class MyClass
{
    @Persistent(valueStrategy=IdGeneratorStrategy.SEQUENCE, sequence="yourseq")
    private long myfield;
    ...
}
```

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 JDO Meta-Data configuration. Additional properties for configuring sequences are set in the JDO Meta-Data, see the available properties below. Unsupported properties by a database are silently ignored by DataNucleus.

Property	Description	Required
key-min-value	determines the minimum value a sequence can generate	No
key-max-value	determines the maximum value a sequence can generate	No
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
sequence-catalog-name	Name of the catalog where the sequence is.	No.
sequence-schema-name	Name of the schema where the sequence is.	No.

This value generator will generate values unique across different JVMs

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. Any field using this strategy will NOT be present in any INSERT statement, and will be set in the datastore as a result.

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 **datastore identity** you need to set the *strategy* attribute. You can configure the Meta-Data for the class something like this (replacing 'myclass' with your class name) :

```
<class name="MyClass">
    <datastore-identity strategy="identity"/>
    ...
</class>
```

or using annotations

```
@PersistenceCapable
@DatastoreIdentity(strategy=IdGeneratorStrategy.IDENTITY)
public class MyClass {...}
```

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 (replacing 'myclass' and 'myfield' with your class and field names) :

```
<class name="myclass" identity-type="application">
    <field name="myfield" primary-key="true" value-strategy="identity"/>
    ...
</class>
```

or using annotations

```
@PersistenceCapable
public class MyClass
{
    @Persistent(valueStrategy=IdGeneratorStrategy.IDENTITY, primaryKey="true")
    long myfield;
}
```

Please be aware that if you have an inheritance tree with the base class defined as using "identity" then the column type for the PK of the base table will be defined as `AUTO_INCREMENT` / `IDENTITY` / `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).

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())

This value generator will generate values unique across different JVMs

increment

Applies to RDBMS, ODF, Excel, OOXML, HBase, Cassandra, MongoDB, Neo4j.

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 strategy will work with any datastore. This method requires a *sequence* table in the database and creates one if doesn't exist.

To configure a **datastore identity** class to use this generation method you simply add this to the classes Meta-Data.

```
<class name="MyClass" ... >
    <datastore-identity strategy="increment"/>
    ...
</class>
```

or using annotations

```
@PersistenceCapable
@DatastoreIdentity(strategy=IdGeneratorStrategy.INCREMENT)
public class MyClass {...}
```

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.

```
<class name="MyClass" ... >
    <field name="myfield" primary-key="true" value-strategy="increment"/>
    ...
</class>
```

or using annotations

```
@PersistenceCapable
public class MyClass
{
    @Persistent(valueStrategy=IdGeneratorStrategy.INCREMENT, primaryKey="true")
    long myfield;
    ...
}
```

Additional properties for configuring this generator are set in the JDO Meta-Data, see the available properties below. Unsupported properties are silently ignored by DataNucleus.

Property	Description	Required
key-initial-value	First value to be allocated.	No. Defaults to 1
key-cache-size	number of unique identifiers to cache. The keys are pre-allocated, cached and used on demand. If *key-cache-size* is greater than 1, it may generate holes in the object keys in the database, if not all keys are used. Refer to persistence property **datanucleus.valuegeneration.increment.allocationSize**	No. Defaults to 10
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*
sequence-name	name for the sequence (overriding the "sequence-table-basis" above). The row in the table will use this in the PK column	No
sequence-table-name	Table name for storing the sequence.	No. Defaults to `SEQUENCE_TABLE`
sequence-catalog-name	Name of the catalog where the table is.	No.
sequence-schema-name	Name of the schema where the table is.	No.
sequence-name-column-name	Name for the column that represent sequence names.	No. Defaults to `SEQUENCE_NAME`
sequence-nextval-column-name	Name for the column that represent incremeting sequence values.	No. Defaults to `NEXT_VAL`
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.

Property	Description	Required
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.

This value generator will generate values unique across different JVMs

uuid-string

Applicable to all datastores.

This generator creates identities with 16 characters in string format. The identity contains the IP address of the local machine where DataNucleus is running, as well as other necessary components to provide uniqueness across time.

this 'string' contains non-standard characters so is not usable on all datastores. You are better off with a standard UUID in most situations

This generator can be used in concurrent applications. It is especially useful in situations where large numbers of transactions within a certain amount of time have to be made, and the additional overhead of synchronizing the concurrent creation of unique identifiers through the database would break performance limits. It doesn't require datastore access to generate the identities and so has performance benefits over some of the other generators.

For a class using **datastore identity** you need to add metadata something like the following

```
<class name="myclass">
    <datastore-identity strategy="uuid-string"/>
    ...
</class>
```

To configure an **application identity** class to use this generation method you simply add this to the class' JDO Meta-Data.

```
<class name="myclass">
    <field name="myfield" primary-key="true" value-strategy="uuid-string"/>
    ...
</class>
```

uuid-hex

Applicable to all datastores.

This generator creates identities with 32 characters in hexadecimal format. The identity contains the IP address of the local machine where DataNucleus is running, as well as other necessary

components to provide uniqueness across time.

This generator can be used in concurrent applications. It is especially useful in situations where large numbers of transactions within a certain amount of time have to be made, and the additional overhead of synchronizing the concurrent creation of unique identifiers through the database would break performance limits. It doesn't require datastore access to generate the identities and so has performance benefits over some of the other generators.

For a class using **datastore identity** you need to add metadata something like the following

```
<class name="myclass">
    <datastore-identity strategy="uuid-hex"/>
    ...
</class>
```

To configure an **application identity** class to use this generation method you simply add this to the class' JDO Meta-Data.

```
<class name="myclass">
    <field name="myfield" primary-key="true" value-strategy="uuid-hex"/>
    ...
</class>
```

datastore-uuid-hex

Applicable to RDBMS (SQLServer, MySQL).

This method is like the "uuid-hex" option above except that it utilises datastore capabilities to generate the UUIDHEX code. Consequently this only works on some RDBMS. The disadvantage of this strategy is that it makes a call to the datastore for each new UUID required. The generated UUID is in the same form as the AUID strategy where identities are generated in memory and so the AUID strategy is the recommended choice relative to this option.

For a class using **datastore identity** you need to add metadata something like the following

```
<class name="myclass">
    <datastore-identity strategy="datastore-uuid-hex"/>
    ...
</class>
```

To configure an **application identity** class to use this generation method you simply add this to the class' JDO Meta-Data.

```
<class name="myclass">
    <field name="myfield" primary-key="true" value-strategy="datastore-uuid-hex"/>
    ...
</class>
```

uuid

Applicable to all datastores.

This generator uses the JRE UUID class to generate String values. The values are 128-bit (36 character) of the form *0e400c2c-b3a0-4786-a0c6-f2607bf643eb*.

This generator can be used in concurrent applications. It is especially useful in situations where large numbers of transactions within a certain amount of time have to be made, and the additional overhead of synchronizing the concurrent creation of unique identifiers through the database would break performance limits.

For a class using **datastore identity** you need to add metadata something like the following

```
<class name="MyClass">
    <datastore-identity strategy="uuid"/>
    ...
</class>
```

or using annotations

```
@PersistenceCapable
@DatastoreIdentity(customStrategy="uuid")
public class MyClass {...}
```

To configure an **application identity** class to use this generation method you simply add this to the class' JDO Meta-Data.

```
<class name="MyClass" ... >
    <field name="myfield" primary-key="true" value-strategy="uuid"/>
    ...
</class>
```

or using annotations

```
public class MyClass
{
    @Persistent(customValueStrategy="uuid", primaryKey="true")
    String myfield;
}
```

This value generator will generate values unique across different JVMs

uuid-object

Applicable to all datastores.

This generator uses the JRE UUID class to generate UUID values. The values are 128-bit (36 character) of the form "0e400c2c-b3a0-4786-a0c6-f2607bf643eb"

This generator can be used in concurrent applications. It is especially useful in situations where large numbers of transactions within a certain amount of time have to be made, and the additional overhead of synchronizing the concurrent creation of unique identifiers through the database would break performance limits.

To configure an **application identity** class to use this generation method you simply add this to the class' JDO Meta-Data.

```
<class name="myclass">
    <field name="myfield" primary-key="true" value-strategy="uuid-object"/>
    ...
</class>
```

Or using annotations

```
public class MyClass
{
    @Persistent(customValueStrategy="uuid-object")
    UUID myField;
}
```

This value generator will generate values unique across different JVMs

auid

Applicable to all datastores.

This generator uses a Java implementation of DCE UUIDs to create unique identifiers without the overhead of additional database transactions or even an open database connection. The identifiers are Strings of the form *LLLLLLLL-MMMM-HHHH-CCCC-NNNNNNNNNNNN* where 'L', 'M', 'H', 'C' and 'N' are the DCE UUID fields named time low, time mid, time high, clock sequence and node.

This generator can be used in concurrent applications. It is especially useful in situations where large numbers of transactions within a certain amount of time have to be made, and the additional overhead of synchronizing the concurrent creation of unique identifiers through the database would break performance limits.

For a class using **datastore identity** you need to add metadata something like the following

```
<class name="myclass" ... >
    <datastore-identity strategy="auid"/>
    ...
</class>
```

To configure an **application identity** class to use this generation method you simply add this to the class' JDO Meta-Data.

```
<class name="myclass" ... >
    <field name="myfield" primary-key="true" value-strategy="auid"/>
    ...
</class>
```

This value generator will generate values unique across different JVMs

timestamp

Applicable to all datastores.

This method will create a java.sql.Timestamp of the current time (at insertion in the datastore).

For a class using **datastore identity** you need to add metadata something like the following

```
<class name="myclass>
    <datastore-identity strategy="timestamp"/>
    ...
</class>
```

To configure an **application identity** class to use this generation method you simply add this to the

class' JDO Meta-Data.

```
<class name="myclass">
    <field name="myfield" primary-key="true" value-strategy="timestamp"/>
    ...
</class>
```

timestamp-value

Applicable to all datastores.

This method will create a long of the current time in millisecs (at insertion in the datastore).

For a class using **datastore identity** you need to add metadata something like the following

```
<class name="myclass">
    <datastore-identity strategy="timestamp-value"/>
    ...
</class>
```

To configure an **application identity** class to use this generation method you simply add this to the class' JDO Meta-Data.

```
<class name="myclass">
    <field name="myfield" primary-key="true" value-strategy="timestamp-value"/>
    ...
</class>
```

max

Applicable to RDBMS.

This method is database neutral and uses the *"select max(column) from table" + 1* strategy to create unique ids. The unique identifier value returned from the database is translated to a java type: java.lang.Long.

This is not recommended since it makes a DB call for every record to be inserted and hence is inefficient. Each DB call will run a scan in all table contents causing contention and locks in the table. We instead recommend the use of either Sequence, Identity or UUID based value generators - which you use would depend on your datastore.

For a class using **datastore identity** you need to add metadata something like the following

```
<class name="myclass">
    <datastore-identity strategy="max"/>
    ...
</class>
```

To configure an **application identity** class to use this generation method you simply add this to the class' JDO Meta-Data.

```
<class name="myclass">
    <field name="myfield" primary-key="true" value-strategy="max"/>
    ...
</class>
```

This value generator will **NOT** guarantee to generate values unique across different JVMs. This is because it will select the "max+1" and before creating the record another thread may come in and insert one.

Standalone ID generation

This section describes how to use the DataNucleus Value Generator API for generating unique keys for objects outside the DataNucleus (JDO) runtime. DataNucleus defines a framework for identity generation and provides many builtin strategies for identities. You can make use of the same strategies described above but for generating identities manually for your own use. The process is described below

The DataNucleus Value Generator API revolves around 2 classes. The entry point for retrieving generators is the **ValueGenerationManager**. This manages the appropriate **ValueGenerator** classes. Value generators maintain a block of cached ids in memory which avoid reading the database each time it needs a new unique id. Caching a block of unique ids provides you the best performance but can cause "holes" in the sequence of ids for the stored objects in the database.

Let's take an example. Here we want to obtain an identity using the **TableGenerator** ("increment" above). This stores identities in a datastore table. We want to generate an identity using this. Here is what we add to our code

```

```

```
PersistenceManagerImpl pm = (PersistenceManagerImpl) ... // cast your pm to impl ;

// Obtain a ValueGenerationManager
ValueGenerationManager mgr = new ValueGenerationManager();

// Obtain a ValueGenerator of the required type
Properties properties = new Properties();
properties.setProperty("sequence-name", "GLOBAL"); // Use a global sequence number
(for all tables)
ValueGenerator generator = mgr.createValueGenerator("MyGenerator",
    org.datanucleus.store.rdbms.valuegenerator.TableGenerator.class, props, pm
.getStoreManager(),
                new ValueGenerationConnectionProvider()
                {
                    RDBMSManager rdbmsManager = null;
                    ManagedConnection con;
                    public ManagedConnection retrieveConnection()
                    {
                        rdbmsManager = (RDBMSManager) pm.getStoreManager();
                        try
                        {
                            // important to use TRANSACTION_NONE like DataNucleus does
                            con = rdbmsManager.getConnection(Connection
.TRANSACTION_NONE);;
                            return con;
                        }
                        catch (SQLException e)
                        {
                            logger.error("Failed to obtain new DB connection for
identity generation!");
                            throw new RuntimeException(e);
                        }
                    }
                    public void releaseConnection()
                    {
                        try
                        {
                            con.close();
                            con = null;
                        }
                        catch (DataNucleusException e)
                        {
                            logger.error("Failed to close DB connection for identity
generation!");
                            throw new RuntimeException(e);
                        }
                        finally
                        {
                            rdbmsManager = null;
                        }
                    }
```

```
                });

// Retrieve the next identity using this strategy
Long identifier = (Long)generator.next();
```

Some ValueGenerators are specific to RDBMS datastores, and some are generic, so bear this in mind when selecting and adding your own.

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), or less likely as an entry in a join table. 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.

You cannot have a 1-1 relation to a long/int field! JDO is for use with object-oriented systems, not flat data.

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

```
public class Account
{
    ...

    @Column(name="USER_ID")
    User user;
}

public class User
{
    ...
}
```

or using XML metadata

```
<package name="mydomain">
    <class name="User" table="USER">
        ...
    </class>

    <class name="Account" table="ACCOUNT">
        ...
        <field name="user">
            <column name="USER_ID"/>
        </field>
    </class>
</package>
```

This contrasts with JPA mapping where you have to *explicitly* specify that it is a one-to-one relation!

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

Things to note :-

Account has the object reference (and so owns the relation) to **User** and so its table holds the foreign-key

If you call *PM.deletePersistent()* 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.

If you invoke an operation that will retrieve the one-to-one field, and you only want it to retrieve the foreign key value for later use (and **not** join to the related table) you specify the *recursion-depth* as 0 for the field/property.

Unidirectional (JoinTable)

Supported for RDBMS. Other datastores simply ignore the join table and store the relation in a column in the table of the object with the field.

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

```
public class Account
{
    User user;

    ...
}

public class User
{
    ...
}
```

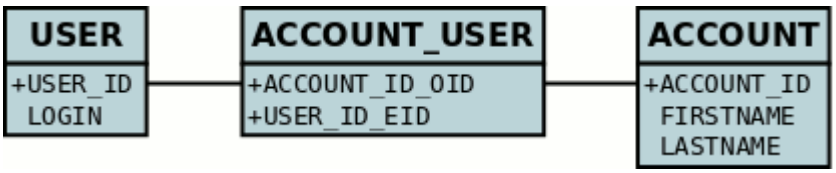
so the **Account** class knows about the **User** class, but not vice-versa and the relation is stored using a join table. A particular user could be related to several accounts. If you define the annotations as follows

```
public class Account
{
    ...

