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Introduction to Software Engineering

The Factory Method Design Pattern

For details see Gamma et al. in “Design Patterns”

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The Factory Method Design Pattern

Example / Motivation

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:

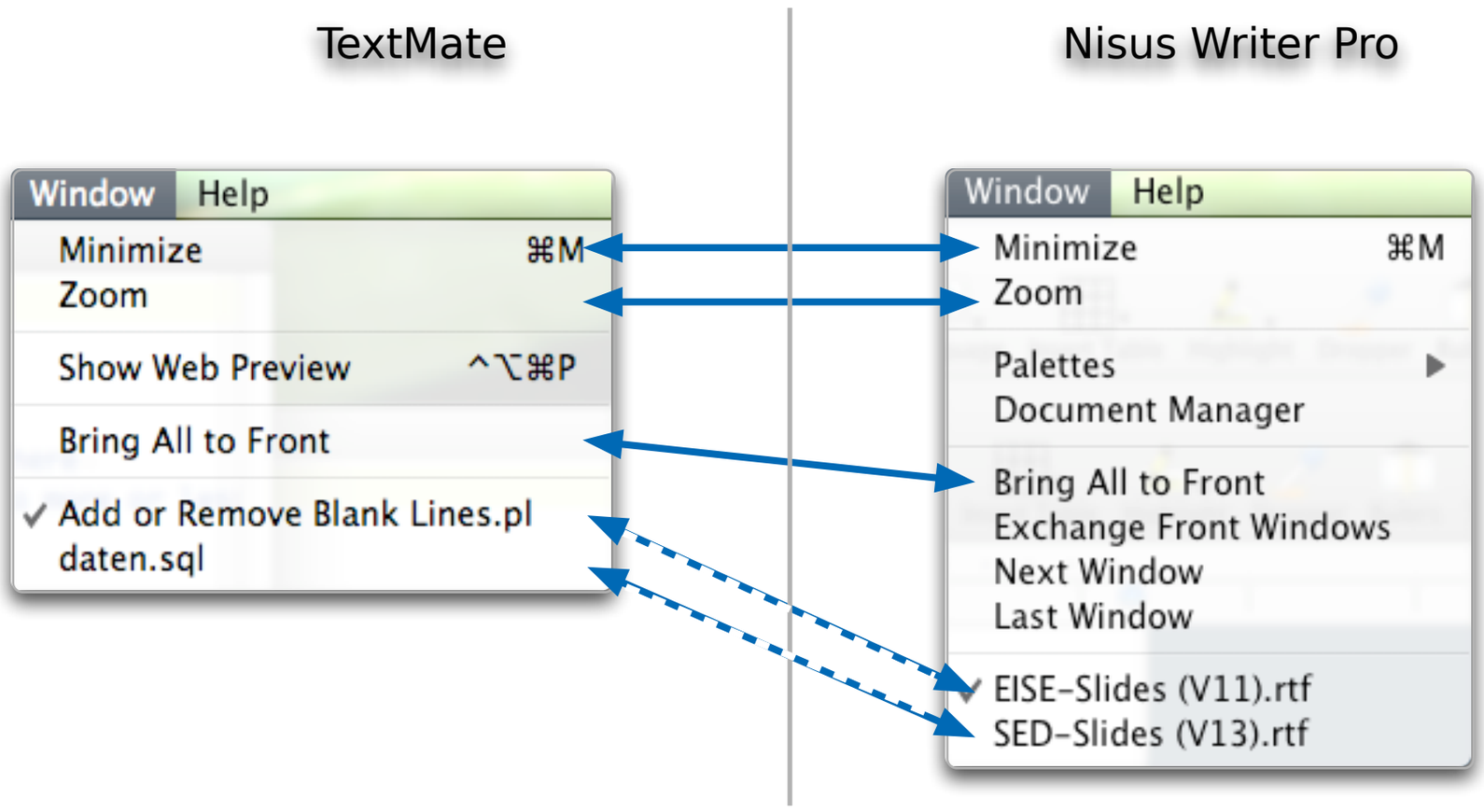
- Text editors
- Word processors
- Vector drawing applications
- Document Viewers
- ...

