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The Factory Method Design Pattern

For details see Gamma et al. in "Design Patterns"



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The Factory Method Design Pattern

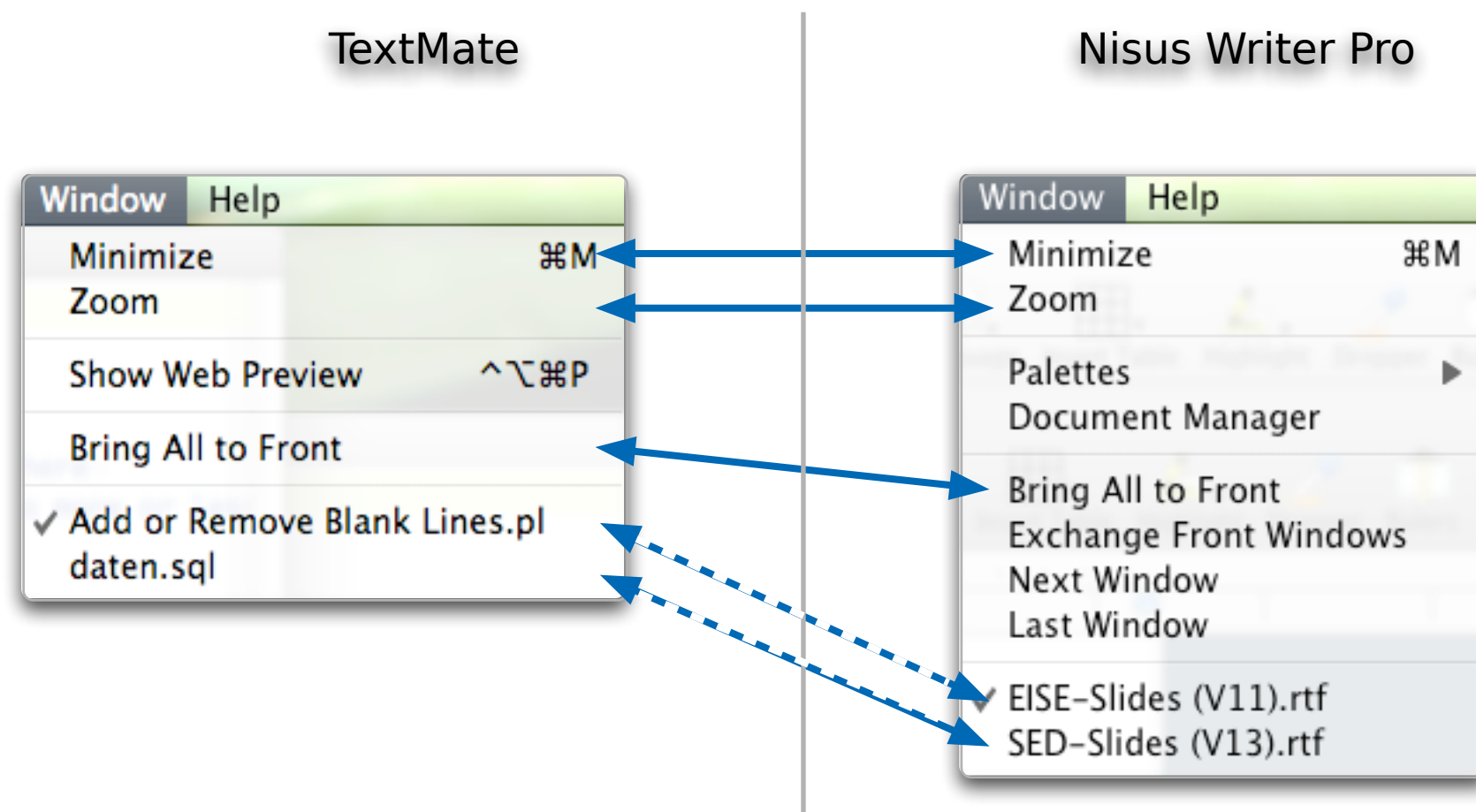
Example / Motivation

- 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.