    @Persistent(table="ACCOUNT_USER")
    @Join
    User user;
}
```

or with XML metadata

```
<package name="mydomain">
    <class name="User" identity-type="datastore">
        ...
    </class>

    <class name="Account" identity-type="datastore">
        ...
        <field name="user" persistence-modifier="persistent" table="ACCOUNT_USER">
            <join/>
        </field>
    </class>
</package>
```

For RDBMS this will create 3 tables in the database, `USER` (for class **User**), `ACCOUNT` (for class **Account**), and a join table `ACCOUNT_USER` as shown below.



If you wish to specify the names of the database tables and columns for these classes, you can use the attribute *table* (on the `<class>` element), the attribute *table* on the `<field>`, the attribute *name* (on the `<column>` element) and the attribute *name* (on the **column** attribute under `<join>`)

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 (ForeignKey)

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

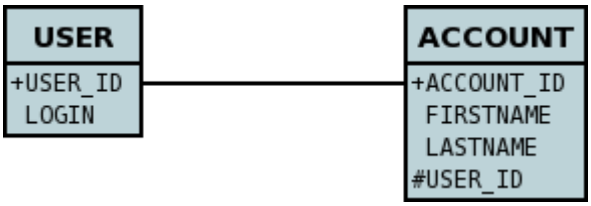
```
public class Account
{
    ...

    @Column(name="USER_ID")
    User user;
}

public class User
{
    ...

    @Persistent(mappedBy="user")
    Account account;
}
```

or using XML metadata

```
<package name="mydomain">
    <class name="User" table="USER">
        ...
        <field name="account" mapped-by="user"/>
    </class>

    <class name="Account" table="ACCOUNT">
        ...
        <field name="user">
            <column name="USER_ID"/>
        </field>
    </class>
</package>
```

The difference is that we added *mapped-by* to the field of **User**. This represents the bidirectionality.

This will create 2 tables in the database, `USER` (for class **User**), and `ACCOUNT` (for class **Account**). With RDBMS the `ACCOUNT` table will have a column `USER_ID` (since RDBMS will place the FK on the side without the "mapped-by"). Like this



With non-RDBMS datastores both tables will have a column containing the "id" of the related object, that is `USER` will have an `ACCOUNT` column, and `ACCOUNT` will have a `USER_ID` column.

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.

If you invoke an operation that will retrieve the one-to-one field (of the non-owner side), and you only want it to retrieve the foreign key value for later use (and **not** join to the related table) you can specify the *recursion-depth* to 0 for the field/property.

Bidirectional (JoinTable)

DataNucleus does not support a BIDIRECTIONAL 1-1 relation using a join table. It is not a use-case that is very common and is not part of the JDO spec. You could look at a unidirectional relation with join table, or model it using a foreign key.

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.

Collections allow duplicates whilst Sets don't 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 an (RDBMS) 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<PC> Unidirectional using Join Table
- Collection<PC> Unidirectional using Foreign-Key
- Collection<PC> Bidirectional using Join Table
- Collection<PC> Bidirectional using Foreign-Key
- Collection<PC> using shared join table (DataNucleus Extension)
- Collection<PC> using shared foreign key (DataNucleus Extension)
- Collection<Simple> using Join Table
- Collection<Simple> using AttributeConverter into single column
- Map<PC, PC> using join table
- Map<Simple, PC> using join table
- Map<Simple,PC> - Unidirectional using foreign-key (key stored in the value class)
- Map<Simple,PC> - Bidirectional using foreign-key (key stored in the value class)
- Map<Simple, Simple> using join table
- Map<Simple, Simple> using AttributeConverter into single column
- Map<PC, Simple> using join table
- Map<PC,Simple> - Unidirectional using foreign-key (value stored in the key class)

If you declare a field as a Collection, you can instantiate it as either Set-based or as List-based. With a List an "ordering" column is required, whereas with a Set it isn't. Consequently DataNucleus needs to know if you plan on using it as Set-based or List-based. You do this by adding an "order" element to the field if it is to be instantiated as a List-based collection. If there is no "order" element, then it will be assumed to be Set-based

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.

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, for this reason we do not recommend usage of *JDOHelper.getObjectId(obj)* in the equals/hashCode methods.

Ordering of elements

You can only retain the order in a Collection if you instantiate the Collection as an implementation that supports retaining the order. If the order of elements is important to you, use a List, or instantiate using something like a TreeSet where the order is handled.

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

By default JDO operates with *indexed* lists (i.e adds a surrogate column in the element or in the join table), and you simply add the following where required

```
@Order
```

or using XML

```
<order/>
```

If you have defined the field type as a List then this is not required to be added unless you want to configure details of the order column.

If you want an order column to be stored in a field in the element class then make use of the *mappedBy* of the `@Order`/`<order>`.

DataNucleus also supports *ordered* lists whereby the elements of the List are ordered according to some field (or fields) of the element.

If you have an element with a field called "city" then this specification will use that field for ordering (and not add a surrogate ordering column.

```
@Order(extensions=@Extension(vendorName="datanucleus", key="list-ordering", value
="city ASC"))
```

```
<order>
    <extension vendor-name="datanucleus" key="list-ordering" value="city ASC"/>
</order>
```

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

```
@Element
@Extension(vendorName="datanucleus", 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).

Collection<PC> Unidirectional (JoinTable)

Supported for RDBMS. Other datastores simply ignore the join table and store the relation in a column in the table of the object with the field.

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

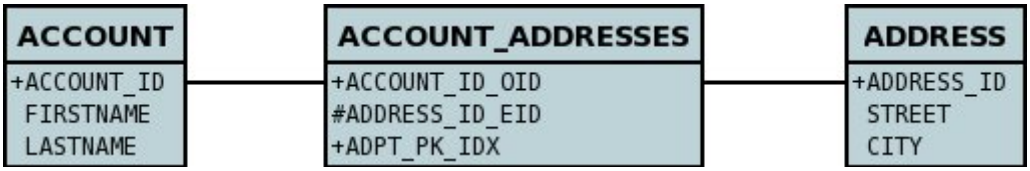
```
public class Account
{
    ...

    @Persistent(table="ACCOUNT_ADDRESSES")
    @Join(column="ACCOUNT_ID_OID")
    @Element(column="ADDRESS_ID_EID")
    Collection<Address> addresses;
}

public class Address
{
    ...
}
```

or using XML metadata

```
<package name="com.mydomain">
    <class name="Account">
        ...
        <field name="addresses" table="ACCOUNT_ADDRESSES">
            <collection element-type="com.mydomain.Address"/>
            <join column="ACCOUNT_ID_OID"/>
            <element column="ADDRESS_ID_EID"/>
        </field>
    </class>

    <class name="Address">
        ...
    </class>
</package>
```

The crucial part is the *join* element on the field element - this signals to JDO 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* attribute on the `class` element
- To specify the names of the columns where the fields of a class are stored, specify the *column* attribute on the `field` element.
- To specify the name of the join table, specify the *table* attribute on the `field` element with the collection.
- To specify the names of the join table columns, use the *column* attribute of `join`, `element` elements.
- To specify the foreign-key between container table and join table, specify `<foreign-key>` below the `<join>` element.
- To specify the foreign-key between join table and element table, specify `<foreign-key>` below either the `<field>` element or the `<element>` element.
- If you wish to share the join table with another relation then use the DataNucleus "shared join table" extension
- The join table will, by default, be given a primary key. If you want to omit this then you can turn it off using the DataNucleus metadata extension "primary-key" (within `<join>`) set to false.
- The column `ADPT_PK_IDX` is added by DataNucleus so that duplicates can be stored. You can control this by adding an `<order>` element and specifying the column name for the order column (within `<field>`).
- If you want the set to include nulls, you can turn on this behaviour by adding the DataNucleus extension metadata "allow-nulls" to the `<field>` set to true

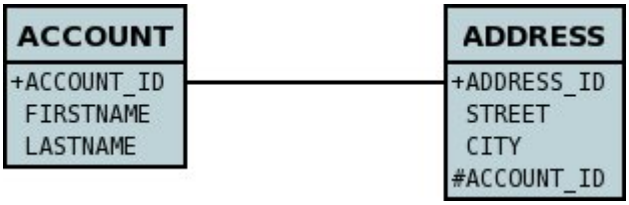
Collection<PC> Unidirectional (ForeignKey)

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
{
    ...

    @Element(column="ACCOUNT_ID")
    Collection<Address> addresses;
}

public class Address
{
    ...
}
```

```
<package name="com.mydomain">
    <class name="Account">
        ...
        <field name="addresses">
            <collection element-type="com.mydomain.Address"/>
            <element column="ACCOUNT_ID"/>
        </field>
    </class>

    <class name="Address">
        ...
    </class>
</package>
```

Again there will be 2 tables, one for **Address**, and one for **Account**.



Note that we have no "mapped-by" attribute specified, and also no "join" element.

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* attribute on the `class` element
- To specify the names of the columns where the fields of a class are stored, specify the *column* attribute on the `field` element.
- To specify the foreign-key between container table and element table, specify `<foreign-key>` below either the `<field>` element or the `<element>` element.
- To specify the names of the columns used in the schema for the foreign key in the **Address** table you should use the `<element>` element within the field of the collection.

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<PC> Bidirectional (JoinTable)

Supported for RDBMS. Other datastores simply ignore the join table and store the relation in a column in the table of the object with the field.

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

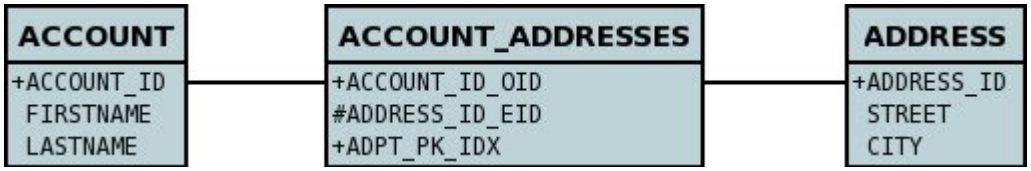
```
public class Account
{
    ...

    @Persistent(mappedBy="account")
    @Join
    Collection<Address> addresses;
}

public class Address
{
    ...
}
```

or using XML metadata

```
<package name="com.mydomain">
    <class name="Account">
        ...
        <field name="addresses" mapped-by="account">
            <collection element-type="com.mydomain.Address"/>
            <join/>
        </field>
    </class>

    <class name="Address">
        ...
        <field name="account"/>
    </class>
</package>
```

The crucial part is the *join* element on the field element - this signals to JDO 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* attribute on the `class` element
- To specify the names of the columns where the fields of a class are stored, specify the *column* attribute on the `field` element.
- To specify the name of the join table, specify the *table* attribute on the `field` element with the collection.
- To specify the names of the join table columns, use the *column* attribute of `join`, `element` elements.
- To specify the foreign-key between container table and join table, specify `<foreign-key>` below the `<join>` element.
- To specify the foreign-key between join table and element table, specify `<foreign-key>` below either the `<field>` element or the `<element>` element.
- If you wish to share the join table with another relation then use the DataNucleus "shared join table" extension
- The join table will, by default, be given a primary key. If you want to omit this then you can turn it off using the DataNucleus metadata extension "primary-key" (within `<join>`) set to false.

- The column `ADPT_PK_IDX` is added by DataNucleus so that duplicates can be stored. You can control this by adding an `<order>` element and specifying the column name for the order column (within `<field>`).
- 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.
- If you want the set to include nulls, you can turn on this behaviour by adding the extension metadata "allow-nulls" to the <field> set to true

Collection<PC> Bidirectional (ForeignKey)

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

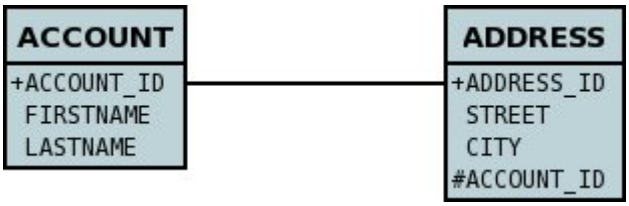
```
public class Account
{
    ...

    @Persistent(mappedBy="account")
    Collection<Address> addresses;
}

public class Address
{
    @Column(name="ACCOUNT_ID")
    Account account;
}
```

or using XML metadata

```
<package name="com.mydomain">
    <class name="Account">
        ...
        <field name="addresses" mapped-by="account">
            <collection element-type="com.mydomain.Address"/>
        </field>
    </class>

    <class name="Address">
        ...
        <field name="account">
            <column name="ACCOUNT_ID"/>
        </field>
    </class>
</package>
```

The crucial part is the *mapped-by* on the "1" side of the relationship. This tells the JDO 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* attribute on the `class` element
- To specify the names of the columns where the fields of a class are stored, specify the *column* attribute on the `field` element.
- To specify the foreign-key between container table and element table, specify `<foreign-key>` below either the `<field>` element or the `<element>` 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.

Collection<PC> (Shared JoinTable)

Supported for RDBMS.

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 shown 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

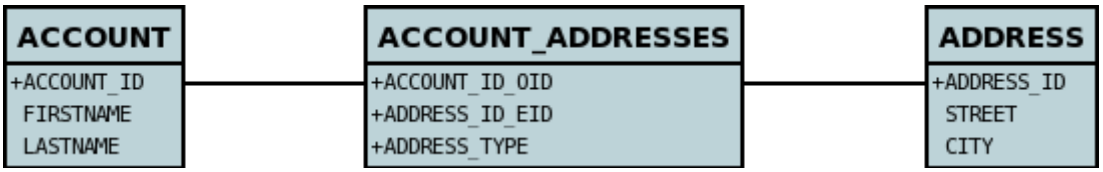
```
import org.datanucleus.api.jdo.annotations.SharedRelation;

public class Account
{
    ...

    @Persistent
    @Join(table="ACCOUNT_ADDRESSES", columns={@Column(name="ACCOUNT_ID_OID")})
    @Element(columns={@Column(name="ADDRESS_ID_EID")})
    @SharedRelation(column="ADDRESS_TYPE", value="work")
    Collection<Address> workAddresses;

    @Persistent
    @Join(table="ACCOUNT_ADDRESSES", columns={@Column(name="ACCOUNT_ID_OID")})
    @Element(columns={@Column(name="ADDRESS_ID_EID")})
    @SharedRelation(column="ADDRESS_TYPE", value="home")
    Collection<Address> homeAddresses;

    ...
}
```

or using XML metadata

```
<package name="com.mydomain">
    <class name="Account">
        ...
        <field name="workAddresses" persistence-modifier="persistent"
table="ACCOUNT_ADDRESSES">
            <collection element-type="com.mydomain.Address"/>
            <join column="ACCOUNT_ID_OID"/>
            <element column="ADDRESS_ID_EID"/>
            <extension vendor-name="datanucleus" key="relation-discriminator-column"
value="ADDRESS_TYPE"/>
            <extension vendor-name="datanucleus" key="relation-discriminator-pk"
value="true"/>
            <extension vendor-name="datanucleus" key="relation-discriminator-value"
value="work"/>
        </field>
        <field name="homeAddresses" persistence-modifier="persistent"
table="ACCOUNT_ADDRESSES">
            <collection element-type="com.mydomain.Address"/>
            <join column="ACCOUNT_ID_OID"/>
            <element column="ADDRESS_ID_EID"/>
            <extension vendor-name="datanucleus" key="relation-discriminator-column"
value="ADDRESS_TYPE"/>
            <extension vendor-name="datanucleus" key="relation-discriminator-pk"
value="true"/>
            <extension vendor-name="datanucleus" key="relation-discriminator-value"
value="home"/>
        </field>
    </class>

    <class name="Address">
        ...
    </class>
</package>
```

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<PC> (Shared ForeignKey)

Supported for RDBMS.

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 shown 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

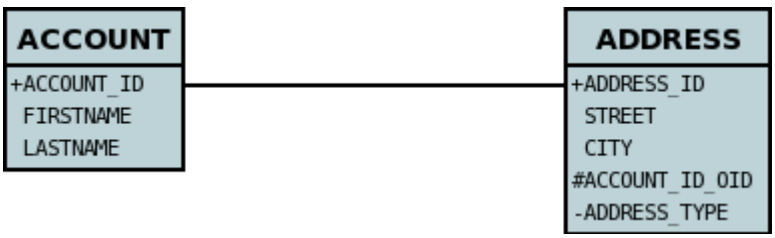
```
import org.datanucleus.api.jdo.annotations.SharedRelation;

public class Account
{
    ...