Our framework should - in particular - **be able to manage the documents.**

The Factory Method Design Pattern

Example / Motivation -

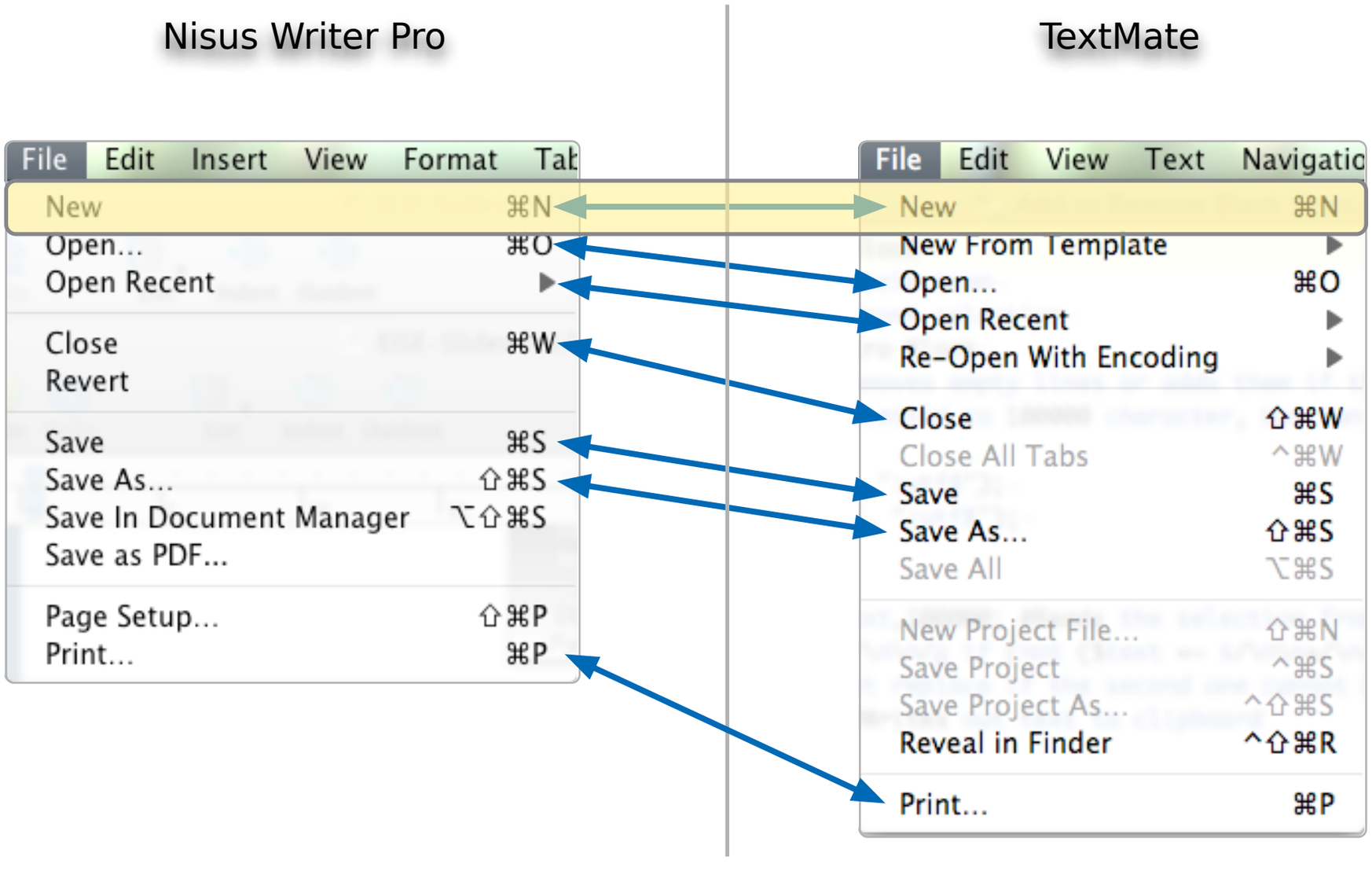
Common functionality for handling documents



The Factory Method Design Pattern

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


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

```
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


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

public class MyApplication extends Application {

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

}
```