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Example / Motivation -

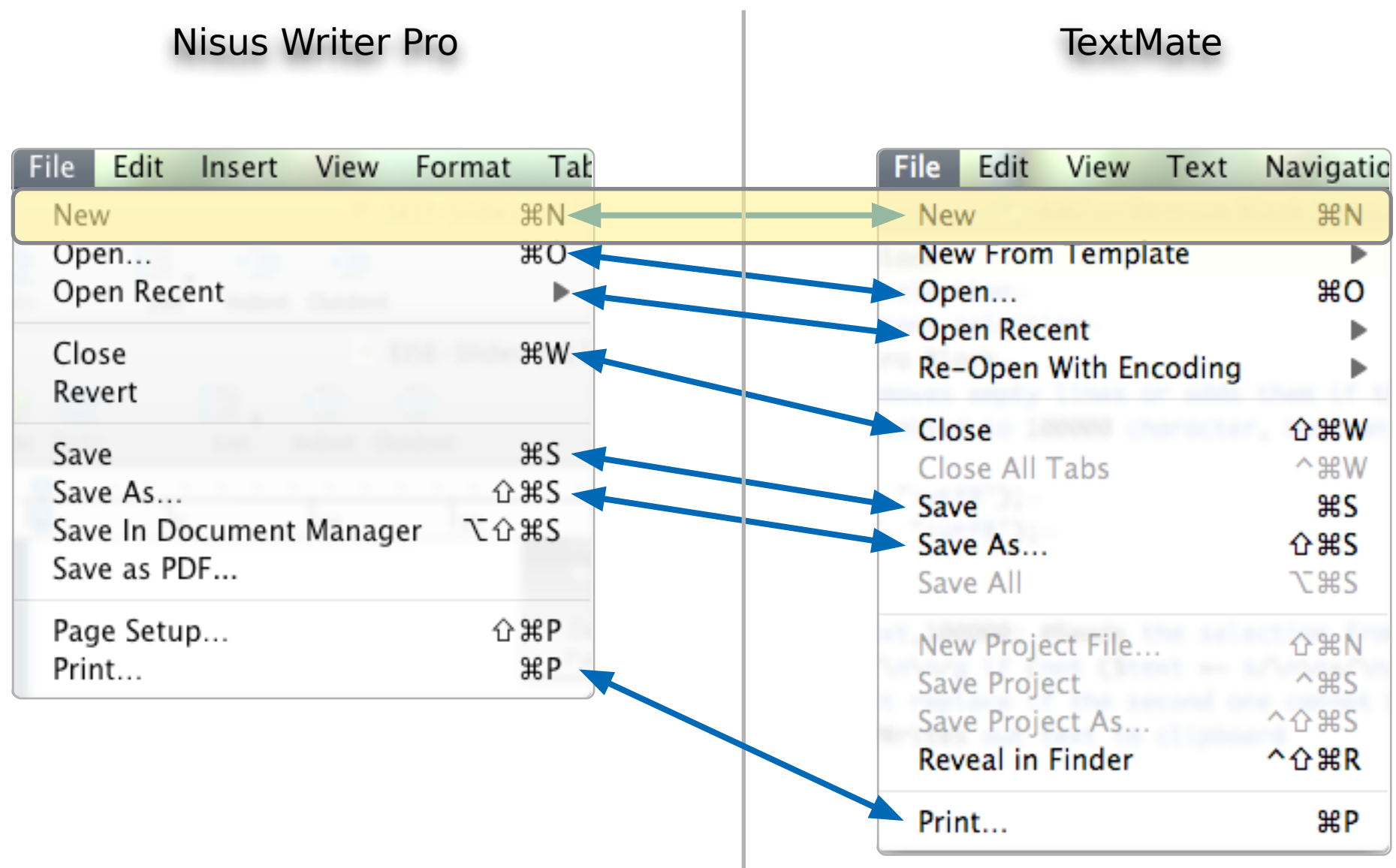
Common functionality for handling documents



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

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```
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

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

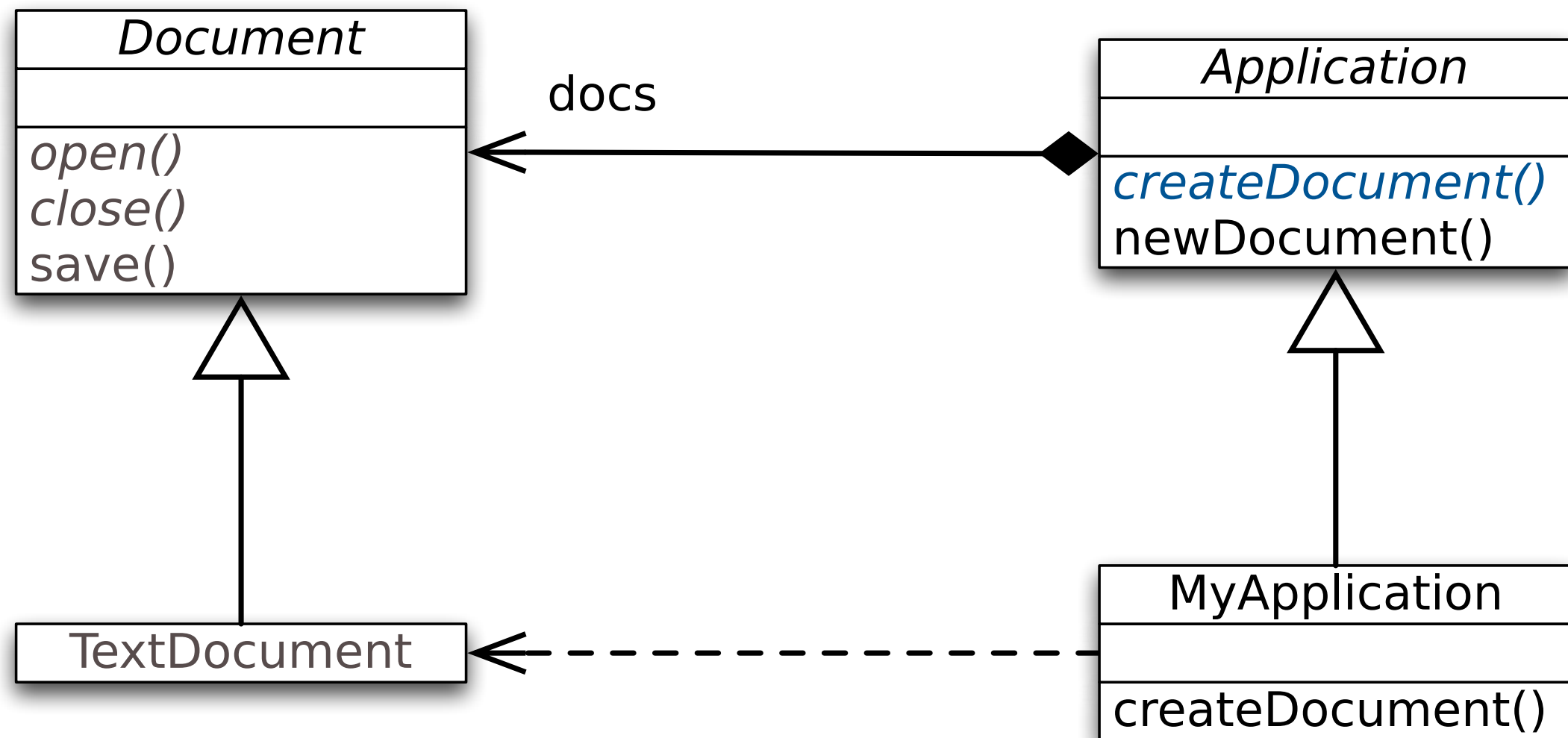
```
public class MyApplication extends Application {  
    public Document createDocument() {  
        return new TextDocument();  
    }  
}
```