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

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

    ...
}
```

or using XML metadata

```
<package name="com.mydomain">
    <class name="Account">
        ...
        <field name="workAddresses" persistence-modifier="persistent">
            <collection element-type="com.mydomain.Address"/>
            <element column="ACCOUNT_ID_OID"/>
            <extension vendor-name="datanucleus" key="relation-discriminator-column"
value="ADDRESS_TYPE"/>
            <extension vendor-name="datanucleus" key="relation-discriminator-value"
value="work"/>
        </field>
        <field name="homeAddresses" persistence-modifier="persistent">
            <collection element-type="com.mydomain.Address"/>
            <element column="ACCOUNT_ID_OID"/>
            <extension vendor-name="datanucleus" key="relation-discriminator-column"
value="ADDRESS_TYPE"/>
            <extension vendor-name="datanucleus" key="relation-discriminator-value"
value="home"/>
        </field>
    </class>

    <class name="Address">
        ...
    </class>
</package>
```

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



Collection<Simple> (JoinTable)

Supported for RDBMS. Other datastores simply ignore the join table and store the collection in a column in the owning objects table.

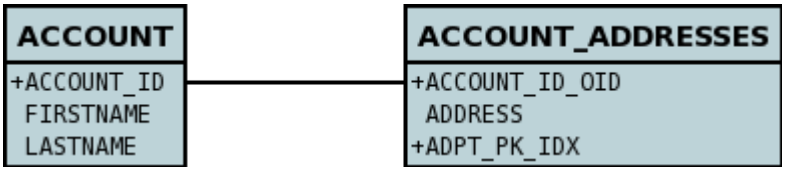
All of the examples above show a 1-N relationship between 2 persistable classes. If you want the element to be primitive or Object types then follow this section. For example, when you have a Collection of Strings. This will be persisted in the same way as the "Join Table" examples above. A join table 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

```
public class Account
{
    ...

    @Persistent
    @Join
    @Element(column="ADDRESS")
    Collection<String> addresses;
}
```

or using XML metadata

```
<package name="com.mydomain">
    <class name="Account">
        ...
        <field name="addresses" persistence-modifier="persistent">
            <collection element-type="java.lang.String"/>
            <join/>
            <element column="ADDRESS"/>
        </field>
    </class>
</package>
```

In the datastore the following is created



The `ACCOUNT` table is as before, but this time we only have the "join table". In our MetaData we used the `<element>` tag to specify the column name to use for the actual address String.

the column `ADPT_PK_IDX` is added by DataNucleus so that duplicates can be stored. You can control the name of this column by adding an `<order>` element and specifying the column name for the order column (within `<field>`).

Collection<Simple> using AttributeConverter (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 JDO AttributeConverter.

```
public class Account
{
    ...

    @Persistent
    @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 convertToDatastore(Collection<String> attribute)
    {
        if (attribute == null)
        {
            return null;
        }

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

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

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

Map<PC,PC> (JoinTable)

Supported for RDBMS. Other datastores simply ignore the join table and store the relation in a column in the table of the object with the field.

Here we have a Map field, with key and value as persistable classes.

```
@PersistenceCapable
public class Account
{
    ...
    Map<Name, Address> addresses;
}

@PersistenceCapable
public class Name {...}

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

If we define the annotations like this

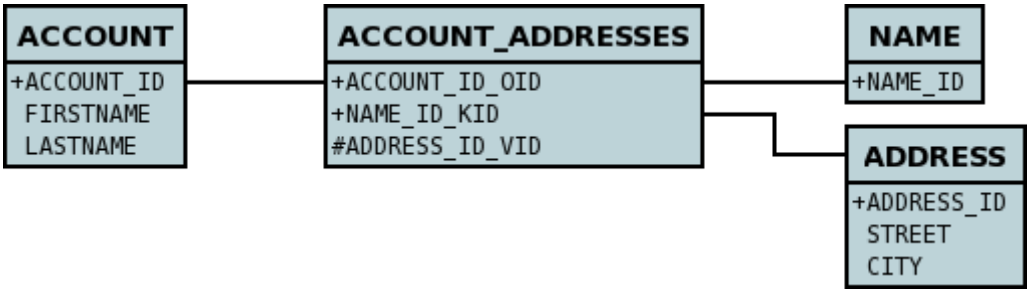
```
@PersistenceCapable
public class Account
{
    @Join
    Map<Name, Address> addresses;
}
```

or using XML metadata

```
<package name="com.mydomain">
    <class name="Account" identity-type="datastore">
        ...
        <field name="addresses" persistence-modifier="persistent">
            <map/>
            <join/>
        </field>
    </class>

    <class name="Address" identity-type="datastore">
        ...
    </class>

    <class name="Name" identity-type="datastore">
    </class>
</package>
```

we don't need to set the keyType or valueType since we are using generics.

This will create 4 tables in the datastore, one for **Account**, one for **Address**, one for **Name** and a join table containing foreign keys to the key/value tables.



If you want to configure the names of the columns in the "join" table you would use the `<key>` and `<value>` sub-elements of `<field>`, something like this

```
<field name="addresses" persistence-modifier="persistent" table="ACCOUNT_ADDRESS">
    <map/>
    <join>
        <column name="ACCOUNT_ID"/>
    </join>
    <key>
        <column name="NAME_ID"/>
    </key>
    <value>
        <column name="ADDRESS_ID"/>
    </value>
</field>
```

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* attribute on the `class` element
- To specify the names of the columns where the fields of a class are stored, specify the *column* attribute on the `field` element.
- To specify the name of the join table, specify the *table* attribute on the **field** element.
- To specify the names of the columns of the join table, specify the *column* attribute on the `join`, `key`, and `value` elements.
- To specify the foreign-key between container table and join table, specify `<foreign-key>` below the `<join>` element.
- To specify the foreign-key between join table and key table, specify `<foreign-key>` below the `<key>` element.
- To specify the foreign-key between join table and value table, specify `<foreign-key>` below the `<value>` element.

Which changes the names of the join table to `ACCOUNT_ADDRESS` from `ACCOUNT_ADDRESSES` and the names of the columns in the join table from `ACCOUNT_ID_OID` to `ACCOUNT_ID`, from `NAME_ID_KID` to `NAME_ID`, and from `ADDRESS_ID_VID` to `ADDRESS_ID`.

Map<Simple,PC> (JoinTable)

Supported for RDBMS. Other datastores simply ignore the join table and store the relation in a column in the table of the object with the field.

Here our key is a simple type (in this case a String) and the values are *persistable*. Like this

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

    ...
}

public class Address {...}
```

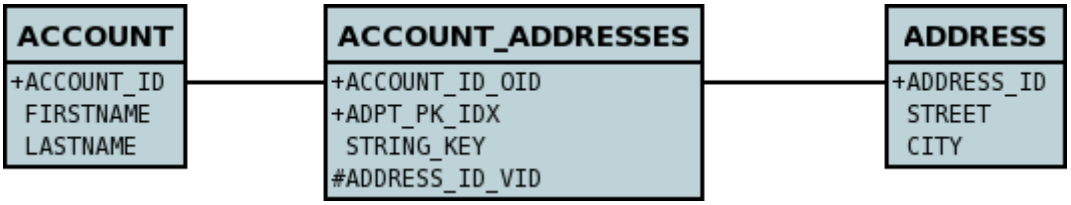
So we configure the Account class for persisting the Map into a join table, like this

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

or using XML metadata

```
<package name="com.mydomain">
    <class name="Account" identity-type="datastore">
        ...
        <field name="addresses" persistence-modifier="persistent">
            <map/>
            <join/>
        </field>
    </class>

    <class name="Address" identity-type="datastore">
        ...
    </class>
</package>
```

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



If you want to configure the names of the columns in the "join" table you would use the `<key>` and `<value>` subelements of `<field>` as shown above.

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,PC> 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. Here we use a field of the value as the key. The classes are like this

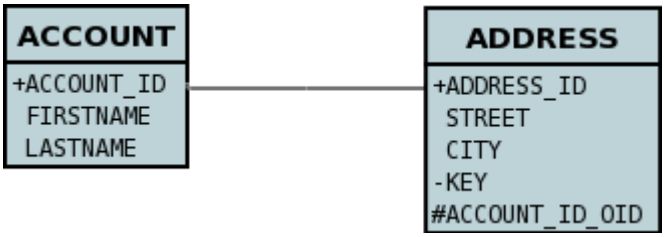
```
public class Account
{
    Map<String, Address> addresses;
}

public class Address
{
    String alias; // Use as key
}
```

In this relationship, the **Account** class has a Map of **Address** objects, yet the **Address** knows nothing about the **Account**. We define the annotations like this

```
public class Account
{
    ...
    @Key(mappedBy="alias")
    Map<String, Address> addresses;
}
```

```
<package name="com.mydomain">
    <class name="Account" identity-type="datastore">
        ...
        <field name="addresses" persistence-modifier="persistent">
            <map/>
            <key mapped-by="alias"/>
            <value column="ACCOUNT_ID_OID"/>
        </field>
    </class>

    <class name="Address" identity-type="datastore">
        ...
        <field name="alias" null-value="exception">
            <column name="KEY" length="20" jdbc-type="VARCHAR"/>
        </field>
    </class>
</package>
```

There will be 2 tables, one for **Address**, and one for **Account**. Note that we now have no "join" annotation/element.



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 *value* 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**. If you wish to have an **Address** assigned to multiple **Accounts** then you should use the "Join Table" relationship above.

Map<Simple,PC> 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
{
    Map<String, Address> addresses;
}

public class Address
{
    String alias; // Use as key

    Account account;
}
```

The only difference to the variant above is the bidirectional link back to the Account from Address.

So we define our metadata in a similar way

```
<package name="com.mydomain">
    <class name="Account" identity-type="datastore">
        ...
        <field name="addresses" persistence-modifier="persistent" mapped-by="account">
            <map/>
            <key mapped-by="alias"/>
        </field>
    </class>

    <class name="Address" identity-type="datastore">
        ...
        <field name="account"/>
        <field name="alias" null-value="exception">
            <column name="KEY" length="20" jdbc-type="VARCHAR"/>
        </field>
    </class>
</package>
```

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

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

Map<Simple, Simple> (JoinTable)

Supported for RDBMS. Other datastores simply ignore the join table and store the map in a column in the table of the object with the field.

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

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

    ...
}
```

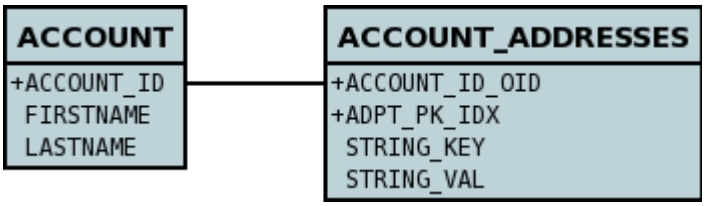
If you define the annotations for these classes as follows

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

    ...
}
```

or using XML metadata

```
<package name="com.mydomain">
    <class name="Account" identity-type="datastore">
        ...
        <field name="addresses" persistence-modifier="persistent">
            <map key-type="java.lang.String" value-type="java.lang.String"/>
            <join/>
        </field>
    </class>
</package>
```

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



If you want to configure the names of the columns in the "join" table you would use the `<key>` and `<value>` subelements of `<field>` as shown above.

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 (Column)

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

```
public class Account
{
    ...

    @Persistent
    @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 convertToDatastore(Map<String, String> attribute)
    {
        if (attribute == null)
        {
            return null;
        }

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

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

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

Map<PC,Simple> (JoinTable)

Supported for RDBMS. Other datastores simply ignore the join table and store the relation in a column in the table of the object with the field.

Here our value is a simple type (in this case a String) and the keys are *persistable*. Like this

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

    ...
}

public class Address {...}
```

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

or using XML metadata

```
<package name="com.mydomain">
    <class name="Account" identity-type="datastore">
        ...
        <field name="addresses" persistence-modifier="persistent">
            <map/>
            <join/>
        </field>
    </class>

    <class name="Address" identity-type="datastore">
        ...
    </class>
</package>
```

This operates exactly the same as "Map<Simple, PC>" except that the additional table is for the key instead of the value.

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

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 key. We're using a field (*businessAddress*) in the Address class as the value of the map.

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

public class Address
{
    String businessPhoneNumber; // Use as value
}
```

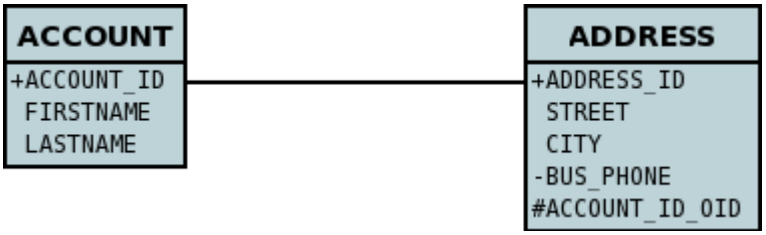
We define the MetaData like this

```
public class Account
{
   @Value(mappedBy="businessPhoneNumber")
   Map<Address, String> phoneNumbers;
}
```

```
<package name="com.mydomain">
    <class name="Account" identity-type="datastore">
        ...
        <field name="phoneNumbers">
            <map/>
            <key column="ACCOUNT_ID_OID"/>
            <value mapped-by="businessPhoneNumber"/>
        </field>
    </class>

    <class name="Address" identity-type="datastore">
        ...
        <field name="businessPhoneNumber" null-value="exception">
            <column name="BUS_PHONE" length="20" jdbc-type="VARCHAR"/>
        </field>
    </class>
</package>
```

There will be 2 tables, one for **Address**, and one for **Account**. The key thing here is that we have specified a "mapped-by" on the `<value>` element.

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 `<key>` 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**. If you wish to have an **Address** assigned to multiple **Accounts** then you should use the "Join Table" relationship above.

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.

You cannot have an N-1 relation to a long or int field! JDO is for use with object-oriented systems, not flat data.

Unidirectional (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

```
public class Account
{
    ...

    @Column(name="USER_ID")
    User user;
}

public class User
{
    ...
}
```

or using XML metadata

```
<package name="mydomain">
    <class name="User" table="USER">
        <field name="id" primary-key="true">
            <column name="USER_ID"/>
        </field>
        ...
    </class>

    <class name="Account" table="ACCOUNT">
        <field name="id" primary-key="true">
            <column name="ACCOUNT_ID"/>
        </field>
        ...
        <field name="user">
            <column name="USER_ID"/>
        </field>
    </class>
</package>
```

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

This is exactly the same as a 1-1 Unidirectional relation.

Unidirectional (JoinTable)

Supported for RDBMS. Other datastores simply ignore the join table and store the relation in a column in the table of the object with the field.