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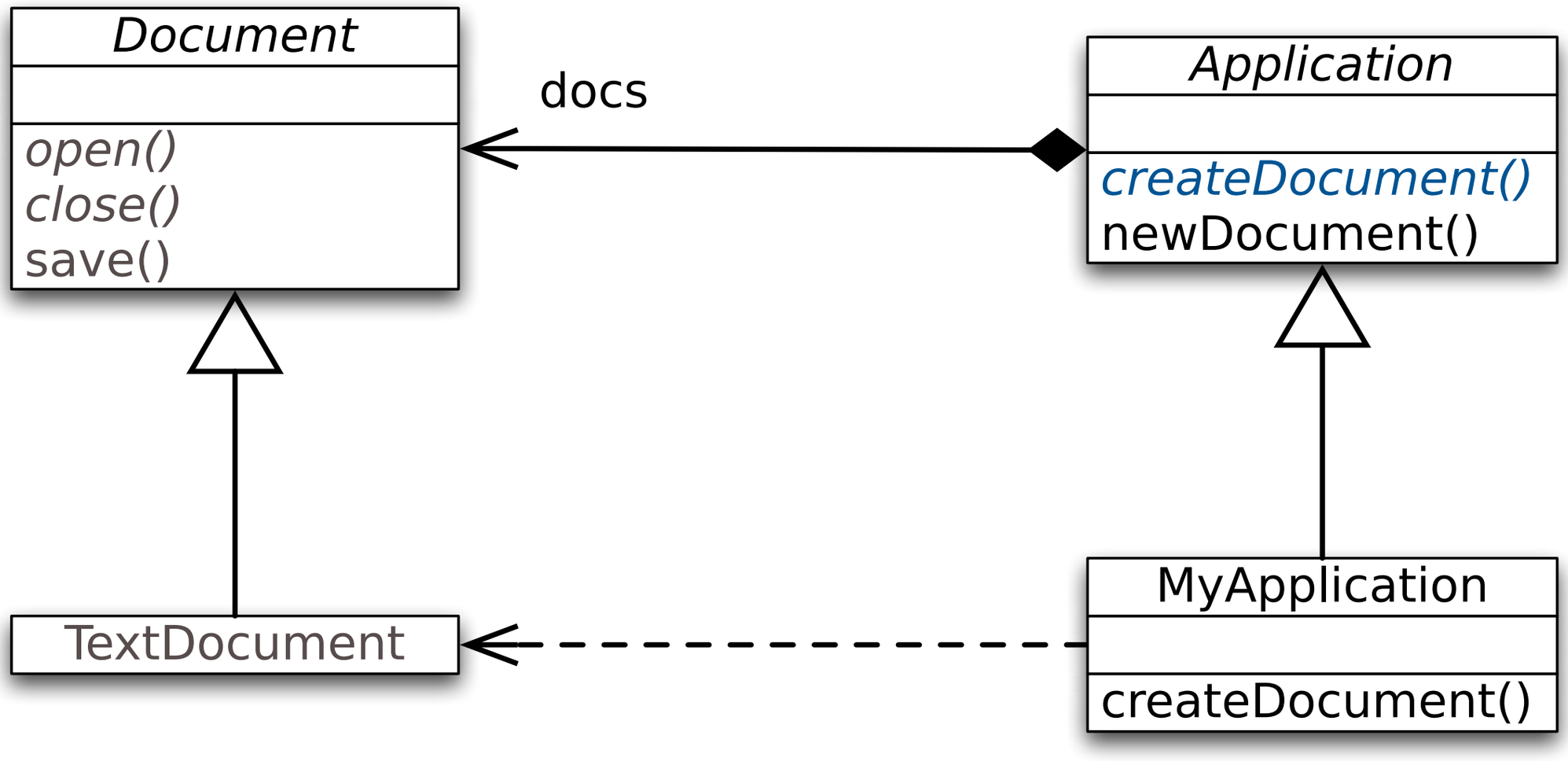
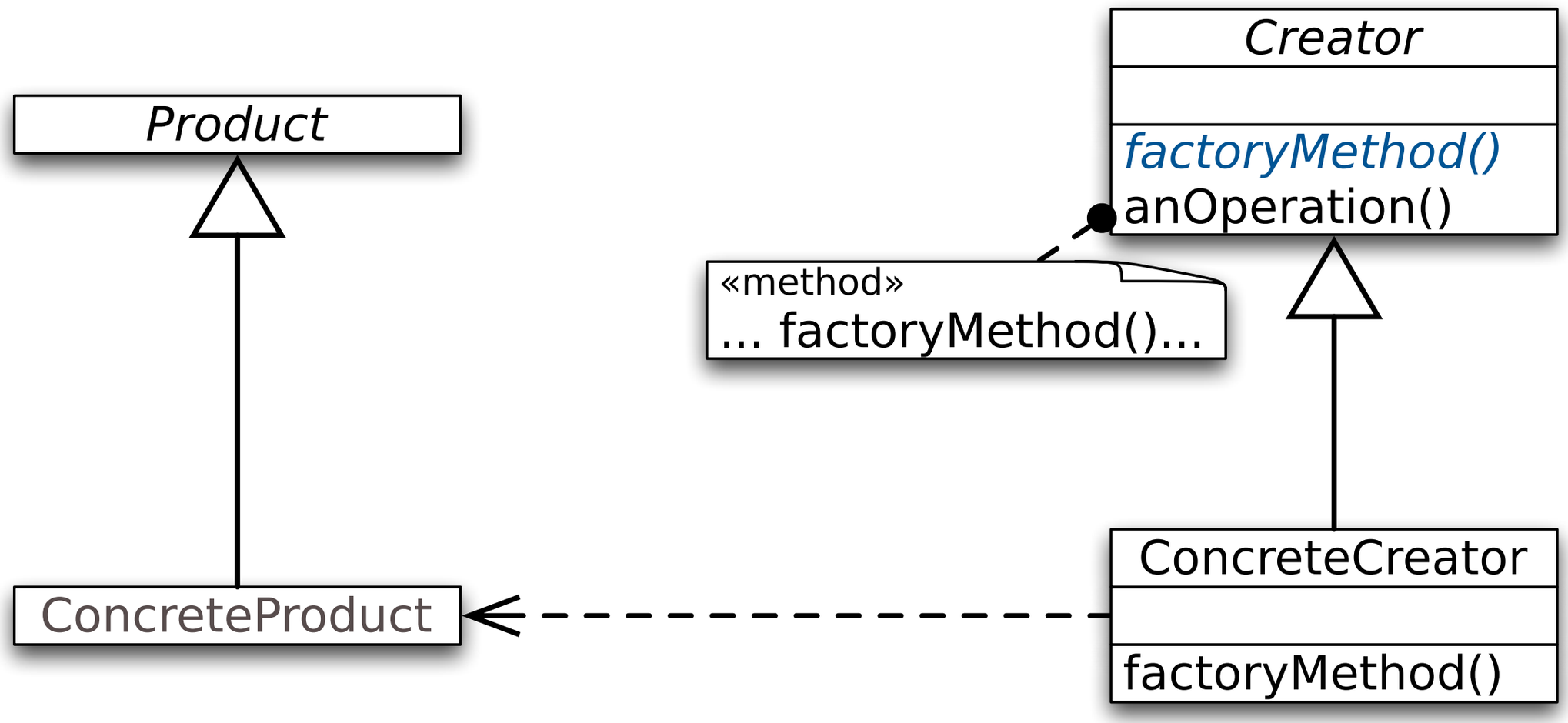
Example / Motivation -

Class Diagram of an Application Using the Framework



The Factory Method Design Pattern

Structure



The Factory Method Design Pattern

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)