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Example / Motivation -

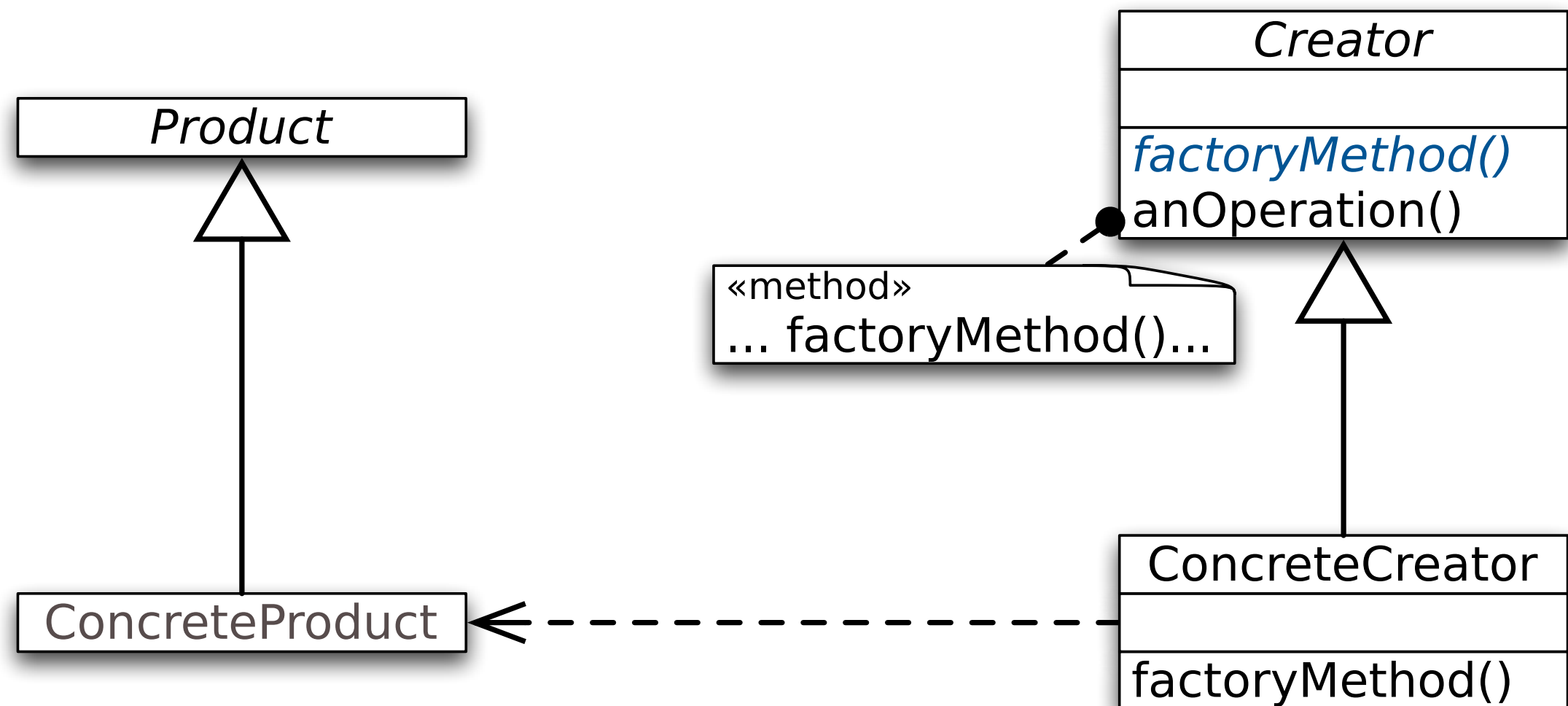
Class Diagram of an Application Using the Framework

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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.