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

```
public class Account
{
    User user;

    ...
}

public class User
{
    ...
}
```

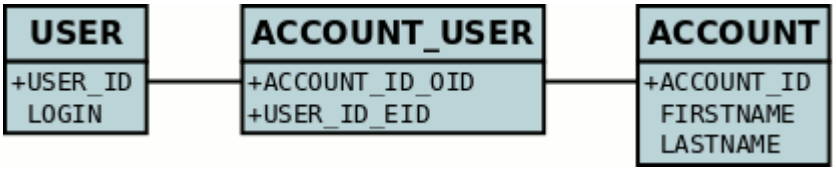
so the **Account** class ("N" side) knows about the **User** class ("1" side), but not vice-versa and the relation is stored using a join table. A particular user could be related to several accounts. If you define the annotations as follows

```
public class Account
{
    ...

    @Persistent(table="ACCOUNT_USER")
    @Join
    User user;
}
```

or with XML metadata

```
<package name="mydomain">
    <class name="User" identity-type="datastore">
        ...
    </class>

    <class name="Account" identity-type="datastore">
        ...
        <field name="user" persistence-modifier="persistent" table="ACCOUNT_USER">
            <join/>
        </field>
    </class>
</package>
```

For RDBMS this will create 3 tables in the database, `USER` (for class **User**), `ACCOUNT` (for class **Account**), and a join table `ACCOUNT_USER` as shown below.



If you wish to specify the names of the database tables and columns for these classes, you can use the attribute *table* (on the `<class>` element), the attribute *table* on the `<field>`, the attribute *name* (on the `<column>` element) and the attribute *name* (on the **column** attribute under `<join>`)

For non-RDBMS datastores there is no join-table, simply a "column" in the `ACCOUNT` table, storing the "id" of the related object

Bidirectional (ForeignKey)

This relationship is described in the guide for 1-N relationships. This relation 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.

Bidirectional (JoinTable)

This relationship is described in the guide for 1-N relationships. This relation uses a Join Table to link to the "N" object, with this table holding the relationship.

For non-RDBMS datastores there is no join table, and each side will have a "column" (or equivalent) in the "table", storing the "id" of the related object(s).

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 Set, Map, List or subclasses of these, although the only one that supports a true M-N is for a Set/Collection.

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.

If you want to have a M-N relation between classes and think of adding extra information to the join table, please think about where in your Java model that "extra information" is stored, and consider how JDO can know where to persist it. You would model this situation by creating an intermediate persistable class containing the extra information and make the relations to this intermediate class.

The various possible relationships are described below.

- M-N Set relation
- M-N Ordered List relation
- M-N Indexed List - modelled as 2 1-N Unidirectional relations using Join Table
- M-N Map - modelled as 2 1-N Unidirectional using Join Table

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, for this reason we do not recommend usage of *JDOHelper.getObjectId(obj)* in the *equals()*/*hashCode()* methods.

Using Set

Supported for RDBMS. Other datastores simply ignore the join table and store the relation in a column in the table of the object with the field.

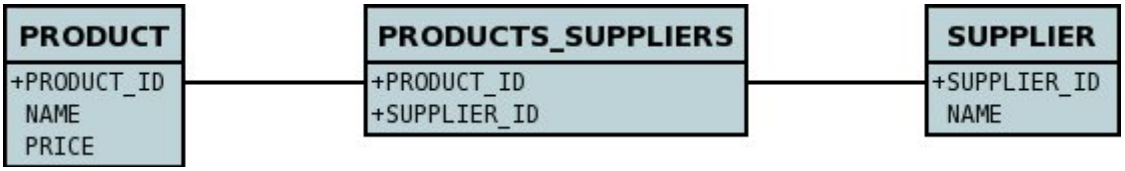
If you define the Meta-Data for these classes as follows

```
public class Product
{
    ...

    @Persistent(table="PRODUCTS_SUPPLIERS")
    @Join(column="PRODUCT_ID")
    @Element(column="SUPPLIER_ID")
    Set<Supplier> suppliers;
}

public class Supplier
{
    ...

    @Persistent(mappedBy="suppliers")
    Set<Products> products;
}
```

or using XML metadata

```
<package name="mydomain">
    <class name="Product" identity-type="datastore">
        ...
        <field name="suppliers" table="PRODUCTS_SUPPLIERS">
            <collection element-type="mydomain.Supplier"/>
            <join>
                <column name="PRODUCT_ID"/>
            </join>
            <element>
                <column name="SUPPLIER_ID"/>
            </element>
        </field>
    </class>

    <class name="Supplier" identity-type="datastore">
        ...
        <field name="products" mapped-by="suppliers">
            <collection element-type="mydomain.Product"/>
        </field>
    </class>
</package>
```

Note how we have specified the information only once regarding join table name, and join column names as well as the `<join>`/`@Join`. This is the JDO standard way of specification, and results in a single join table.



Using Ordered Lists

Supported for RDBMS. Other datastores simply ignore the join table and store the relation in a column in the table of the object with the field.

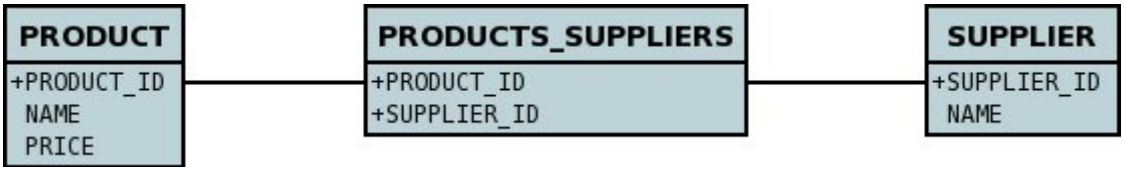
In this case our fields are of type List instead of Set used above. If you define the annotations for these classes as follows

```
public class Product
{
    ...

    @Persistent(table="PRODUCTS_SUPPLIERS")
    @Join(column="PRODUCT_ID")
    @Element(column="SUPPLIER_ID")
    @Order(extensions=@Extension(vendorName="datanucleus", key="list-ordering", value
="id ASC"))
    List<Supplier> suppliers
}

public class Supplier
{
    ...

    @Persistent
    @Order(extensions=@Extension(vendorName="datanucleus", key="list-ordering", value
="id ASC"))
    List<Product> products
}
```

or using XML metadata

```
<package name="mydomain">
    <class name="Product" identity-type="datastore">
        ...

        <field name="suppliers">
            <collection element-type="mydomain.Supplier"/>
            <order>
                <extension vendor-name="datanucleus" key="list-ordering" value="id
ASC"/>
            </order>
            <join/>
        </field>
    </class>

    <class name="Supplier" identity-type="datastore">
        ...

        <field name="products">
            <collection element-type="mydomain.Product"/>
            <order>
                <extension vendor-name="datanucleus" key="list-ordering" value="id
ASC"/>
            </order>
            <join/>
        </field>
    </class>
</package>
```

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 ordered list specification 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 ordering.



Using indexed Lists

Supported for RDBMS. Other datastores simply ignore the join table and store the relation in a column in the table of the object with the field.

Firstly a true M-N relation with Lists is impossible since there are two lists, and it is undefined as to which one applies to which side etc. What is shown below is two independent 1-N unidirectional join table relations.

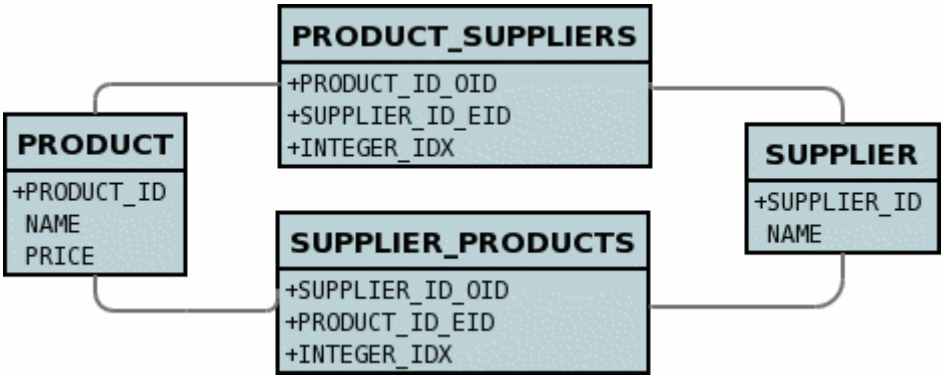
If you define the Meta-Data for these classes as follows

```
public class Product
{
    ...

    @Join
    List<Supplier> suppliers;
}

public class Supplier
{
    ...

    @Join
    List<Products> products;
}
```

or using XML metadata

```
<package name="mydomain">
    <class name="Product" identity-type="datastore">
        ...
        <field name="suppliers" persistence-modifier="persistent">
            <collection element-type="mydomain.Supplier"/>
            <join/>
        </field>
    </class>

    <class name="Supplier" identity-type="datastore">
        ...
        <field name="products" persistence-modifier="persistent">
            <collection element-type="mydomain.Product"/>
            <join/>
        </field>
    </class>
</package>
```

There will be 4 tables, one for **Product**, one for **Supplier**, and the join tables. The difference from the Set example is in the contents of the join tables. An index column is added to keep track of the position of objects in the Lists.



In the case of a (indexed) List at both ends it doesn't make sense to use a single join table because the ordering can only be defined at one side, so you have to have 2 join tables.

Using Map

Supported for RDBMS. Other datastores simply ignore the join table and store the relation in a column in the table of the object with the field.

If we reformulate our classes to use Map fields.

```
public class Product
{
    Map<String, Supplier> suppliers;

    ...
}

public class Supplier
{
    Map<String, Product> products;

    ...
}
```

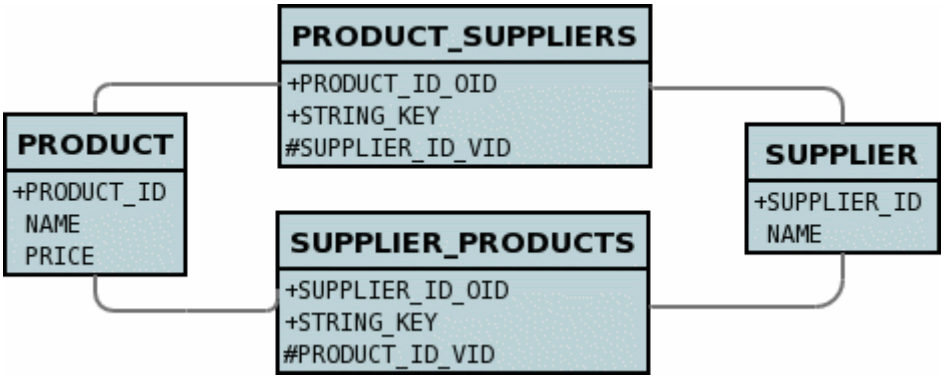
If you define the Meta-Data for these classes as follows

```
public class Product
{
    @Join
    Map<String, Supplier> suppliers;

    ...
}

public class Supplier
{
    @Join
    Map<String, Product> products;

    ...
}
```

or using XML metadata

```
<package name="mydomain">
    <class name="Product" identity-type="datastore">
        ...
        <field name="suppliers" persistence-modifier="persistent">
            <map/>
            <join/>
        </field>
    </class>

    <class name="Supplier" identity-type="datastore">
        ...
        <field name="products" persistence-modifier="persistent">
            <map/>
            <join/>
        </field>
    </class>
</package>
```

This will create 4 tables in the datastore, one for **Product**, one for **Supplier**, and the join tables which also contains the keys to the Maps (a String).



Arrays

JDO allows implementations to **optionally** support the persistence of arrays. DataNucleus provides full support for arrays in similar ways that collections are supported. DataNucleus supports persisting arrays as

- Single Column - the array is byte-streamed into a single column in the table of the containing object.
- Serialised - the array is serialised into single column in the table of the containing object.
- Using a Join Table - where the array relation is persisted into the join table, with foreign-key links to an element table where the elements of the array are *persistable*
- Using a Foreign-Key in the element - only available where the array is of a *persistable* type
- 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

JDO has no simple way of detecting *changes* to an arrays contents. To update an array you must EITHER replace the array field with the new array value OR update the array element and then call *JDOHelper.makeDirty(obj, "fieldName");*

Single Column Arrays

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 (but we don't want them serialised).

In terms of metadata required we simply define the field as "persistent". You could add `<array>` to be explicit but the type of the field is an array, and the type declaration also defines the component type so nothing more is needed. This results in a datastore schema as follows

DataNucleus supports persistence of the following array types in this way : *boolean[], byte[], char[], double[], float[], int[], long[], short[], Boolean[], Byte[], Character[], Double[], Float[], Integer[], Long[],*

Short[], BigDecimal[], BigInteger[]

When using PostgreSQL you can persist an array of *int, short, long, Integer, Short, Long* into a column of type *int array*, or an array of *String* into a column of type *text array*.

See also :-

- MetaData reference for <array> element
- Annotations reference for @Element

Serialised Arrays

Let's suppose you have a class something like the previous example

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

    ...
}
```

and now we want to persist the permissions as **serialised** into the table of the account. We define metadata like this

```
public class Account
{
    @Serialized
    byte[] permissions;
    ...
}
```

or using XML metadata

```
<class name="Account" identity-type="datastore">
    ...
    <field name="permissions" serialized="true" column="PERMISSIONS"/>
</class>
```

That is, you define the field as **serialized**. To define arrays of short, long, int, or indeed any other supported array type you would do the same as above. This results in a datastore schema as follows

DataNucleus supports persistence of many array types in this way, including : *boolean[], byte[], char[], double[], float[], int[], long[], short[], Boolean[], Byte[], Character[], Double[], Float[], Integer[], Long[], Short[], BigDecimal[], BigInteger[], String[], java.util.Date[], java.util.Locale[]*

See also :-

- MetaData reference for <field> element
- MetaData reference for <array> element
- Annotations reference for @Persistent
- Annotations reference for @Element
- Annotations reference for @Serialized

Arrays persisted into Join Tables

DataNucleus will support arrays persisted into a join table. Let's take the example above and make the "permission" a class in its own right, so we have

```
public class Account
{
    ...

    Permission[] permissions;
}

public class Permission
{
    ...
}
```

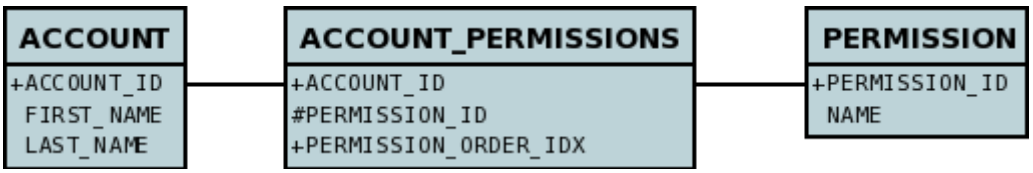
So an **Account** has an array of **Permissions**, and both of these objects are entities. We want to persist the relationship using a join table. We define the MetaData as follows

```
public class Account
{
    ...

    @Join(column="ACCOUNT_ID")
    @Element(column="PERMISSION_ID")
    @Order(column="PERMISSION_ORDER_IDX")
    Permission[] permissions;
}
```

or using XML metadata

```
<class name="Account" table="ACCOUNT">
    <field name="permissions" table="ACCOUNT_PERMISSIONS">
        <array/>
        <join column="ACCOUNT_ID"/>
        <element column="PERMISSION_ID"/>
        <order column="PERMISSION_ORDER_IDX"/>
    </field>
</class>
<class name="Permission" table="PERMISSION">
    <field name="name"/>
</class>
```

This results in a datastore schema as follows



See also :-

- MetaData reference for <array> element
- MetaData reference for <element> element
- MetaData reference for <join> element
- MetaData reference for <order> element
- Annotations reference for @Element
- Annotations reference for @Order

Arrays 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 of a *persistable* type. Let's take the same example above. So we have

```
public class Account
{
    ...

    Permission[] permissions;
}

public class Permission
{
    ...
}
```

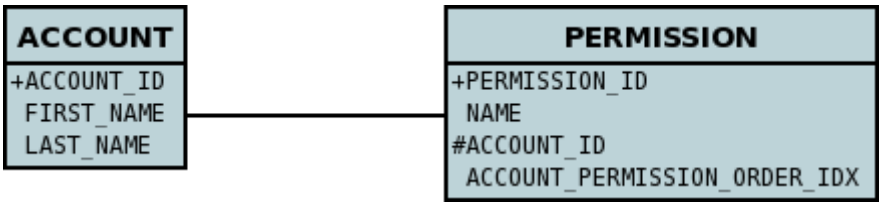
and the metadata is

```
public class Account
{
    ...