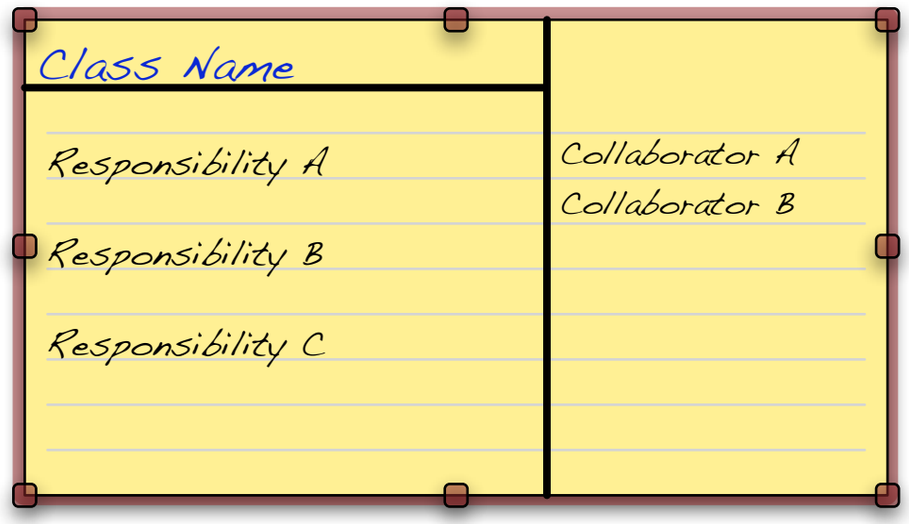
- **The framework's code only deals with the Product interface**; therefore it can work with any user-defined ConcreteProduct class.
- **Provides a hook for subclasses**

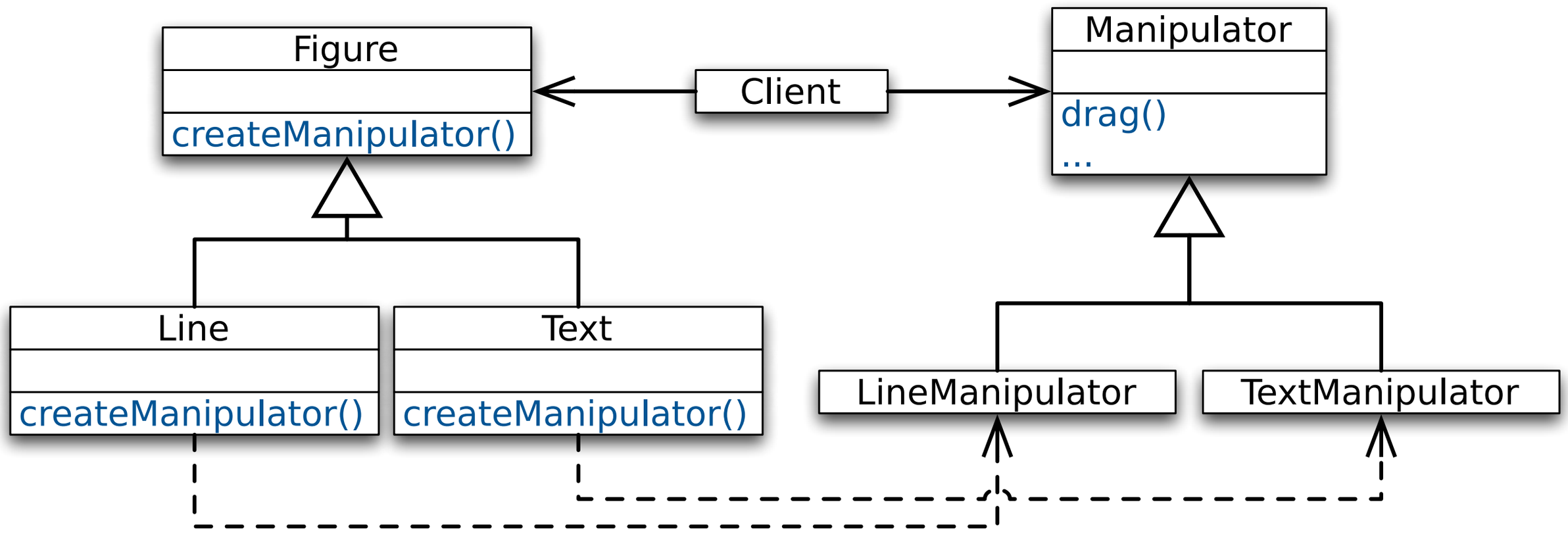
The hook can be used for providing an extended version of an object.

The Factory Method Design Pattern

Consequences (II)

- Connects parallel class hierarchies





The Factory Method Design Pattern

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:

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

Applied to our example:

```
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


```
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 Method**s are usually called within **Template Method**s
- Abstract Factory is often implemented with factory methods

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The Abstract Factory Design Pattern

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How to create families of related classes that implement a (set of) common interface(s)?