The Factory Method Design Pattern

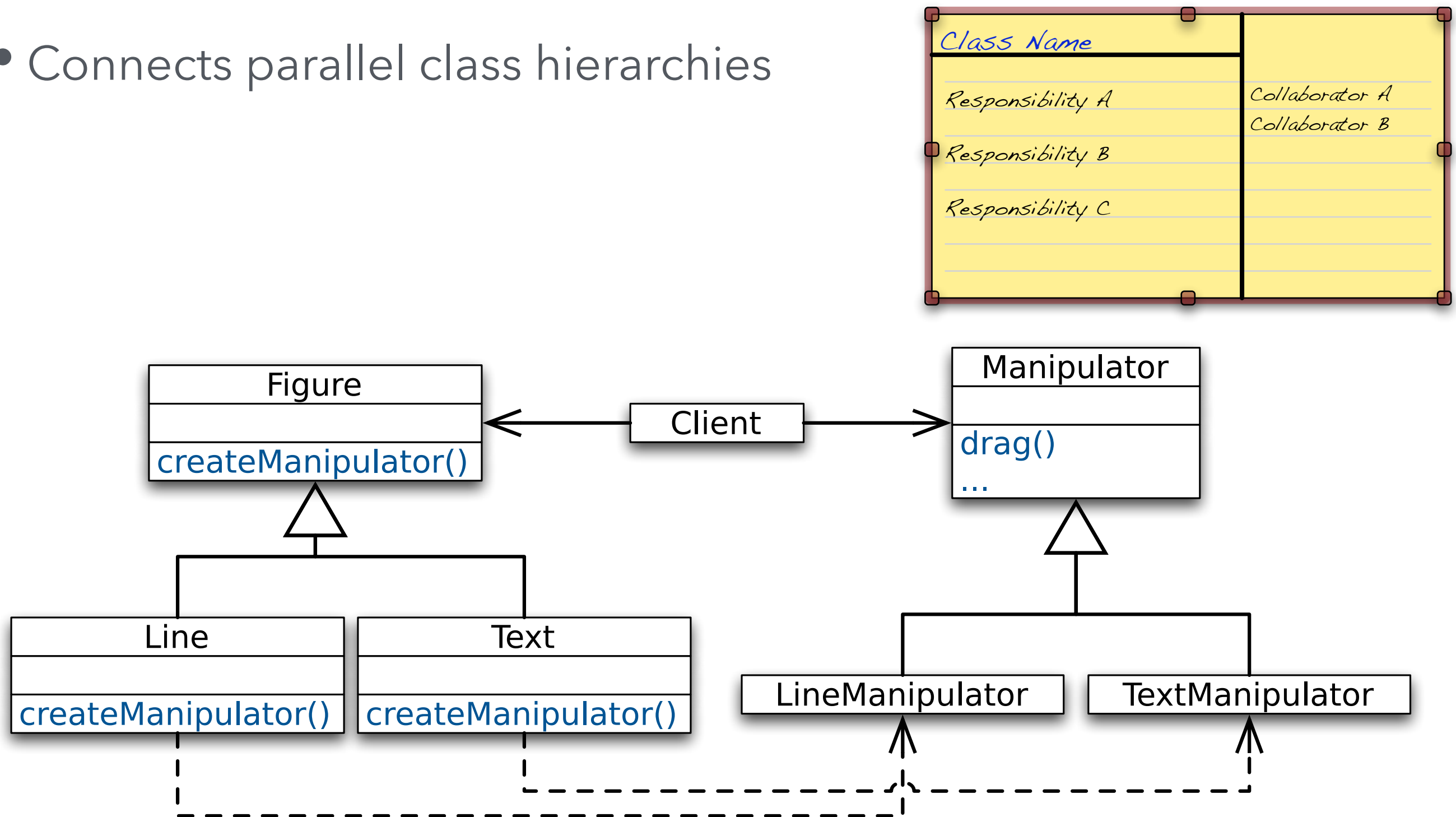
Consequences (I)

- **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



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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:

```
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();  
        }  
    }  
}
```

The Factory Method Design Pattern

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

Placeholder | 16

- Factory Methods are usually called within Template Methods
- 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)?

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Motivation / Example Scenario

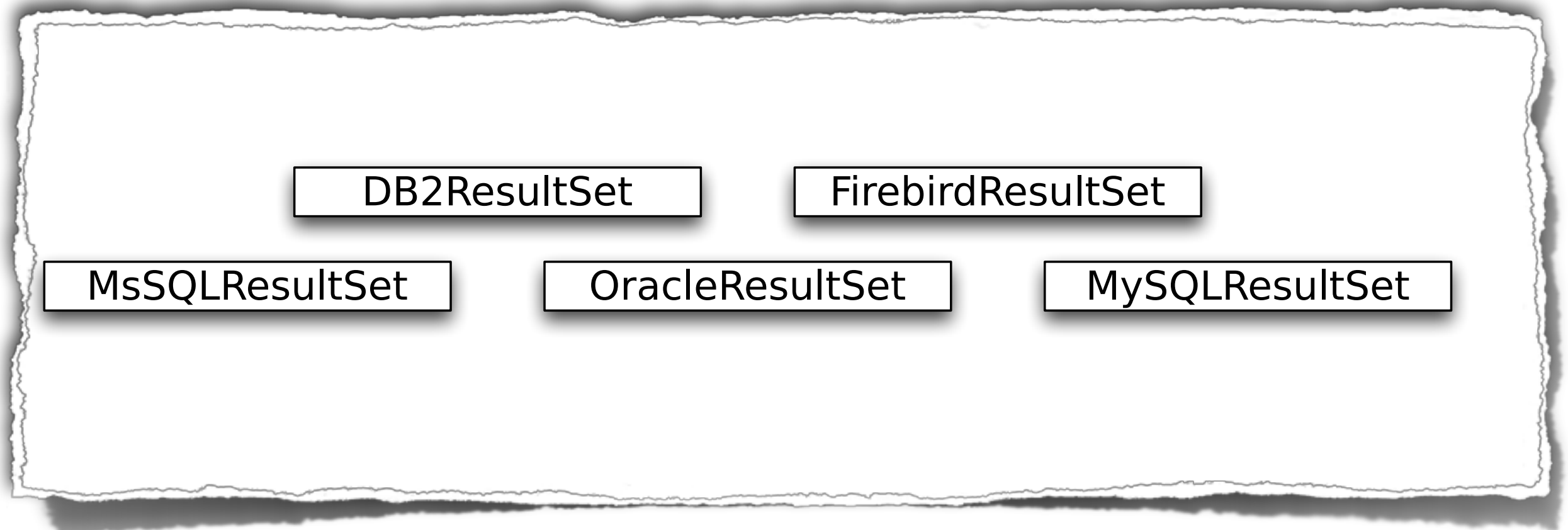
Our goal is to support different databases.

