The Factory Method
Design Pattern

For details see Gamma et al. in “Design Patterns”
Let’s assume we want to develop a framework for applications that can present multiple documents to the user (MDI style).

We want to support a wide variety of applications:

- Text editors
- Word processors
- Vector drawing applications
- Document Viewers
- ...

Our framework should - in particular - be able to manage the documents.
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Example / Motivation -
Common functionality for handling documents
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Example / Motivation -
Common functionality for handling documents

(In the following, we focus on the implementation of “New”.)
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**Intent**

Define an interface for creating an object, but let subclasses decide which class to instantiate.

(Factory Method lets a class defer instantiation to subclasses.)
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Example / Motivation -
A Possible Implementation of the Framework

```java
public abstract class Document {
    public abstract void open();
    public abstract void close();
}
```

```java
public abstract class Application {
    private List<Document> docs = new ArrayList<Document>();
    public void newDocument() {
        Document doc = createDocument();
        // the framework manages the documents
        docs.add(doc);
        doc.open();
    }
    ...
    public abstract Document createDocument(); // factory method
}
```
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Example / Motivation - Implementation of an Application Using the Framework

```java
public class TextDocument extends Document {
    ... // implementation of the abstract methods
}
```

```java
public class MyApplication extends Application {

    public Document createDocument() {
        return new TextDocument();
    }

}
```
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Example / Motivation -
Class Diagram of an Application Using the Framework

```
open()
close()
save()
createDocument()
newDocument()
```

```
Document
  open()
  close()
  save()

Application
  createDocument()
  newDocument()

MyApplication
  createDocument()
```
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Structure

```
Product

ConcreteProduct

Creator

factoryMethod()

anOperation()

ConcreteCreator

factoryMethod()
```

«method»

... factoryMethod(...)...
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Participants

• **Product**
  … defines the interface of objects the factory method creates.

• **ConcreteProduct**
  … implements the Product interface.

• **Creator**
  … declares the factory method, which returns an object of type Product. Creator may also define a default implementation of the factory method that returns a default ConcreteProduct object.

• **ConcreteCreator**
  … overrides the factory method to return an instance of a ConcreteProduct.
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Consequences (I)

• The framework’s code only deals with the Product interface; therefore it can work with any user-defined ConcreteProduct class.

• Provides a hook for subclasses
  The hook can be used for providing an extended version of an object.
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Consequences (II)

Connects parallel class hierarchies

<table>
<thead>
<tr>
<th>Class Name</th>
<th>Collaborator A</th>
<th>Collaborator B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Responsibility A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Responsibility B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Responsibility C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure
createManipulator()

Client

Manipulator
drag()
...

Line
createManipulator()

Text
createManipulator()

LineManipulator

TextManipulator
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Implementation

Two major variants:

- **Creator** is abstract
- **Creator** is concrete and provides a reasonable default implementation
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Implementation - Parameterized factory methods

(E.g. imagine a document previewer which can handle very different types of documents.)

General form:

```java
public abstract class Creator {
    public abstract Product createProduct(ProductId pid);
}
```

Applied to our example:

```java
public abstract class Application {
    public abstract Document createDocument(Type e);
}

public class MyApplication extends Application {
    public Document createDocument(Type e) {
        switch (e) {
            case Type.JPEG: return new JPEGDocument();
            case Type.PDF: return new PDFDocument();
        }
    }
}
```
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Implementation - Parameterized factory methods

```java
public abstract class Application {

    private Class<? extends Document> clazz;

    public Application(Class<? extends Document> clazz){
        this.clazz = clazz;
    }

    public abstract Document createDocument(){
        return clazz.newInstance();
    }
}
```

It is possible to use Java reflection in a type safe way.
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Related Patterns

- **Factory Methods** are usually called within **Template Methods**
- Abstract Factory is often implemented with factory methods
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For details see Gamma et al. in “Design Patterns”
How to create families of related classes that implement a (set of) common interface(s)?
Our goal is to support different databases.

Requirements:

▶ The application should support several databases
  (We want to be able to change the database at startup time.)

▶ We want to support further databases
  (We want to make the implementation unaware of the specific database(s).)
A result set enables the iteration over the result of an SQL query.