The Abstract Factory Method Design Pattern

Motivation / Example Scenario

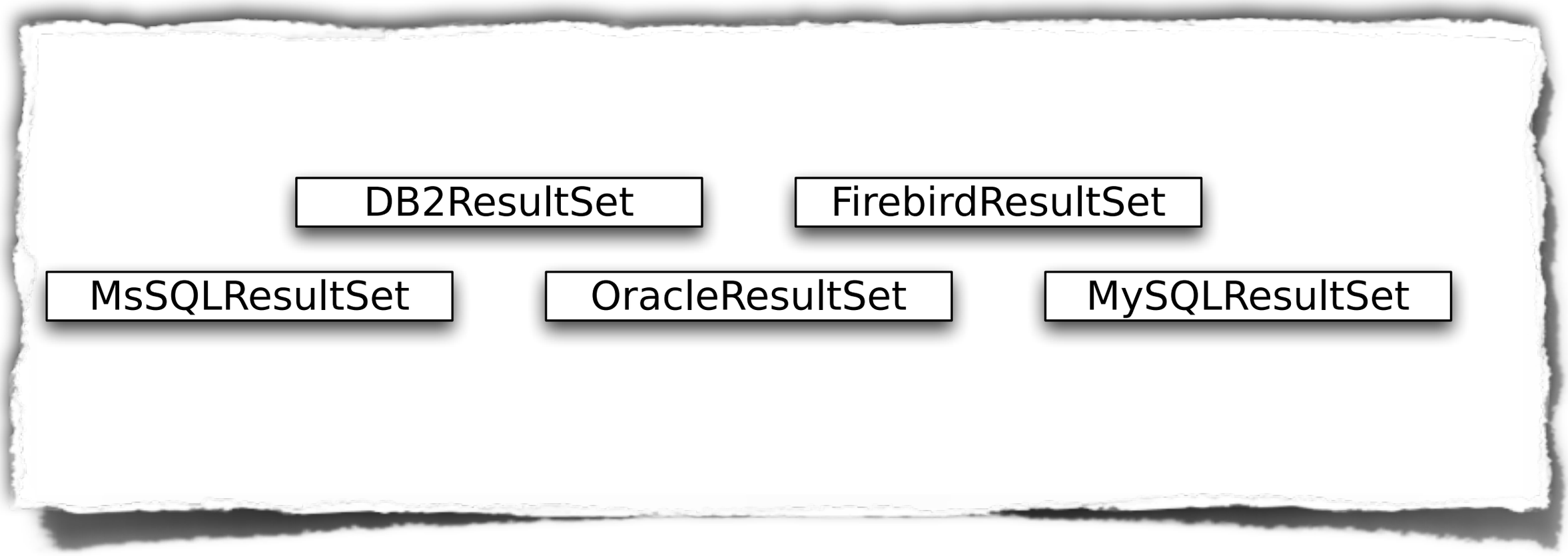
Our goal is to support different databases.

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).)

Supporting Variety

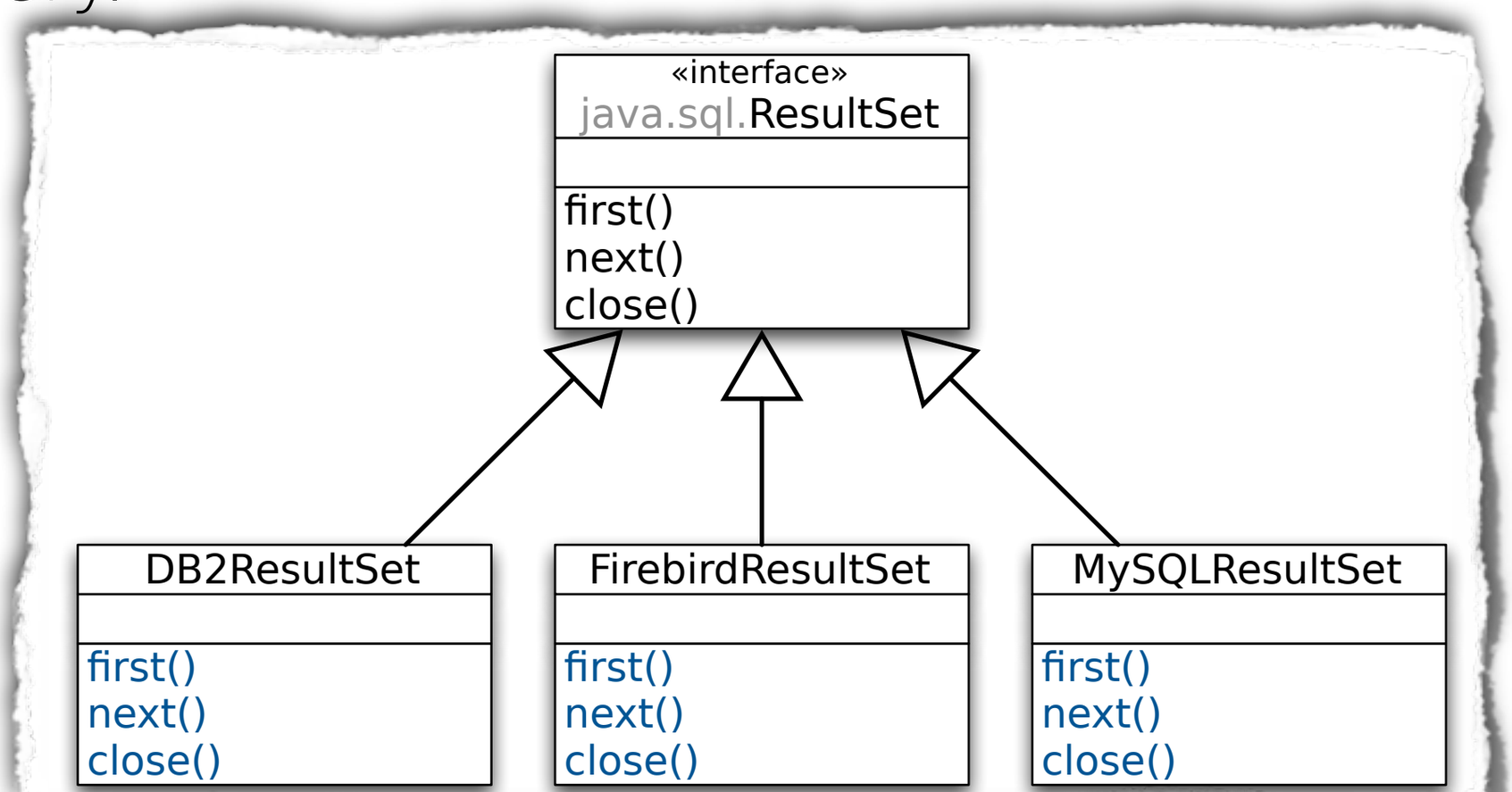
A result set enables the iteration over the result of an SQL query.



How to provide an interface to all of these different kinds of ResultSets?