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

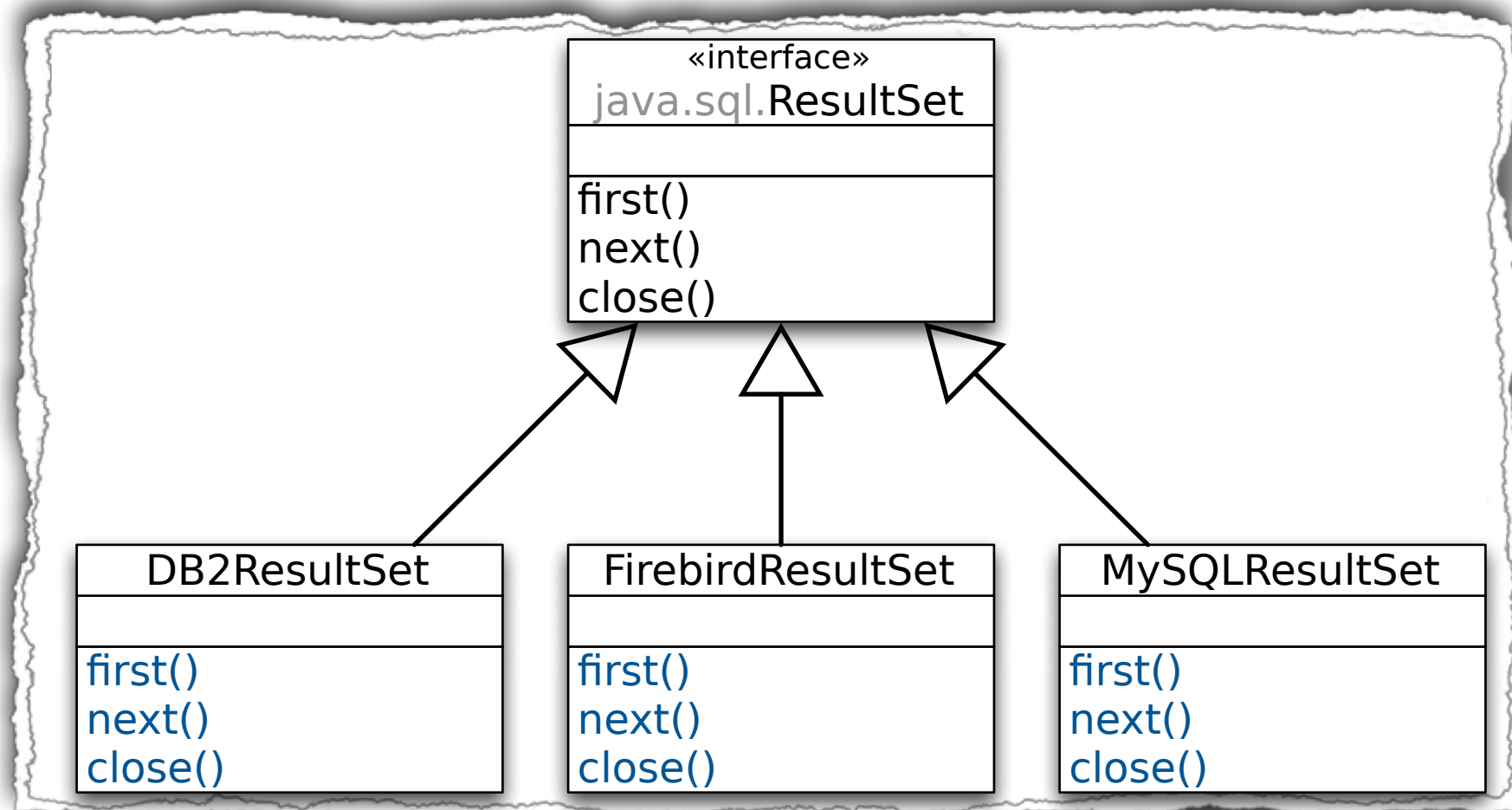
A result set enables the iteration over the result of an SQL query.