How to provide an interface to all of these different kinds of ResultSets?
A result set enables the iteration over the result of an SQL query.

A common interface is introduced to abstract from the concrete classes.
To complete the abstraction of the database, one also needs to create class hierarchies for:

- CallableStatements,
- PreparedStatements,
- Blobs,
- ...

The code interacting with the database can now deal with ResultSets and SQL statements without referring to the concrete classes, e.g., Firebird-ResultSet.

However, we still have to know the concrete implementation subclass at creation time!
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Issues

• How can we avoid to know about the concrete product types at creation time?
  We want to avoid to write:
  PreparedStatement = new FBPreparedStatement();

• Hard-coding product types as above makes it impossible to select a different database

• Even offline changes are difficult as it is easy to miss one constructor and end up with FireBird’s FBPreparedStatement while a DB2 database is used
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Issues -

*How can we avoid to know about the concrete product types at creation time?*

**Swapping Code**

- Swap in and out different files when compiling for a different database
- Does neither require subclassing nor a special creation logic

**Trade-offs**

- Application code is completely unaware of different databases
- Needs configuration management of source files
- Does not allow different databases to be chosen at startup, e.g., if more than one is supported

**Solution**

```java
// DB2 Version
java.sql.ResultSet

// MySQL Version
java.sql.ResultSet

// MaxDB Version
java.sql.ResultSet
```
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Structure
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Participants

- **AbstractFactory**
  ... provides an interface *for creating products of a family*

- **ConcreteFactory**
  ... implements the operations to create concrete products

- **AbstractProduct**
  ... declares the interface for concrete products

- **ConcreteProduct**
  ... provides an implementation for the product created by the corresponding **ConcreteFactory**

- **Client**
  ... creates products by calling the **ConcreteFactory**; uses the **AbstractProduct** interface
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Consequences

- **Abstracts away from concrete products**
  (Clients can be ignorant about concrete products they are using, even at creation time.)

- **Exchanging product families is easy**
  (Changing one line can completely swap the behavior of a whole product family.)

- **Ensures consistency among products**
  (As family selection is concentrated to one line, one may not accidentally mix product types.)

- **Supporting new kinds of products is difficult**
  (Adding new products involves changing the abstract factory and all of its subclasses.)

- **Creation of objects is non-standard**
  (Clients need to know to use the factory rather than a constructor.)
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Issues -

How can we avoid to know about the concrete product types at creation time?

Factory Class

- Group creation functions into a special "factory" class responsible for creating the objects to interact with the database on request.

- Has functions like...

  createStatement(), createBlob() and preparedStatement() as part of its interface

- Different factory subclasses provide implementations for different databases.

Statement s = connection.createStatement();
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Product Creation

- Creation of database objects is done by accessing the global variable connection of type `Connection` (the "factory")

```java
Statement = connection.createStatement();
```

- To interact with a different database the connection is initialized differently:

```java
connection = DriverManager.getConnection("org.postgresql.Driver")
or
connection = DriverManager.getConnection("org.mysql.Driver")
```

- We can make the initialization value for `DriverManager.getConnection` a parameter of the application
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Applied
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Summary

- Application code can be ignorant about different databases
- Only one line of code (or configuration parameter) must vary to support various databases
- Allows different databases to be chosen at startup
- Enforces creation of consistent product families (Prevents FBBlob from being used with a DB2 database.)
- Code must follow a new convention for creating products from a family (Instead of using the standard constructor.)
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Example from the POS Domain.

```java
/*interface*/
IJavaPOSDevicesFactory

getNewCashDrawer() : jpos.CashDrawer
getNewCoinDispenser() : jpos.CoinDispenser
...

NCRJavaPOSDevicesFactory

getNewCashDrawer() : jpos.CashDrawer
getNewCoinDispenser() : jpos.CoinDispenser
...

{ return new com.ibm.pos.jpos.CashDrawer; }

jpos.CashDrawer

isDrawerOpened() : boolean
...

com.ibm.pos.jpos.CashDrawer

isDrawerOpened() : boolean
...

com.ncr.posdevices.CashDrawer

isDrawerOpened() : boolean
...
```

Example from the POS Domain.
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Related Patterns

- A concrete factory is often a singleton