    @Element(column="ACCOUNT_ID")
    @Order(column="ACCOUNT_PERMISSION_ORDER_IDX")
    Permission[] permissions;
}
```

or using XML metadata

```
<class name="Account" table="ACCOUNT">
    ...
    <field name="permissions">
        <array/>
        <element column="ACCOUNT_ID"/>
        <order column="ACCOUNT_PERMISSION_ORDER_IDX"/>
    </field>
</class>
<class name="Permission" table="PERMISSION">
    <field name="name"/>
</class>
```

This results in a datastore schema as follows



See also :-

- MetaData reference for <array> element

- MetaData reference for <element> element
- MetaData reference for <order> element
- Annotations reference for @Element
- Annotations reference for @Order

Simple array stored in join table

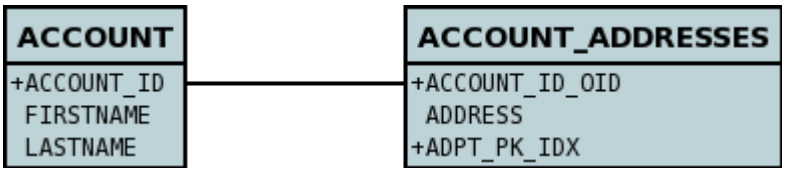
If you want an array of non-entity objects be stored in a "join" table, you can follow this example. We have an **Account** that stores a Collection of addresses. These addresses are simply Strings. We define the annotations like this

```
public class Account
{
    ...

    @Join(table="ACCOUNT_ADDRESSES")
    String[] addresses;
}
```

or using XML metadata

```
<class name="Account" table="ACCOUNT">
    ...
    <field name="permissions">
        <array/>
        <join table="ACCOUNT_ADDRESSES"/>
        <element column="ACCOUNT_ID"/>
        <order column="ACCOUNT_PERMISSION_ORDER_IDX"/>
    </field>
</class>
```

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.

Interfaces

JDO requires that implementations support the persistence of interfaces as first class objects (FCO's). DataNucleus provides this capability. It follows the same general process as for java.lang.Object since both interfaces and java.lang.Object are basically *references* to some persistable object.

To demonstrate interface handling let's introduce some classes. Let's 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;
    ...
}
```

JDO doesn't define how an interface is persisted in the datastore. Obviously there can be many implementations and so no obvious solution. DataNucleus supports the following. With non-RDBMS datastores there is a single column holding the interface field value. With RDBMS you have the option of storing this interface field value in several different ways, as below.

Applicable to RDBMS.

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`, or by placement of the `package.jdo` file so that when the owning class for the interface field is encountered so is the metadata for the implementations.

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.

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

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

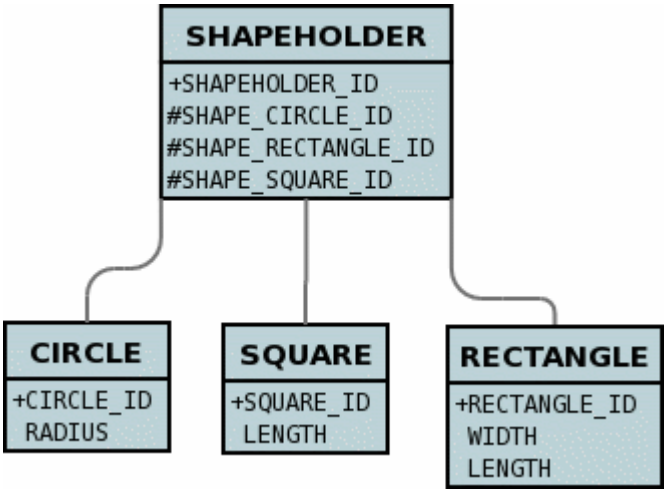
JDO also allows users to specify a list of classes implementing the interface on a field-by-field basis, defining which of these implementations are accepted for a particular interface field. To do this you define the Meta-Data like this

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

    ...
}
```

or using XML metadata

```
<package name="mydomain">
    <class name="ShapeHolder">
        <field name="shape" persistence-modifier="persistent"
               field-type="mydomain.Circle,mydomain.Rectangle,mydomain.Square"/>
</class>
```

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

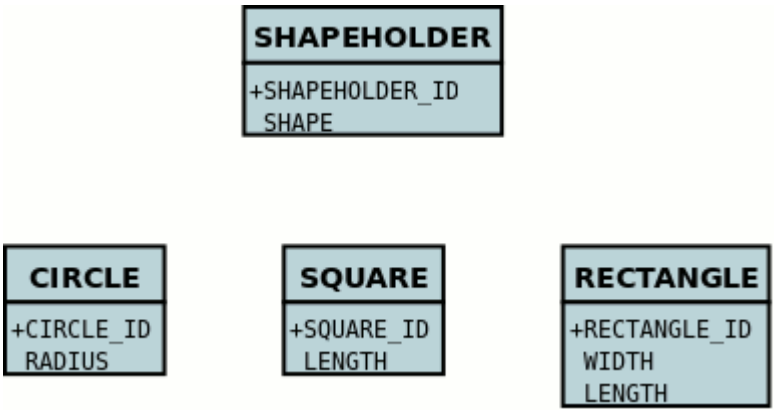


So DataNucleus adds foreign keys from the containers table to all of the possible implementation tables for the *shape* field.

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

```
<class name="ShapeHolder">
    <field name="shape" persistence-modifier="persistent">
        <extension vendor-name="datanucleus" key="mapping-strategy" value="identity"/>
    </field>
</class>
```

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

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

    ...
}
```

```
<class name="ShapeHolder">
    <field name="shapes" persistence-modifier="persistent">
        <collection element-type="mydomain.Shape"/>
        <join/>
        <extension vendor-name="datanucleus" key="implementation-classes"

value="mydomain.Circle,mydomain.Rectangle,mydomain.Square,mydomain.Triangle"/>
    </field>
</class>
```

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

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

JDO requires that implementations support the persistence of java.lang.Object as first class objects (FCO's). DataNucleus provides this capability and also provides that java.lang.Object can be stored as serialised. It follows the same general process as for Interfaces since both interfaces and java.lang.Object are basically *references* to some persistable object.

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

JDO doesn't define how an object FCO is persisted in the datastore. Obviously there can be many "implementations" and so no obvious solution. 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;
}
```

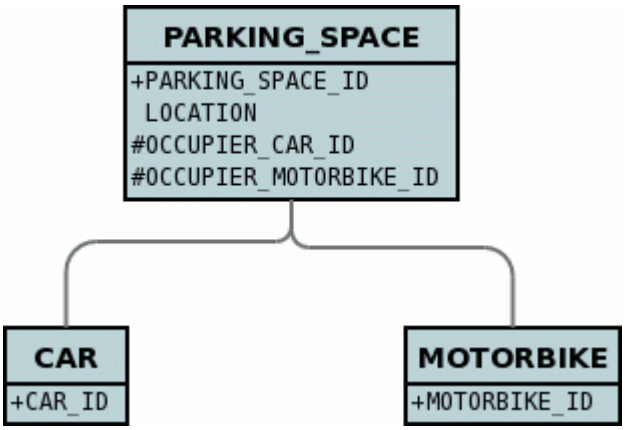
So we have a space in a car park, and in that space we have an occupier of the space. We have some legacy data and so can't make the type of this "occupier" an interface type, so we just use *java.lang.Object*. Now we know that we can only have particular types of objects stored there (since there are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

```
@Persistent(types={mydomain.samples.vehicles.Car.class, mydomain.samples.vehicles
.Motorbike.class})
Object occupier;
```

or using XML metadata

```
<package name="mydomain.samples.object">
    <class name="ParkingSpace">
        <field name="location"/>
        <field name="occupier" persistence-modifier="persistent"
               field-type="mydomain.samples.vehicles.Car,
mydomain.samples.vehicles.Motorbike"/>
        </field>
</class>
```

This will result in the following database schema.



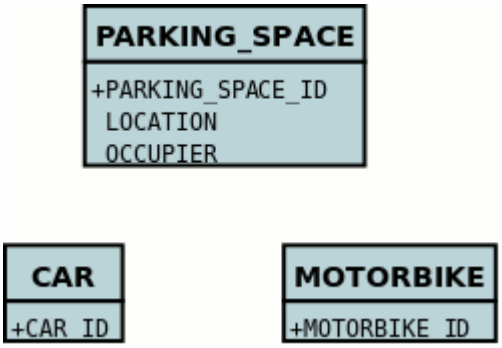
So DataNucleus adds foreign keys from the ParkingSpace table to all of the possible implementation tables for the *occupier* field.

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.

```
<class name="ParkingSpace">
    <field name="location"/>
    <field name="occupier" persistence-modifier="persistent">
        <extension vendor-name="datanucleus" key="mapping-strategy" value="identity"/>
    </field>
</class>
```

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 serialized, like this

```
public class MyClass
{
    ...
    @Serialized
    Object myObject;
}
```

```
<class name="MyClass">
    ...
    <field name="myObject" serialized="true"/>
</class>
```

Similarly, where you have a collection of Objects using a join table, the objects are, by default, stored in the table of the persistable instance. If instead you want them to occupy a single BLOB column of the join table, you should specify the "embedded-element" attribute of <collection> like this

```
<class name="MyClass">
    <field name="myCollection">
        <collection element-type="java.lang.Object" serialized-element="true"/>
        <join/>
    </field>
</class>
```

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

Embedded Fields

The JDO 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. JDO 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. JDO provides a MetaData attribute that you can use to signal this.

```
@PersistenceCapable(embeddedOnly="true")
public class MyClass
{
    ...
}
```

or using XML metadata

```
<jdo>
    <package name="com.mydomain.samples.embedded">
        <class name="MyClass" embedded-only="true">
            ...
        </class>
    </package>
</jdo>
```

With the above MetaData (using the *embedded-only* attribute), in our application any objects of the class **MyClass cannot** be persisted in their own right. They can only be embedded into other objects.

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

- Embedded PCs - where you have a 1-1 relationship and you want to embed the other persistable into the same table as the your object
- Embedded Nested PCs - like the first example except that the other object also has another persistable 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)

Embedded class structure

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.

You can have inheritance in an embedded type, but this is only supported for RDBMS and MongoDB. You must specify a discriminator in the embedded type and stored all inherited fields in the single table.

Embedding persistable objects (1-1)

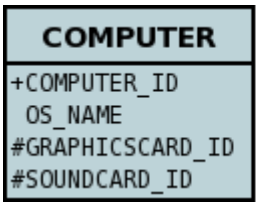
Applicable to RDBMS, Excel, OOXML, ODF, HBase, MongoDB, Neo4j, Cassandra, JSON

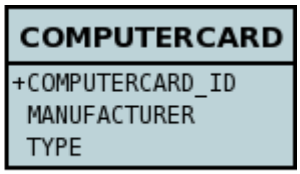
In a typical 1-1 relationship between 2 classes, the 2 classes in the relationship are persisted to their own table, and a foreign key is managed between them. With JDO and DataNucleus you can persist the related persistable object as embedded into the same table. This results in a single table in the 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 `COMPUTER` and we also want to persist the PC cards into the *same table*. We define our MetaData like this

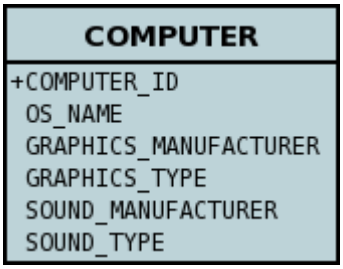
```
public class Computer
{
    @Embedded(nullIndicatorColumn="GRAPHICS_MANUFACTURER", members={
        @Persistent(name="manufacturer", column="GRAPHICS_MANUFACTURER"),
        @Persistent(name="type", column="GRAPHICS_TYPE")})
    private ComputerCard graphicsCard;

    @Embedded(nullIndicatorColumn="SOUND_MANUFACTURER", members={
        @Persistent(name="manufacturer", column="SOUND_MANUFACTURER"),
        @Persistent(name="type", column="SOUND_TYPE")})
    private ComputerCard soundCard;

    ...
}

@PersistenceCapable(embeddedOnly="true")
public class ComputerCard
{
    ...
}
```

or using XML metadata

```
<jdo>
    <package name="com.mydomain.samples.embedded">
        <class name="Computer" identity-type="datastore" table="COMPUTER">
            ...
            <field name="graphicsCard" persistence-modifier="persistent">
                <embedded null-indicator-column="GRAPHICS_MANUFACTURER">
                    <field name="manufacturer" column="GRAPHICS_MANUFACTURER"/>
                    <field name="type" column="GRAPHICS_TYPE"/>
                </embedded>
            </field>
            <field name="soundCard" persistence-modifier="persistent">
                <embedded null-indicator-column="SOUND_MANUFACTURER">
                    <field name="manufacturer" column="SOUND_MANUFACTURER"/>
                    <field name="type" column="SOUND_TYPE"/>
                </embedded>
            </field>
        </class>

        <class name="ComputerCard" embedded-only="true">
            ...
        </class>
    </package>
</jdo>
```

So here we will end up with a table `COMPUTER` with columns `COMPUTER_ID`, `OS_NAME`,

GRAPHICS_MANUFACTURER, GRAPHICS_TYPE, SOUND_MANUFACTURER, SOUND_TYPE. If we call *makePersistent()* on any objects of type **Computer**, they will be persisted into this table.



You will notice in the MetaData our use of the attribute *null-indicator-column*. This is used when retrieving objects from the datastore and detecting if it is a NULL embedded object. In the case we have here, if the column GRAPHICS_MANUFACTURER is null at retrieval, then the embedded "graphicsCard" field will be set as null. Similarly for the "soundCard" field when SOUND_MANUFACTURER is null.

If the **ComputerCard** class above has a reference back to the related **Computer**, JDO defines a mechanism whereby this will be populated. You would add the XML element `owner-field` to the `<embedded>` tag defining the field within **ComputerCard** that represents the **Computer** it relates to. When this is specified DataNucleus will populate it automatically, so that when you retrieve the **Computer** and access the **ComputerCard** objects within it, they will have the link in place.

It should be noted that in this latter (embedded) case we can still persist objects of type **ComputerCard** into their own table - the MetaData definition for **ComputerCard** is used for the table definition in this case.

Please note that if, instead of specifying the <embedded> block we had specified **embedded** in the field element we would have ended up with the same thing, just that the fields and columns would have been mapped using their default mappings, and that the `<embedded>` provides control over how they are mapped.

See also :-

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

MongoDB embedding control

For MongoDB you have one further control over how the persistable object is embedded. Since the datastore effectively is a JSON document, the default is to nest the embedded object, so our example could be represented as

```
{ "OS_NAME" : "Windows" ,
  "COMPUTER_ID" : 1 ,
  "graphicsCard" : { "GRAPHICS_MANUFACTURER" : "NVidea" ,
          "GRAPHICS_TYPE" : "AGP"},
  "soundCard" : { "SOUND_MANUFACTURER" : "Intel" ,
          "SOUND_TYPE" : "Other"}
}
```

If you set the field(s) to use **flat** embedding using the **nested** extension, like this

```
public class Computer
{
    @Embedded(nullIndicatorColumn="GRAPHICS_MANUFACTURER", members={
        @Persistent(name="manufacturer", column="GRAPHICS_MANUFACTURER"),
        @Persistent(name="type", column="GRAPHICS_TYPE")})
    @Extension(vendorName="datanucleus", key="nested", value="false")
    private ComputerCard graphicsCard;

    @Embedded(nullIndicatorColumn="SOUND_MANUFACTURER", members={
        @Persistent(name="manufacturer", column="SOUND_MANUFACTURER"),
        @Persistent(name="type", column="SOUND_TYPE")})
    @Extension(vendorName="datanucleus", key="nested", value="false")
    private ComputerCard soundCard;

    ...
}
```

then the resultant representation will be

```
{ "OS_NAME" : "Windows",
  "COMPUTER_ID" : 1,
  "GRAPHICS_MANUFACTURER" : "NVidea",
  "GRAPHICS_TYPE" : "AGP",
  "SOUND_MANUFACTURER" : "Intel",
  "SOUND_TYPE" : "Other"
}
```

Embedding nested persistable objects

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

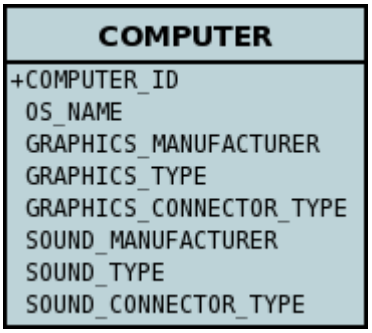
In the above example we had an embedded persistable object within a persisted object. What if our embedded persistable object also contain another persistable object. So, using the above example what if **ComputerCard** contains an object of type **Connector** ?