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 `ResultSet` 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

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
- Does not allow multiple databases to be used at runtime

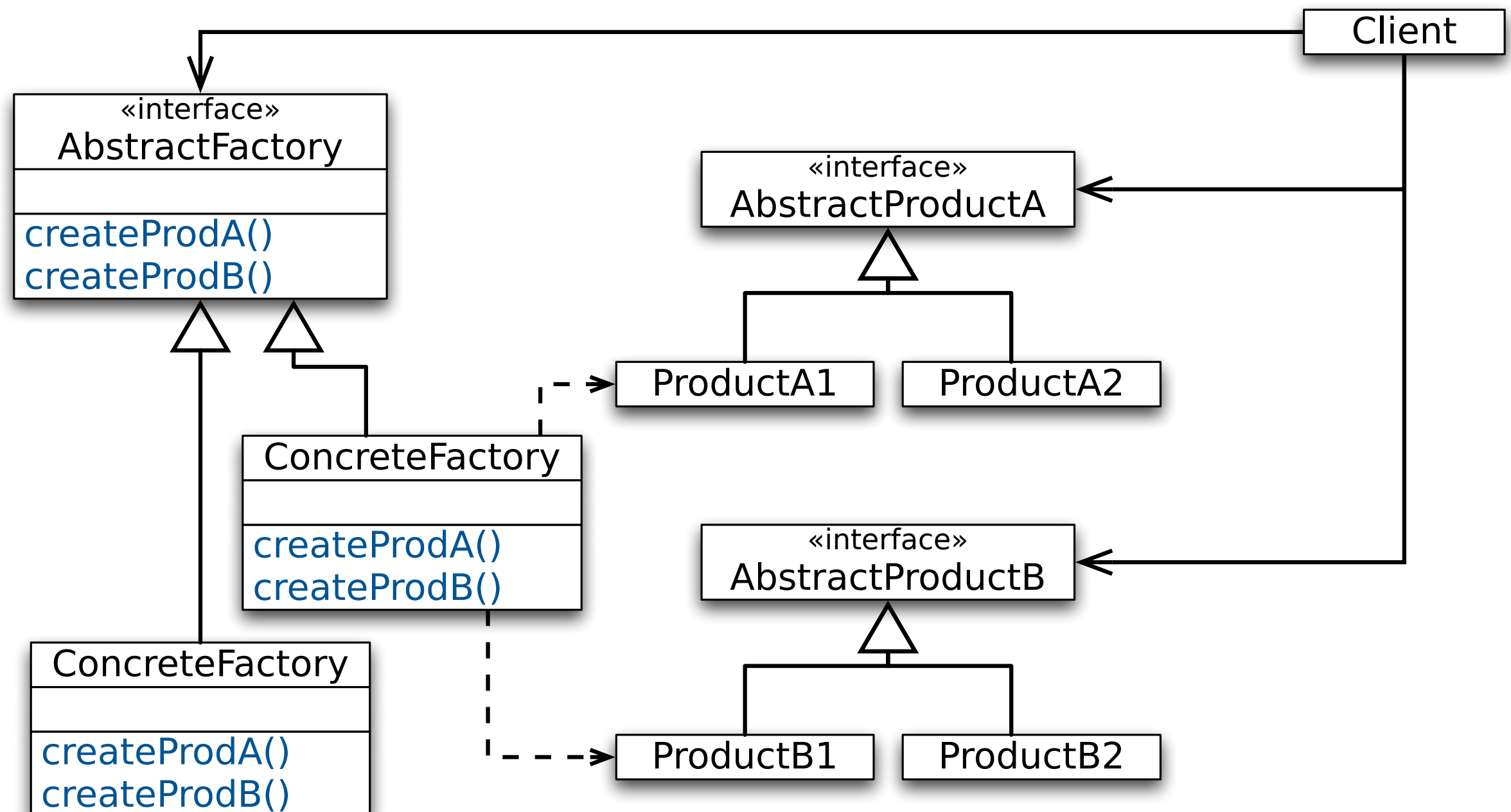
java.sql.ResultSet
// DB2 Version

java.sql.ResultSet
// MySQL Version

java.sql.ResultSet
// MaxDB Version

The Abstract Factory Method Design Pattern

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.)