Supporting Variety by Providing a Common Interface

A result set enables the iteration over the result of an SQL query.



A common interface is introduced to abstract from the concrete classes.

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Motivation / Example Scenario

- 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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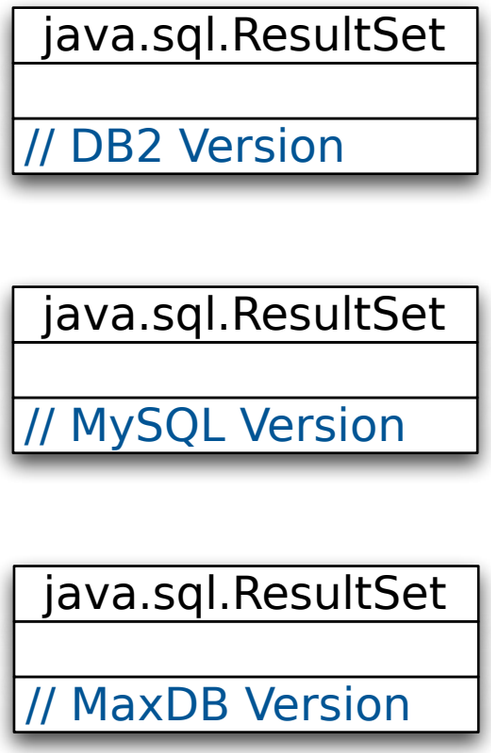
Issues -

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

Solution

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

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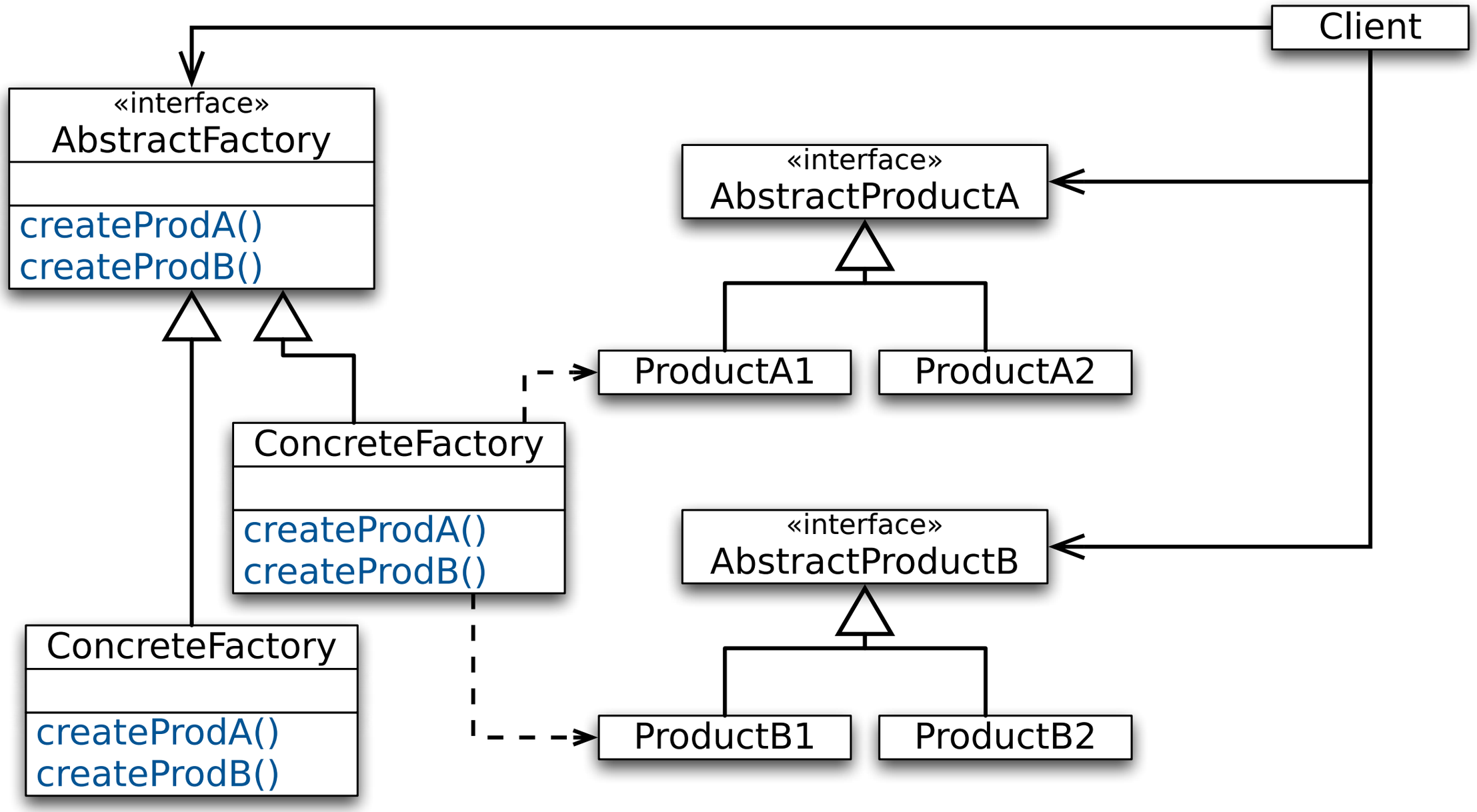
Structure



The Abstract Factory Method Design Pattern

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

The Abstract Factory Method Design Pattern

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.)