```
@PersistenceCapable(embeddedOnly="true")
public class ComputerCard
{
    Connector connector;

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

    ...
}

@PersistenceCapable(embeddedOnly="true")
public class Connector
{
    int type;
}
```

Well we want to store all of these objects into the same record in the `COMPUTER` table, so we define our XML metadata like this

```
<jdo>
    <package name="com.mydomain.samples.embedded">
        <class name="Computer" identity-type="datastore" table="COMPUTER">
            ....
            <field name="graphicsCard" persistence-modifier="persistent">
                <embedded null-indicator-column="GRAPHICS_MANUFACTURER">
                    <field name="manufacturer" column="GRAPHICS_MANUFACTURER"/>
                    <field name="type" column="GRAPHICS_TYPE"/>
                    <field name="connector">
                        <embedded>
                            <field name="type" column="GRAPHICS_CONNECTOR_TYPE"/>
                        </embedded>
                    </field>
                </embedded>
            </field>
            <field name="soundCard" persistence-modifier="persistent">
                <embedded null-indicator-column="SOUND_MANUFACTURER">
                    <field name="manufacturer" column="SOUND_MANUFACTURER"/>
                    <field name="type" column="SOUND_TYPE"/>
                    <field name="connector">
                        <embedded>
                            <field name="type" column="SOUND_CONNECTOR_TYPE"/>
                        </embedded>
                    </field>
                </embedded>
            </field>
        </class>

        <class name="ComputerCard" table="COMPUTER_CARD">
            ....
        </class>

        <class name="Connector" embedded-only="true">
            <field name="type"/>
        </class>
    </package>
</jdo>
```

So we simply nest the embedded definition of the **Connector** objects within the embedded definition of the **ComputerCard** definitions for **Computer**. JDO 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.



you cannot specify **nested** embedded column information using JDO annotations; use XML metadata instead.

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 elements but with all inherited fields stored in the same table with a discriminator (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 **Devices**. So we define our classes as

```
public class Network
{
    private String name;
    private Collection<Device> devices = new HashSet<>();

    ...
}

public class Device
{
    private String name;
    private String ipAddress;

    ...
}
```

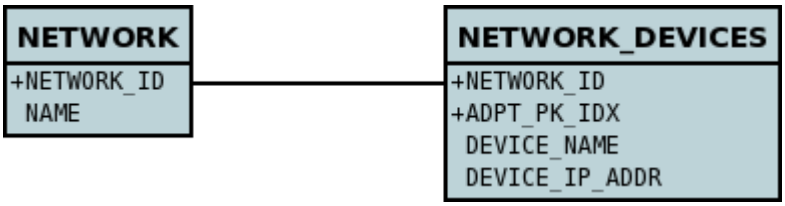
We decide that instead of **Device** having its own table, we want to persist them into the join table of its relationship with the **Network** since they are only used by the network itself. We define our annotations like this

```
public class Network
{
    @Element(embeddedMapping={
        @Embedded(members={
            @Persistent(name="name", column="DEVICE_NAME"),
            @Persistent(name="ipAddress", column="DEVICE_IP_ADDR")})
    })
    @Join(column="NETWORK_ID")
    private Collection<Device> devices = new HashSet<>();

    ...
}

@PersistenceCapable(embeddedOnly="true")
public class Device
{
    private String name;
    private String ipAddress;

    ...
}
```

or using XML metadata

```
<jdo>
    <package name="com.mydomain.samples.embedded">
        <class name="Network" identity-type="datastore" table="NETWORK">
            ...
            <field name="devices" persistence-modifier="persistent"
table="NETWORK_DEVICES">
                <collection element-type="com.mydomain.samples.embedded.Device"/>
                <join>
                    <column name="NETWORK_ID"/>
                </join>
                <element>
                    <embedded>
                        <field name="name">
                            <column name="DEVICE_NAME" allows-null="true"/>
                        </field>
                        <field name="ipAddress">
                            <column name="DEVICE_IP_ADDR" allows-null="true"/>
                        </field>
                    </embedded>
                </element>
            </field>
        </class>

        <class name="Device" table="DEVICE" embedded-only="true">
            <field name="name">
                <column name="NAME"/>
            </field>
            <field name="ipAddress">
                <column name="IP_ADDRESS"/>
            </field>
        </class>
    </package>
</jdo>
```

So here we will end up with a table `NETWORK` with columns `NETWORK_ID`, and `NAME`, and a table `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.



Please note that if, instead of specifying the `<embedded>` block we had specified `embedded-element` in the collection element we would have ended up with the same thing, just that the fields and columns would be mapped using their default mappings, and that the `<embedded>` provides control over how they are mapped.

You note that in our example above DataNucleus has added an extra column `ADPT_PK_IDX` to provide

the primary key of the join table now that we're storing the elements as embedded. A variation on this would have been if we wanted to maybe use the DEVICE_IP_ADDR as the other part of the primary key, in which case the ADPT_PK_IDX would not be needed. You would specify XML metadata like this

```
<field name="devices" persistence-modifier="persistent" table="NETWORK_DEVICES">
    <collection element-type="com.mydomain.samples.embedded.Device"/>
    <join>
        <primary-key name="NETWORK_DEV_PK">
            <column name="NETWORK_ID"/>
            <column name="DEVICE_IP_ADDR"/>
        </primary-key>
        <column name="NETWORK_ID"/>
    </join>
    <element>
        <embedded>
            <field name="name">
                <column name="DEVICE_NAME" allows-null="true"/>
            </field>
            <field name="ipAddress">
                <column name="DEVICE_IP_ADDR" allows-null="true"/>
            </field>
        </embedded>
    </element>
</field>
```

This results in the join table only having the columns NETWORK_ID, DEVICE_IP_ADDR, and DEVICE_NAME, and having a primary key as the composite of NETWORK_ID and DEVICE_IP_ADDR.

See also :-

- MetaData reference for <embedded> element
- MetaData reference for <element> element
- MetaData reference for <join> element
- Annotations reference for @Embedded
- Annotations reference for @Element

MongoDB embedded representation

Since the datastore with MongoDB is effectively a JSON document, our example would be represented as

```
{ "NAME" : "A Name" ,
  "NETWORK_ID" : 1 ,
  "devices" :
      [
        { "DEVICE_NAME" : "Laptop" ,
          "DEVICE_IP_ADDR" : "192.168.1.2"} ,
        { "DEVICE_NAME" : "Desktop" ,
          "DEVICE_IP_ADDR" : "192.168.1.3"} ,
        { "DEVICE_NAME" : "Smart TV" ,
          "DEVICE_IP_ADDR" : "192.168.1.4"}
      ]
}
```

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 JDO 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 but with all inherited fields stored in the same table and a discriminator (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, fetch plans 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 **Films**, keyed by a String alias. So we define our classes as

```
public class FilmLibrary
{
    private String owner;
    private Map<String, Film> films = new HashMap<>();

    ...
}

public class Film
{
    private String name;
    private String director;

    ...
}
```

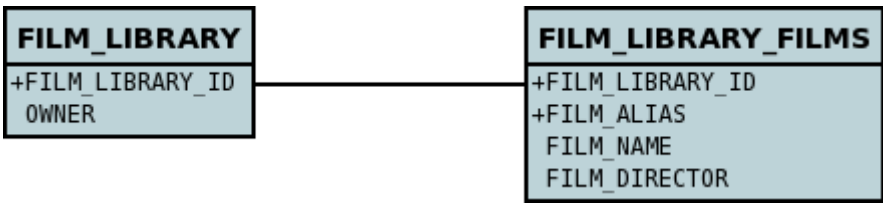
We decide that instead of **Film** having its own table, we want to persist them into the join table of its map relationship with the **FilmLibrary** since they are only used by the library itself. We define our annotations like this

```
public class FilmLibrary
{
    @Key(column="FILM_ALIAS")
    @Value(embeddedMapping={
        @Embedded(members={
            @Persistent(name="name", column="FILM_NAME"),
            @Persistent(name="director", column="FILM_DIRECTOR")})
    })
    @Join(column="FILM_LIBRARY_ID")
    private Map<String, Film> films = new HashMap<>();

    ...
}

@PersistenceCapable(embeddedOnly="true")
public class Film
{
    private String name;
    private String director;

    ...
}
```

or using XML metadata

```
<jdo>
    <package name="com.mydomain.samples.embedded">
        <class name="FilmLibrary" identity-type="datastore" table="FILM_LIBRARY">
            ...
            <field name="films" persistence-modifier="persistent"
table="FILM_LIBRARY_FILMS">
                <map/>
                <join>
                    <column name="FILM_LIBRARY_ID"/>
                </join>
                <key>
                    <column name="FILM_ALIAS"/>
                </key>
                <value>
                    <embedded>
                        <field name="name">
                            <column name="FILM_NAME"/>
                        </field>
                        <field name="director">
                            <column name="FILM_DIRECTOR" allows-null="true"/>
                        </field>
                    </embedded>
                </value>
            </field>
        </class>

        <class name="Film" embedded-only="true">
            <field name="name"/>
            <field name="director"/>
        </class>
    </package>
</jdo>
```

So here we will end up with a table `FILM_LIBRARY` with columns `FILM_LIBRARY_ID`, and `OWNER`, and a table `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.



Please note that if, instead of specifying the `<embedded>` block we had specified `embedded-key` or `embedded-value` in the map element we would have ended up with the same thing, just that the fields and columns would be mapped using their default mappings, and that the <embedded> provides control over how they are mapped.

See also :-

- MetaData reference for <embedded> element
- MetaData reference for <key> element
- MetaData reference for <value> element
- MetaData reference for <join> element
- Annotations reference for @Embedded
- Annotations reference for @Key
- Annotations reference for @Value

Serialised Fields

JDO 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.

JDO's definition of serialising encompasses several types of fields. These are described below

- Serialised Array fields - where you want to serialise the array into a single "BLOB" column.
- Serialised Collection fields - where you want to serialise the collection into a single "BLOB" column.
- Serialised Collection elements - where you want to serialise the collection elements into a single column in a join table.
- Serialised Map fields - where you want to serialise the map into a single "BLOB" column
- Serialised Map keys/values - where you want to serialise the map keys and/or values into single column(s) in a join table.
- Serialised persistable fields - where you want to serialise a PC object into a single "BLOB" column.
- Serialised Reference (Interface/Object) fields - where you want to serialise a reference field into a single "BLOB" column.
- Serialised field to local disk - not part of the JDO spec but available as an option for RDBMS datastores usage

Perhaps the most important thing to bear in mind when deciding to serialise a field is that that object must implement *java.io.Serializable*.

Queries cannot be performed on map keys/values stored as serialised.

Serialised Collections

Applicable to RDBMS, HBase, MongoDB

Collections are usually persisted by way of either a *join table*, or by use of a *foreign-key* in the element table. In some situations it is required to store the whole collection in a single column in the table of the class being persisted. This prohibits the querying of such a collection, but will persist the collection in a single statement. Let's take an example. We have the following classes

```
public class Farm
{
    Collection<Animal> animals;
    ...
}
public class Animal
{
    String name;
    Type type;
}
```

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

```
<field name="animals" serialized="true">
    <collection element-type="Animal"/>
    <column name="ANIMALS"/>
</field>
```

So we make use of the *serialized* attribute of <field>. This specification results in a table like this

There are some other combinations of MetaData tags that result in serialising of the whole collection in the same way. These are as follows

- **Collection of non-*persistable* elements, and no <join> is specified.** Since the elements don't have a table of their own, the only option is to serialise the whole collection and it appears as a single BLOB field in the table of the main class.
- **Collection of *persistable* elements, with "embedded-element" set to true and no <join> is specified.** Since the elements are embedded and there is no join table, then the whole collection is serialised as above.

See also :-

- MetaData reference for <field> element
- Annotations reference for @Persistent
- Annotations reference for @Serialized

Serialised Collection Elements

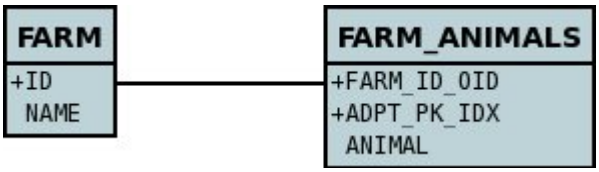
Applicable to RDBMS

In some situations you may want to serialise the element into a single column in the join table. Let's take an example. We have the same classes as in the previous case and we want the *animals* collection to be stored in a join table, and the element serialised into a single column storing the "Animal" object. We define our MetaData like this

```
@Persistent(table="FARM_ANIMALS")
@Element(serialised="true")
Collection<Animal> animals;
```

```
<field name="animals" table="FARM_ANIMALS">
    <collection element-type="Animal" serialised-element="true"/>
    <join column="FARM_ID_OID"/>
</field>
```

So we make use of the *serialized-element* attribute of <collection>. This specification results in tables like this



See also :-

- MetaData reference for <collection> element
- MetaData reference for <join> element
- Annotations reference for @Element

Serialised Maps

Applicable to RDBMS, HBase, MongoDB

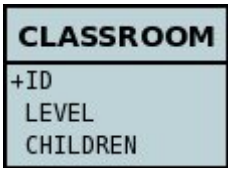
Maps are usually persisted by way of a *join table*, or very occasionaly using a *foreign-key* in the value table. In some situations it is required to store the whole map in a single column in the table of the class being persisted. This prohibits the querying of such a map, but will persist the map in a single statement. Let's take an example. We have the following classes

```
public class ClassRoom
{
    Map<String, Child> children;
    ...
}
public class Child
{
    ...
}
```

and we want the *children* map to be serialised into a single column in the table storing the **ClassRoom** class, so we define our MetaData like this

```
<field name="children" serialized="true">
    <map key-type="java.lang.String" value-type="Child"/>
    <column name="CHILDREN"/>
</field>
```

So we make use of the *serialized* attribute of <field>. This specification results in a table like this



There are some other combinations of MetaData tags that result in serialising of the whole map in the same way. These are as follows

- **Map<non-*persistable*, non-*persistable*>, and no <join> is specified.** Since the keys/values don't have a table of their own, the only option is to serialise the whole map and it appears as a single BLOB field in the table of the main class.
- **Map<non-*persistable*, *persistable*>, with "embedded-value" set to true and no <join> is specified.** Since the keys/values are embedded and there is no join table, then the whole map is serialised as above.

See also :-

- MetaData reference for <map> element
- Annotations reference for @Key
- Annotations reference for @Value
- Annotations reference for @Serialized

Serialised Map Keys/Values

Applicable to RDBMS

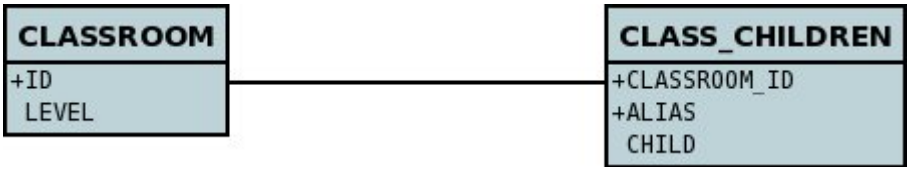
Maps are usually persisted by way of a *join table*, or very occasionaly using a *foreign-key* in the value table. In the join table case you have the option of serialising the keys and/or the values each into a single (BLOB) column in the join table. This is performed in a similar way to serialised elements for collections, but this time using the "serialized-key", "serialized-value" attributes. We take the example in the previous section, with "a classroom of children" and the children stored in a map field. This time we want to serialise the child object into the join table of the map