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Issues -

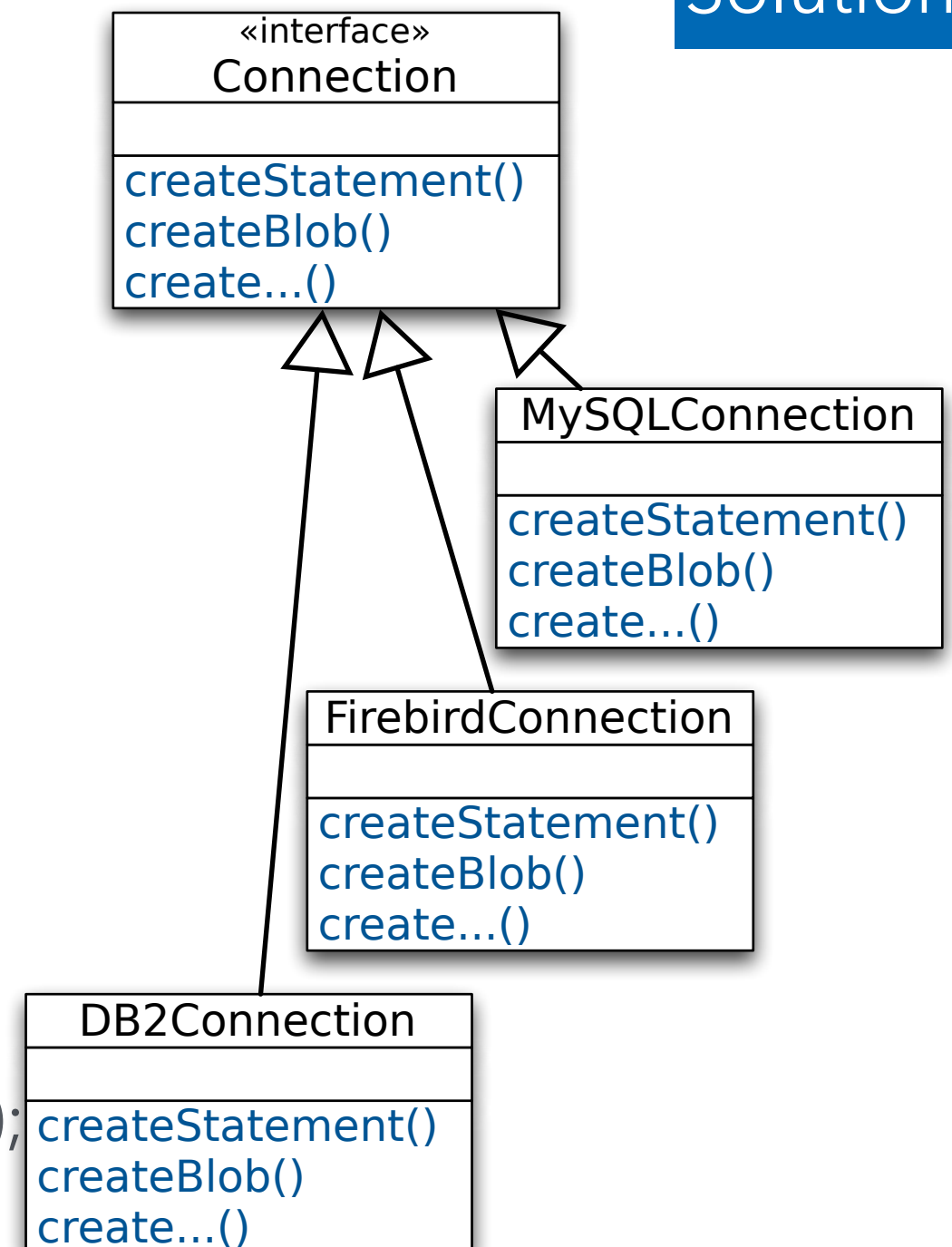
How can we avoid to know about the concrete product types at creation time?

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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();



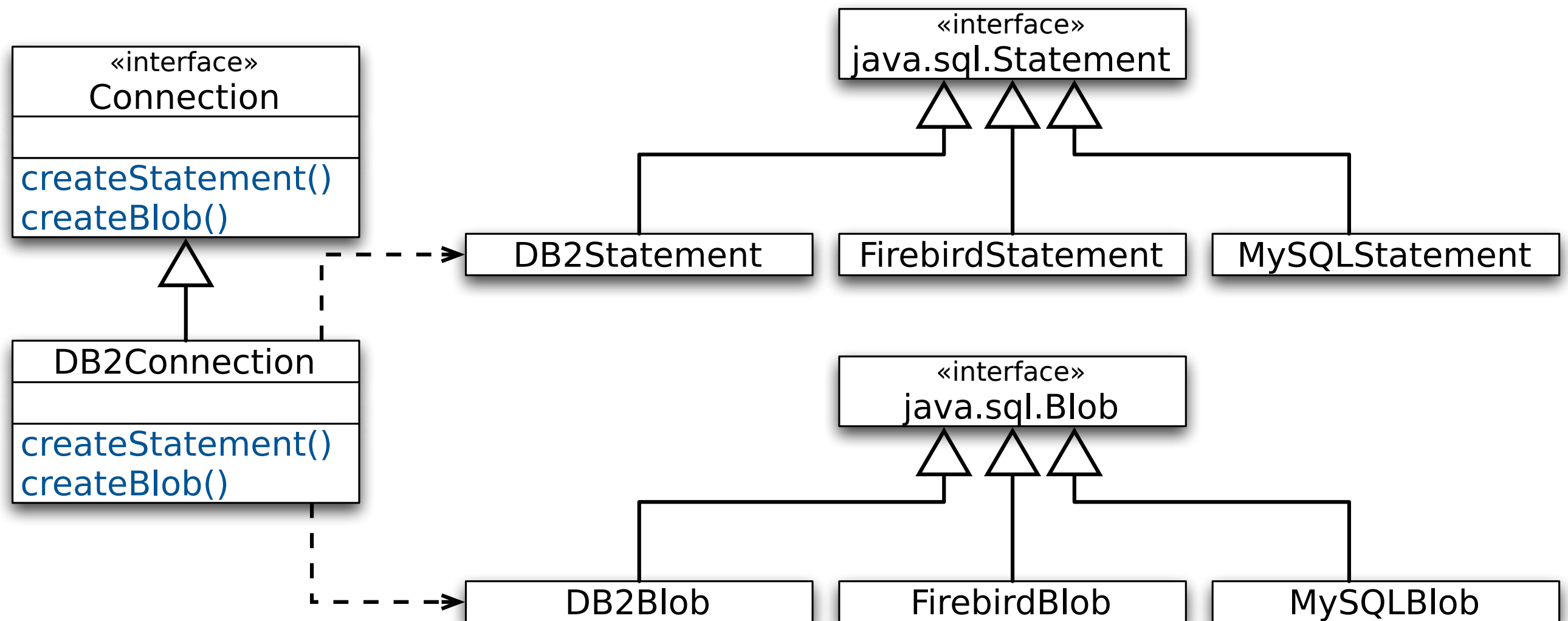
The Abstract Factory Method Design Pattern