The Abstract Factory Method Design Pattern

Issues -

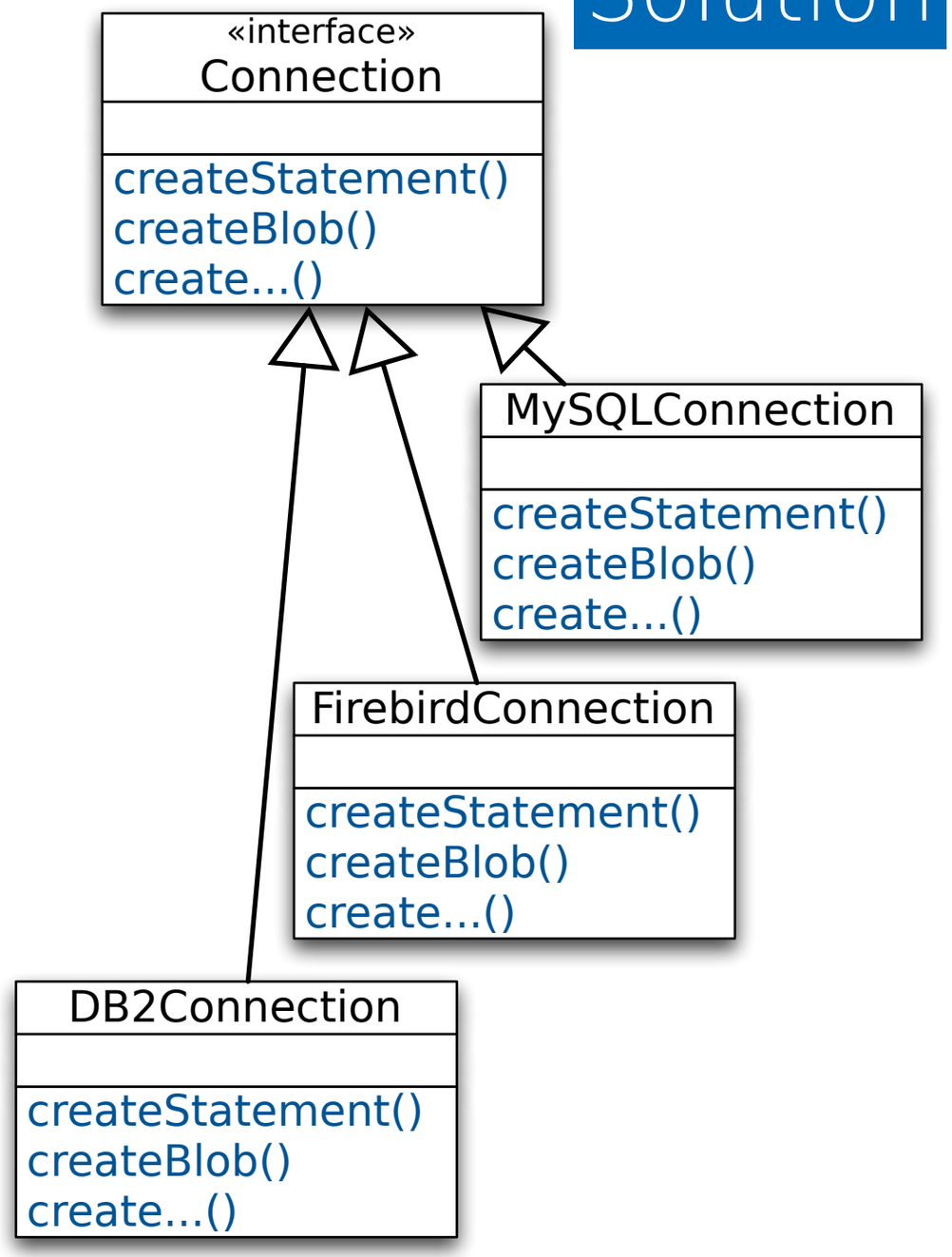
How can we avoid to know about the concrete product types at creation time?

Solution

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 **prepareStatement()** as part of its interface
- Different factory subclasses provide implementations for different databases.