```
@Persistent(table="CLASS_CHILDREN")
@Value(serialised="true")
Map<String, Child> children;
```

or using XML metadata

```
<class name="ClassRoom">
    ...
    <field name="children" table="CLASS_CHILDREN">
        <map key-type="java.lang.String" value-type="Child" serialized-value="true"/>
        <join column="CLASSROOM_ID"/>
        <key column="ALIAS"/>
        <value column="CHILD"/>
    </field>
</class>
<class name="Child"/>
```

So we make use of the *serialized-value* attribute of <map>. This results in a schema like this



See also :-

- MetaData reference for <map> element
- MetaData reference for <join> element
- MetaData reference for <key> element
- MetaData reference for <value> element
- Annotations reference for @Key
- Annotations reference for @Value

Serialised persistable Fields

Applicable to RDBMS, HBase, MongoDB

A field that is a *persistable* object is typically stored as a foreign-key relation between the container

object and the contained object. In some situations it is not necessary that the contained object has an identity of its own, and for efficiency of access the contained object is required to be stored in a BLOB column in the containing object's datastore table. Let's take an example. We have the following classes

```
public class ClassRoom
{
    ...
    Teacher teacher;
}

public class Teacher {...}
```

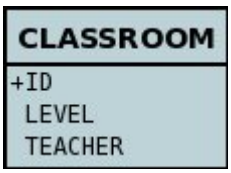
and we want the *teacher* object to be serialised into a single column in the table storing the **ClassRoom** class, so we define our MetaData like this

```
@Serialized
Teacher teacher;
```

or using XML metadata

```
<field name="teacher" serialized="true">
    <column name="TEACHER"/>
</field>
```

So we make use of the *serialized* attribute of <field>. This specification results in a table like this



Serialised Reference (Interface/Object) Fields

Applicable to RDBMS

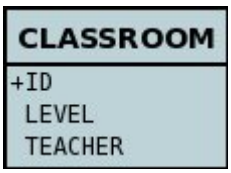
In some situations it is not necessary that the contained object has an identity of its own, and for efficiency of access the contained object is required to be stored in a BLOB column in the containing object's datastore table. Let's take an example using an interface field. We have the following classes

```
public class ClassRoom
{
    Person teacher;
    ...
}
public interface Person {...}
public class Teacher implements Person {...}
```

and we want the *teacher* object to be serialised into a single column in the table storing the **ClassRoom** class, so we define our MetaData like this

```
<field name="teacher" serialized="true">
    <column name="TEACHER"/>
</field>
```

So we make use of the *serialized* attribute of <field>. This specification results in a table like this



See also :-

- MetaData reference for <implements> element
- Annotations reference for @Serialized

Serialised Field to Local File

Applicable to RDBMS

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

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

Or using XML

```
<field name="image" persistence-modifier="persistent">
    <extension vendor-name="datanucleus" key="serializeToFileLocation"
value="person_avatars"/>
</field>
```

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.

Datastore Schema

We have shown earlier how you define MetaData for 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.

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/Column names - mapping classes/fields to table/columns
- Column nullability and default value - what values can be stored in a column
- Column Types - supported column types
- Columns with no field in the class - where you have a column in an existent table but no associated Java field
- Position of a column in a table - allowing ordering of columns in the schema
- Index Constraints - used to mark fields that are referenced often as indexes so that when they are used the performance is optimised.
- Unique Constraints - placed on fields that should have a unique value. That is only one object will have a particular value.
- Foreign-Key Constraints - used to interrelate objects, and allow the datastore to keep the integrity of the data in the datastore.
- Primary-Key Constraints - allow the PK to be set, and also to have a name.
- RDBMS Views - mapping a class to an RDBMS View instead of a Table

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

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

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

```
@PersistenceCapable(table="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. 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
- MetaData reference for <primary-key> element
- Annotations reference for @Column
- Annotations reference for @PrimaryKey

Column names for datastore-identity

When you select *datastore-identity* a surrogate column will be added in the datastore. You need to be able to define the column name if mapping to an existing schema (or wanting to control the schema). So lets say we have the following

```
public class MyClass // persisted to table `MYCLASS`
{
    ...
}

public class MySubClass extends MyClass // persisted to table `MYSUBCLASS`
{
    ...
}
```

We want to define the names of the identity column in `MYCLASS` and `MYSUBCLASS`. Here's how we do it

```
<class name="MyClass" table="MYCLASS">
    <datastore-identity>
        <column name="MY_PK_COLUMN"/>
    </datastore-identity>
    ...
</class>
<class name="MySubClass" table="MYSUBCLASS">
    <datastore-identity>
        <column name="MYSUB_PK_COLUMN"/>
    </datastore-identity>
    ...
</class>
```

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

```
@PersistenceCapable(table="MYCLASS")
@DatastoreIdentity(column="MY_PK_COLUMN")
public class MyClass
{
    ...
}

@PersistenceCapable(table="MYSUBCLASS")
@DatastoreIdentity(column="MYSUB_PK_COLUMN")
public class MySubClass extends MyClass
{
    ...
}
```

So we will have a PK column `MY_PK_COLUMN` in the table `MYCLASS`, and a PK column `MYSUB_PK_COLUMN` in the table `MYSUBCLASS` (and that corresponds to the `MY_PK_COLUMN` value in `MYCLASS`). We could also do

```
<class name="MyClass" table="MYCLASS">
    <datastore-identity>
        <column name="MY_PK_COLUMN"/>
    </datastore-identity>
    ...
</class>
<class name="MySubClass" table="MYSUBCLASS">
    <inheritance strategy="new-table"/>
    <primary-key>
        <column name="MYSUB_PK_COLUMN"/>
    </primary-key>
    ...
</class>
```

See also :-

- Inheritance Guide - defining how to use inheritance between classes
- MetaData reference for <column> element
- MetaData reference for <primary-key> element
- Annotations reference for @Column
- Annotations reference for @PrimaryKey

Column names for application-identity

When you select *application-identity* you have some field(s) that form the "primary-key" of the class. A common situation is that you have inherited classes and each class has its own table, and so the primary-key column names can need defining for each class in the inheritance tree. So lets show an example how to do it

```
public class MyClass // persisted to table `MYCLASS`
{
    long id; // PK field
    ...
}

public class MySubClass extends MyClass // persisted to table `MYSUBCLASS`
{
    ...
}
```

Defining the column name for "MyClass.id" is easy since we use the same as shown previously "column" for the field. Obviously the table "MYSUBCLASS" will also need a PK column. Here's how we define the column mapping

```
<class name="MyClass" identity-type="application" table="MYCLASS">
    <field name="myPrimaryKeyField" primary-key="true">
        <column name="MY_PK_COLUMN"/>
    </field>
    ...
</class>
<class name="MySubClass" identity-type="application" table="MYSUBCLASS">
    <inheritance strategy="new-table"/>
    <primary-key>
        <column name="MYSUB_PK_COLUMN" target="MY_PK_COLUMN"/>
    </primary-key>
    ...
</class>
```

So we will have a PK column `MY_PK_COLUMN` in the table `MYCLASS`, and a PK column `MYSUB_PK_COLUMN` in the table `MYSUBCLASS` (and that corresponds to the `MY_PK_COLUMN` value in `MYCLASS`). You can also use

```
<class name="MyClass" identity-type="application" table="MYCLASS">
    <field name="myPrimaryKeyField" primary-key="true">
        <column name="MY_PK_COLUMN"/>
    </field>
    ...
</class>
<class name="MySubClass" identity-type="application" table="MYSUBCLASS">
    <inheritance strategy="new-table">
        <join>
            <column name="MYSUB_PK_COLUMN" target="MY_PK_COLUMN"/>
        </join>
    </inheritance>
    ...
</class>
```

See also :-

- Inheritance Guide - defining how to use inheritance between classes
- MetaData reference for <inheritance> element
- MetaData reference for <column> element
- MetaData reference for <primary-key> element
- Annotations reference for @Inheritance
- Annotations reference for @Column
- Annotations reference for @PrimaryKey

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 and to set a default value for a column if we ever have need to insert into it and not specify a particular column. 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 our hotel is in the United Kingdom we want the default currency to be pounds, or to use its ISO4217 currency code "GBP". In addition, since the bank transfer reference is optional we want that column to be nullable. So let's specify the MetaData for the class.

```
<class name="Payment">
    <field name="customer" persistence-capable="persistent" column="CUSTOMER_ID"/>
    <field name="bankTransferReference">
        <column name="TRANSFER_REF" allows-null="true"/>
    </field>
    <field name="currency">
        <column name="CURRENCY" default-value="GBP"/>
    </field>
    <field name="amount" column="AMOUNT"/>
</class>
```

So we make use of the *allows-null* and *default-value* attributes. The table, when created by DataNucleus, will then provide the default and nullability that we require. See also :-

- MetaData reference for <column> element
- Annotations reference for @Column

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. To override the default setting (and always the best policy if you are wanting your MetaData to give the same datastore definition with all JDO implementations) you do as follows

```
<class name="Payment">
    <field name="customer" persistence-capable="persistent" column="CUSTOMER_ID">
    <field name="bankTransferReference">
        <column name="TRANSFER_REF" jdbc-type="VARCHAR" length="255" allows-
null="true"/>
    </field>
    <field name="currency">
        <column name="CURRENCY" jdbc-type="CHAR" length="3" default-value="GBP"/>
    </field>
    <field name="amount">
        <column name="AMOUNT" jdbc-type="DECIMAL" length="10" scale="2"/>
    </field>
</class>
```

So we have defined `TRANSFER_REF` to use VARCHAR(255) column type, `CURRENCY` to use CHAR(3) column type, and `AMOUNT` to use DECIMAL(10,2) column type. Please be aware that DataNucleus only supports persisting particular Java types to particular JDBC/SQL types. We have demonstrated above the *jdbc-type* attribute, but there is also an *sql-type* attribute. This is to be used where you want to map to some specific SQL type (and will not be needed in the vast majority of cases - the *jdbc-type* should generally be used).

See also :-

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

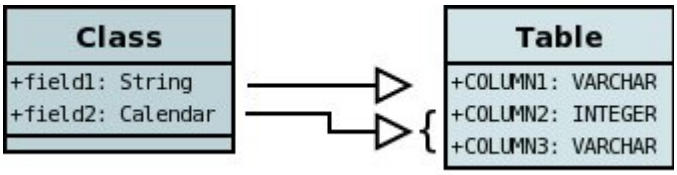
Supported RDBMS Column Types

Applicable to RDBMS.

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 JDOQL 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 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 Type	Number Columns	Queryable	JDBC Type(s)
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.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 Type	Number Columns	Queryable	JDBC Type(s)
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.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 Type	Number Columns	Queryable	JDBC Type(s)
java.util.TimeZone [8]	1	✔	**VARCHAR**, CHAR, LONGVARCHAR, CLOB, BLOB, DATALINK [6], UNIQUEIDENTIFIER [7], XMLTYPE [9]
java.util.TreeMap	0	✔	
java.util.TreeSet	0	✔	
java.util.UUID [8]	1	✔	**VARCHAR**, CHAR, LONGVARCHAR, CLOB, BLOB, DATALINK [6], UNIQUEIDENTIFIER [7], 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.net.URI [8]	1	✔	**VARCHAR**, CHAR, LONGVARCHAR, CLOB, BLOB, DATALINK [6], UNIQUEIDENTIFIER [7], XMLTYPE [9]
java.net.URL [8]	1	✔	**VARCHAR**, CHAR, LONGVARCHAR, CLOB, BLOB, DATALINK [6], UNIQUEIDENTIFIER [7], XMLTYPE [9]
java.io.Serializable	1	✖	LONGVARBINARY, BLOB
Persistable	1	✔	[embedded]
Persistable[]	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 Column Adapter guide.
- **[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 an extension 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	✔	
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	✔	

JDBC Type	Supported	Restrictions
TINYINT	✔	
VARBINARY	✔	
VARCHAR	✔	

Columns with no field in the class

DataNucleus supports mapping of columns in the datastore that have no associated field in the java class. These are useful where you maybe have a table used by other applications and dont use some of the information in your Java model. DataNucleus needs to know about these columns so that it can validate the schema correctly, and also insert particular values when inserting objects into the table. You could handle this by defining your schema yourself so that the particular columns have "DEFAULT" settings, but this way you allow DataNucleus to know about all information. So to give an example

```
<class name="Hotel" table="ESTABLISHMENT">
    <field name="name">
        <column name="NAME"/>
    </field>
    <field name="address">
        <column name="DIRECTION"/>
    </field>
    <field name="telephoneNumber">
        <column name="PHONE"/>
    </field>
    <field name="numberOfRooms">
        <column name="NUMBER_OF_ROOMS"/>
    </field>
    <column name="YEAR_ESTABLISHED" jdbc-type="INTEGER" insert-value="1980"/>
    <column name="MANAGER_NAME" jdbc-type="VARCHAR" insert-value="N/A"/>
</class>
```

So in this example our table `ESTABLISHMENT` has the columns associated with the specified fields and also has columns `YEAR_ESTABLISHED` (that is INTEGER-based and will be given a value of "1980" on any inserts) and `MANAGER_NAME` (VARCHAR-based and will be given a value of "N/A" on any inserts).

Field/Column Position in a Table

With some datastores (notably spreadsheets) it is desirable to be able to specify the relative position of a column in the schema. The default (for DataNucleus) is just to put them in ascending alphabetical order. JDO allows definition of this using the *position* attribute on a **column**. Here's an example, using XML metadata

```
<jdo>
    <package name="mydomain">
        <class name="Person" detachable="true" table="People">
            <field name="personNum">
                <column position="0"/>
            </field>
            <field name="firstName">
                <column position="1"/>
            </field>
            <field name="lastName">
                <column position="2"/>
            </field>
        </class>
    </package>
</jdo>
```

and with annotations

```
@PersistenceCapable(table="People")
public class Person
{
    @Column(position=0)
    long personNum;

    @Column(position=1)
    String firstName;

    @Column(position=2)
    String lastName;
}
```

Index Constraints

Applicable to RDBMS, NeoDatis, MongoDB, Cassandra.

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. JDO provides a mechanism for defining indexes, and hence if a developer knows that a particular field is going to be highly used for querying, they can select that field to be indexed in their (JDO) persistence solution. Let's take an example class, and show how to specify this

```
public class Booking
{
    private int bookingType;
    ...
}
```

We decide that our *bookingType* is going to be highly used and we want to index this in the persistence tool. To do this we define the Meta-Data for our class as

```
<class name="Booking">
    <field name="bookingType">
        <index name="BOOKING_TYPE_INDEX"/>
    </field>
</class>
```

This will mean that DataNucleus will create an index in the datastore for the field and the index will have the name `BOOKING_TYPE_INDEX` (for datastores that support using named indexes). If we had wanted the index to provide uniqueness, we could have made this

```
<index name="BOOKING_TYPE_INDEX" unique="true"/>
```

This has demonstrated indexing the fields of a class. The above example will index together all columns for that field. In certain circumstances you want to be able to index from the column point of view. So we are thinking more from a database perspective. Here we define our indexes at the `<class>` level, like this

```
<class name="Booking">
    <index name="MY_BOOKING_INDEX">
        <column name="BOOKING"/>
    </index>
    ...
</class>
```

This creates an index for the specified column (where the datastore supports columns i.e RDBMS).