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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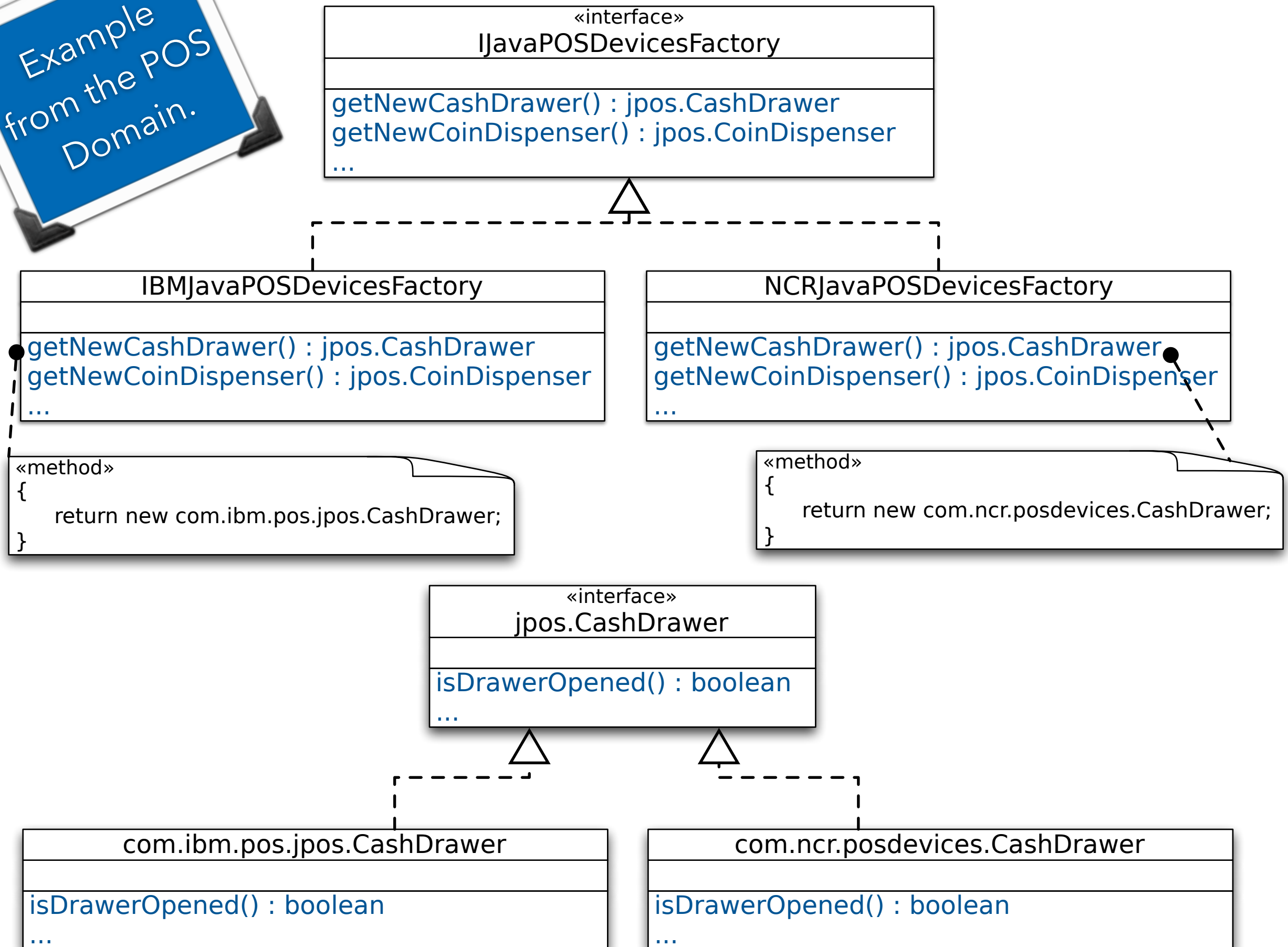
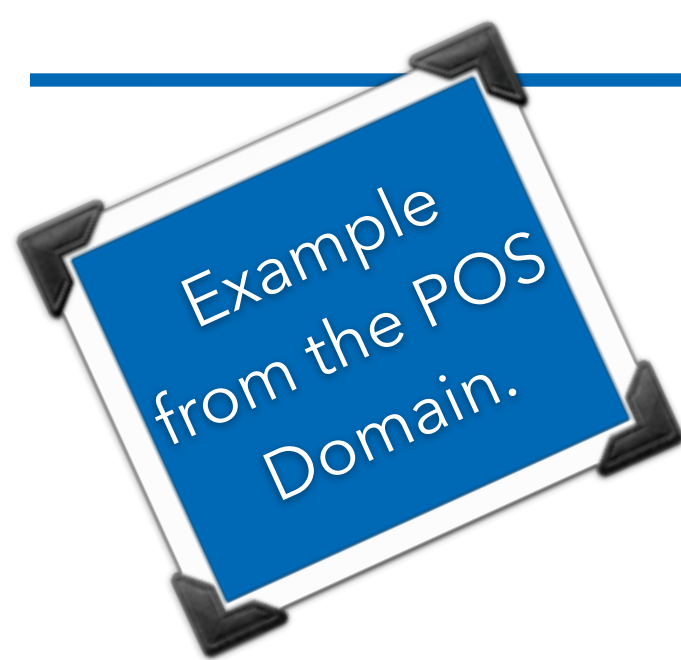
Applied



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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.)



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Related Patterns

- A concrete factory is often a singleton



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