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



The Abstract Factory Method Design Pattern

Product Creation

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

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

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

```
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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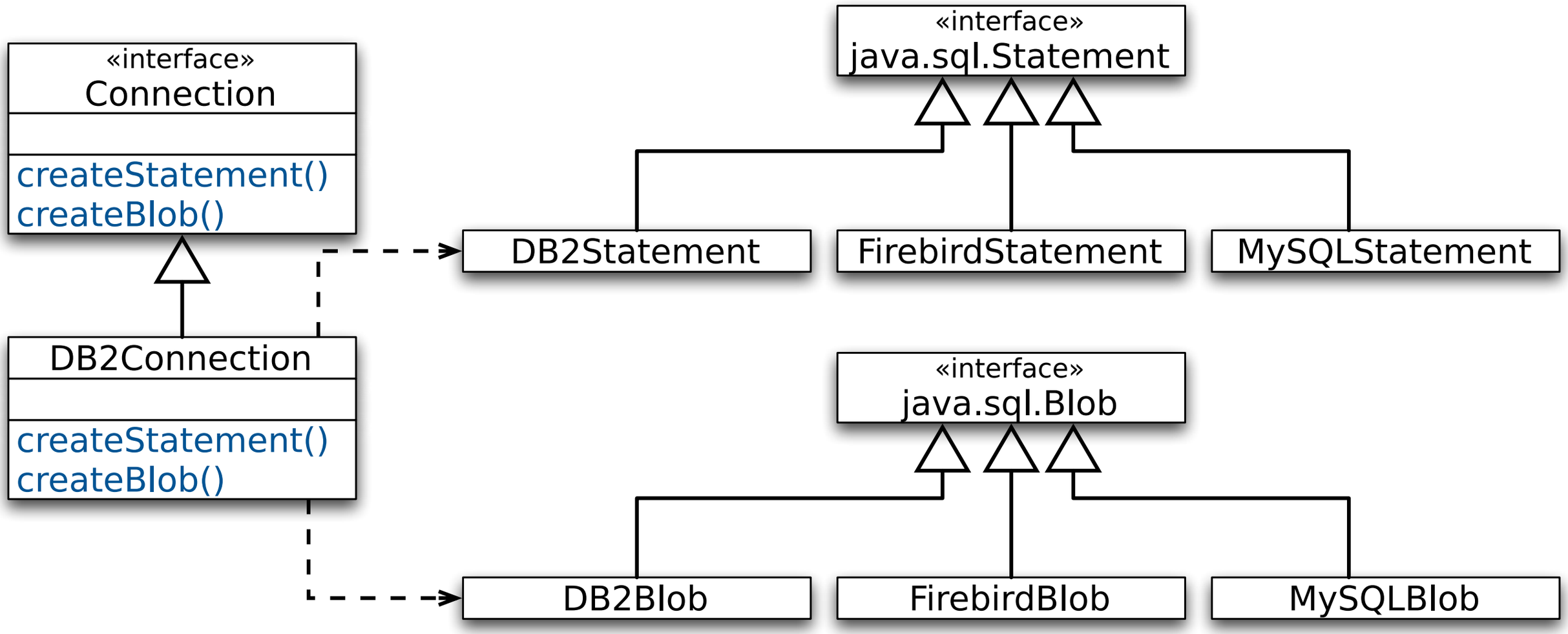
Applied



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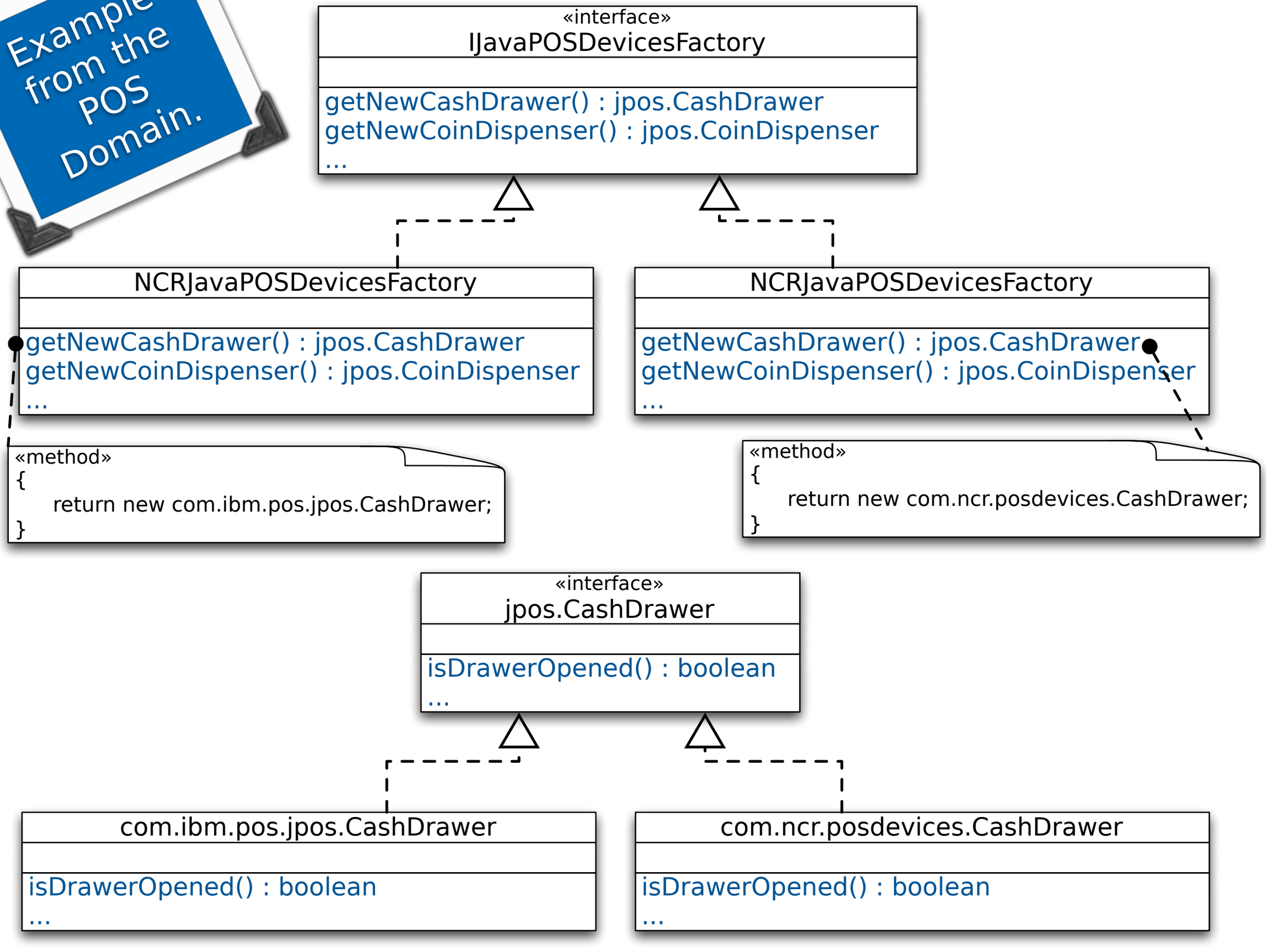
Summary

- 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.)

Example from the POS Domain.



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Related Patterns

- A concrete factory is often a singleton