Specifying ordering of index columns

The default (JDO supported) index specifies ascending index columns. Most RDBMS these days support specifying the ordering of index columns. You can control this as follows

```
<class name="Booking">
    <index name="MY_BOOKING_IDX" unique="true">
        <column name="NAME"/>
        <column name="NUMBER"/>
        <extension vendor-name="datanucleus" key="index-column-ordering"
value="ASC,DESC"/>
    </index>
    ...
</class>
```

or alternatively using annotations

```
@Index(name="MY_BOOKING_IDX" extensions={@Extension(vendorName="datanucleus", key
="index-column-ordering", value="ASC,DESC")})
```

which will create an index with `CREATE UNIQUE INDEX MY_BOOKING_IDX ON BOOKING ("NAME" ASC,"NUMBER" DESC)`

Specifying index type

Some RDBMS allow you to specify the *type* of an index, such as HASH etc. You can control this as follows

```
<class name="Booking">
    <index name="MY_BOOKING_IDX" unique="true">
        <column name="BOOKING"/>
        <extension key="index-type" value="HASH"/>
    </index>
    ...
</class>
```

or alternatively using annotations

```
@Index(name="MY_BOOKING_IDX" extensions={@Extension(vendorName="datanucleus", key
="index-type", value="HASH")})
```

which will create an index with `CREATE UNIQUE HASH INDEX MY_BOOKING_IDX ON BOOKING (BOOKING)`

Enhanced index creation

A final extension is where you just want to dump an amount of SQL onto the end of the `CREATE INDEX` statement (totally RDBMS dependent). We would advise against using this method due to its dependency on the RDBMS

```
<class name="Booking">
    <index name="MY_BOOKING_IDX">
        <extension vendor-name="datanucleus" key="extended-setting" value=" USING
HASH"/>
    </index>
    ...
</class>
```

or alternatively using annotations

```
@Index(name="MY_BOOKING_IDX" extensions={@Extension(vendorName="datanucleus", key
="extended-setting", value=" USING HASH")})
```

See also :-

- MetaData reference for <index> element
- Annotations reference for @Index
- Annotations reference for @Index (class level)

Cassandra : index USING

Cassandra allows creation of indexes with an optional USING keyword. You can specify this via the following extension

```
<class name="Booking">
    <index name="MY_BOOKING_IDX">
        <extension vendor-name="datanucleus" key="cassandra.createIndex.using"
value="'org.apache.cassandra.index.sasi.SASIIndex'"/>
    </index>
    ...
</class>
```

or alternatively using annotations

```
@Index(name="MY_BOOKING_IDX" extensions={@Extension(vendorName="datanucleus", key
="cassandra.createIndex.using", value="'org.apache.cassandra.index.sasi.SASIIndex'")})
```

and the `USING` clause will be appended to any `CREATE INDEX` issued during schema generation.

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. JDO provides a mechanism for defining such unique constraints. Lets take the previous class, and show how to specify this

```
<class name="Booking">
    <field name="bookingType">
        <unique name="BOOKING_TYPE_CONSTRAINT"/>
    </field>
</class>
```

So in an identical way to the specification of an index. This example specification will result in the column(s) for "bookingType" being enforced as unique in the datastore. In the same way you can specify unique constraints directly to columns - see the example above for indexes.

Again, as for index, you can also specify unique constraints at "class" level in the MetaData file. This is useful to specify where the composite of 2 or more columns or fields are unique. So with this example

```
<class name="Booking">
    <unique name="UNIQUE_PERF">
        <field name="performanceDate"/>
        <field name="startTime"/>
    </unique>

    <field name="performanceDate"/>
    <field name="startTime"/>
</class>
```

The table for Booking has a unique constraint on the columns for the fields *performanceDate* and *startTime*

See also :-

- MetaData reference for <unique> element
- Annotations reference for @Unique
- Annotations reference for @Unique (class level)

Foreign Key Constraints

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 ? Lets take an example

```
public class Hotel
{
    private Set rooms;
    ...
}

public class Room
{
    private int numberOfBeds;
    ...
}
```

We now want to control the relationship so that it is linked by a named foreign key, and that we cascade delete the **Room** object when we delete the **Hotel**. We define the Meta-Data like this

```
<class name="Hotel">
    <field name="rooms">
        <collection element-type="com.mydomain.samples.hotel.Room"/>
        <foreign-key name="HOTEL_ROOMS_FK" delete-action="cascade"/>
    </field>
</class>
```

So we now have given the datastore control over the cascade deletion strategy for objects stored in these tables. Please be aware that JDO provides Dependent Fields as a way of allowing cascade deletion. The difference here is that *Dependent Fields* is controlled by DataNucleus, whereas foreign key delete actions are controlled by the datastore (assuming the datastore supports it even)

In the case of a 1-N relation using a join table the equivalent example would be

```
public class Account
{
    ...

    @Persistent
    @Join(foreignKey="ACCOUNT_FK")
    @Element(foreignKey="ADDRESS_FK");
    Collection<Address> addresses;
}

public class Address
{
    ...
}
```

or using XML metadata

```
<package name="com.mydomain">
    <class name="Account">
        ...
        <field name="addresses">
            <collection element-type="com.mydomain.Address"/>
            <join>
                <foreign-key name="ACCOUNT_FK"/>
            </join>
            <element>
                <foreign-key name="ADDRESS_FK"/>
            </element>
        </field>
    </class>

    <class name="Address">
        ...
    </class>
</package>
```

DataNucleus provides an extension that can give significant benefit to users. This is provided via the PersistenceManagerFactory *datanucleus.rdbms.constraintCreateMode*. This property has 2 values. The default is *DataNucleus* which will automatically decide which foreign keys are required to satisfy the relationships that have been specified, whilst utilising the information provided in the MetaData for foreign keys. The other option is *JDO2* which will simply create foreign keys that have been specified in the MetaData file(s).

Note that the *foreign-key* for a 1-N FK relation can be specified as above, or under the *element* element. Note that the *foreign-key* for a 1-N Join Table relation is specified under *field* for the FK

from owner to join table, and is specified under *element* for the FK from join table to element table.

In the special case of application-identity and inheritance there is a foreign-key from subclass to superclass. You can define this as follows

```
<class name="MySubClass">
    <inheritance>
        <join>
            <foreign-key name="ID_FK"/>
        </join>
    </inheritance>
</class>
```

See also :-

- MetaData reference for <foreignkey> element
- Annotations reference for @ForeignKey
- Deletion of related objects using FK constraints

Primary Key Constraints

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 applicatioin identity), or you define the name of the column DataNucleus should use for the primary key (if using datastore identity). What these other parts of the MetaData don't allow is specifying the constraint name for the primary key. You can specify this if you wish, like this

```
<class name="Booking">
    <primary-key name="BOOKING_PK"/>
    ...
</class>
```

When the schema is generated for this table, the primary key will be given the specified name, and will use the column(s) specified by the identity type in use.

In the case where you have a 1-N/M-N relation using a join table you can specify the name of the primary key constraint used as follows

```
<class name="Hotel">
    <field name="rooms">
        <collection element-type="com.mydomain.samples.hotel.Room"/>
        <join>
            <primary-key name="HOTEL_ROOM_PK"/>
        </join>
    </field>
</class>
```

This creates a PK constraint with name `HOTEL_ROOM_PK`.

See also :-

- MetaData reference for <primary-key> element
- Annotations reference for @PrimaryKey
- Annotations reference for @PrimaryKey (class level)

RDBMS Views

Applicable to RDBMS.

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 (though not persisting into them). 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 (persistable) 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 represent the values from this **View**.

```
package mydomain.views;

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;
    }
}
```

and then we define how this class is mapped to the **View**, here using XML but equally possible using annotations

```
<?xml version="1.0"?>
<!DOCTYPE jdo SYSTEM "file:/javax/jdo/jdo.dtd">
<jdo>
    <package name="mydomain.views">
        <class name="SaleableProduct" identity-type="nondurable"
table="SALEABLE_PRODUCT">
            <field name="id"/>
            <field name="name"/>
            <field name="price"/>
            <field name="currency"/>

            <!-- This is the "generic" SQL92 version of the view. -->
            <extension vendor-name="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"/>
        </class>
    </package>
</jdo>
```

Please note the following

- We've defined our class as using "nondurable" identity. We do **not** need to do this, but in our particular case we don't require the identity lookup. In DataNucleus up until 5.1.0.M3 this was a mandatory requirement, but we now allow any identity type.
- 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 querying operation.

```
Extent<SaleableProduct> e = pm.getExtent(SaleableProduct.class);
Iterator<SaleableProduct> iter = e.iterator();
while (iter.hasNext())
{
    SaleableProduct product = iter.next();
}
```

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

Secondary Tables

Applicable to RDBMS

The standard JDO 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. JDO allows persistence of fields of a class into *secondary* tables.

A Secondary table entry maps 1-1 to an owner table entry, and has the same primary key as the owner.

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

```
<class name="Printer" table="PRINTER">
    <join table="PRINTER_TONER" column="PRINTER_REFID"/>

    <field name="id" primary-key="true" column="PRINTER_ID"/>
    <field name="make" column="MAKE"/>
    <field name="model" column="MODEL"/>
    <field name="tonerModel" table="PRINTER_TONER" column="MODEL"/>
    <field name="tonerLifetime" table="PRINTER_TONER" column="LIFETIME"/>
</class>
```

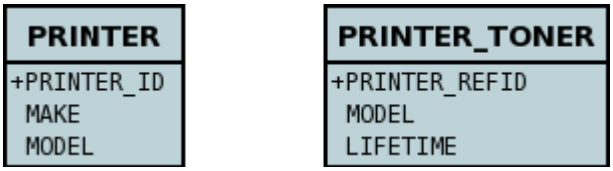
So here we have defined that objects of the **Printer** class will be stored in the primary table `PRINTER`. In addition we have defined that some fields are stored in the table `PRINTER_TONER`. This is achieved by way of

- We will store *tonerModel* and *tonerLifetime* in the table `PRINTER_TONER`. This is achieved by using <field **table="PRINTER_TONER"**>
- The table `PRINTER_TONER` will use a primary key column called `PRINTER_REFID`. This is achieved by using <join table="PRINTER_TONER" column="PRINTER_REFID"/>

You could equally specify this using annotations

```
@PersistenceCapable
@Join(table="PRINTER_TONER", column="PRINTER_REFID")
public class Printer
{
    @Persistent(primaryKey="true", column="PRINTER_ID")
    long id;
    @Column(name="MAKE")
    String make;
    @Column(name="MODEL")
    String model;

    @Persistent(table="PRINTER_TONER", column="MODEL")
    String tonerModel;
    @Persistent(table="PRINTER_TONER", column="LIFETIME")
    int tonerLifetime;
    ...
}
```

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.

Specifying the primary key

You saw above how we defined the column name that will be the primary key of the secondary table (the PRINTER_REFID column). What we didn't show is how to specify the name of the primary key constraint to be generated. To do this you change the MetaData to

```
<class name="Printer" identity-type="datastore" table="PRINTER">
    <join table="PRINTER_TONER" column="PRINTER_REFID">
        <primary-key name="TONER_PK"/>
    </join>

    ...
</class>
```

So this will create the primary key constraint with the name "TONER_PK".

See also :-

- MetaData reference for <primary-key> element
- MetaData reference for <join> element
- Annotations reference for @PrimaryKey
- Annotations reference for @Join

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.

Some identifiers are actually reserved keywords with RDBMS, meaning that to use them you have to quote them. DataNucleus JDO quotes these automatically for you so you don't have to think about it, whereas other ORMs force you to quote these yourself!

Generation of identifier names for RDBMS is controlled by an IdentifierFactory, and DataNucleus provides a default implementation. You can provide your own RDBMS IdentifierFactory plugin to give your own preferred naming if so desired. 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. JDO doesn't define what the names of datastore identifiers should be but DataNucleus provides the following factories for your use.

- datanucleus2 RDBMS IdentifierFactory (default for JDO persistence)

- jpa RDBMS IdentifierFactory (default for JPA persistence)
- datanucleus1 RDBMS IdentifierFactory (used in DataNucleus v1)
- jpox RDBMS IdentifierFactory (compatible with JPOX)

Generation of identifier names for non-RDBMS datastores is controlled by an NamingFactory, and DataNucleus provides a default implementation. 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*. Set it to the symbolic name of the factory you want to use. JDO doesn't define what the names of datastore identifiers should be but DataNucleus provides the following factories for your use.

- datanucleus2 NamingFactory (default for JDO persistence for non-RDBMS)
- 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

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

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

NamingFactory 'datanucleus2'

This is default for JDO persistence to non-RDBMS datastores. Using the 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_ELEMENTS1`
- `MYCLASS_ELEMENTS1` will have columns called `MYCLASS_ID_OID` (FK to owner table) and `MYELEMENT_ID_EID` (FK to element table)
- `MYCLASS_ELEMENTS1` will have column names like `STRING_ELE`, `STRING_KEY`, `STRING_VAL` for non-PC elements/keys/values of collections/maps

- *MyClass.elements2* will be persisted into a column `ELEMENTS2_MYCLASS_ID_OWN` or `ELEMENTS2_MYCLASS_ID_OID` (FK to owner) table
- Any discriminator column will be called `DISCRIMINATOR`
- Any index column in a List will be called `IDX`
- 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`

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 'datanucleus2'

This became the default for JDO persistence from DataNucleus v2.x onwards and changes a few things over the previous "datanucleus1" factory, attempting to make the naming more concise and consistent (we retain "datanucleus1" for backwards compatibility).

Using the same example above, the rules in this *RDBMS 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_ELEMENTS1`
- `MYCLASS_ELEMENTS1` will have columns called `MYCLASS_ID_OID` (FK to owner table) and

MYELEMENT_ID_EID (FK to element table)

- MYCLASS_ELEMENTS1 will have column names like STRING_ELE, STRING_KEY, STRING_VAL for non-PC elements/keys/values of collections/maps
- *MyClass.elements2* will be persisted into a column ELEMENTS2_MYCLASS_ID_OWN or ELEMENTS2_MYCLASS_ID_OID (FK to owner) table
- Any discriminator column will be called DISCRIMINATOR
- Any index column in a List will be called IDX
- 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 'datanucleus1'

This was the default in DataNucleus v1.x for JDO persistence and provided a reasonable default naming of datastore identifiers using the class and field names as its basis.

Using the example above, the rules in this *RDBMS 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 MY_FIELD1
- *MyElement* will be persisted into a table named MYELEMENT
- *MyClass.elements1* will be persisted into a join table called MYCLASS_ELEMENTS1
- MYCLASS_ELEMENTS1 will have columns called MYCLASS_ID_OID (FK to owner table) and MYELEMENT_ID_EID (FK to element table)
- MYCLASS_ELEMENTS1 will have column names like STRING_ELE, STRING_KEY, STRING_VAL for non-PC elements/keys/values of collections/maps
- *MyClass.elements2* will be persisted into a column ELEMENTS2_MYCLASS_ID_OID or ELEMENTS2_ID_OID (FK to owner) table
- Any discriminator column will be called DISCRIMINATOR
- Any index column in a List will be called INTEGER_IDX
- Any adapter column added to a join table to form part of the primary key will be called ADPT_PK_IDX
- Any version column for a table will be called OPT_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 *RDBMS 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`

RDBMS IdentifierFactory 'jpox'

This *RDBMS IdentifierFactory* exists for backward compatibility with JPOX 1.2.0. If you experience changes of schema identifiers when migrating from JPOX 1.2.0 to datanucleus, you should give this one a try. Schema compatibility between JPOX 1.2.0 and datanucleus had been broken e.g. by the number of characters used in hash codes when truncating identifiers: this has changed from 2 to 4.

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).

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.

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)