

Object Creation

Prof. Dr. Dirk Riehle

Friedrich-Alexander University Erlangen-Nürnberg

ADAP C10

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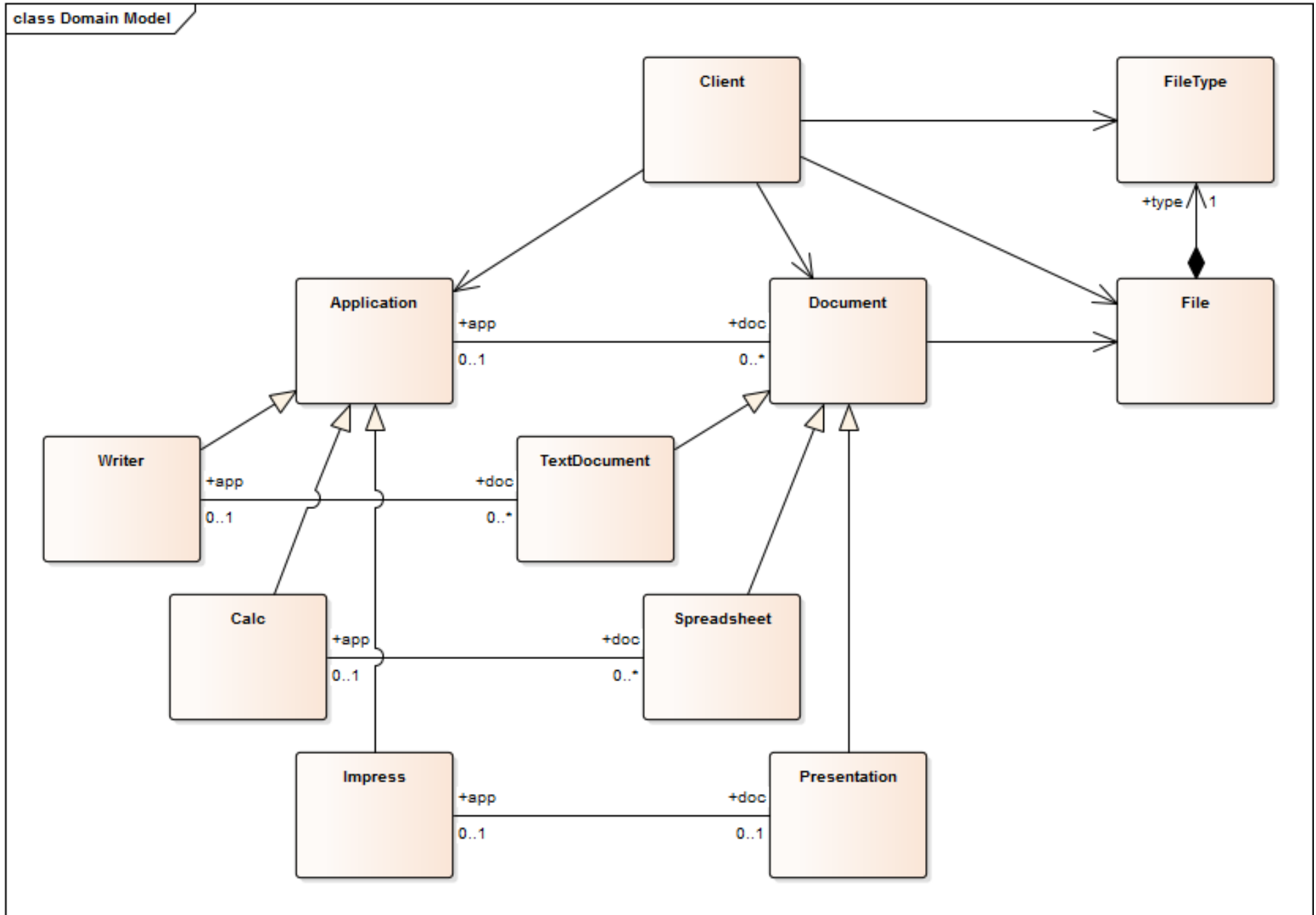
Design Patterns of Object Creation

- 1. Switch / Case**
- 2. Factory Method**
- 3. (Abstract) Factory**
- 4. Product Trader**
- 5. Prototype**

Object Creation Example

- Create a document from its file type (extension)
- Create an application for the document

Application Document Model



Ease of

- 1. Reading code**
- 2. Understanding code**
- 3. Changing code**
- 4. Extending code**

Scenario 1: File-type → Document

- Client is run-time environment, e.g. desktop
- Wants to create document for given file

Switch / Case Applied

```
public class Client {  
  
    public Document createDocument(File file) {  
        String fileType = file.getFileType();  
        Document result = null;  
  
        if (fileType.equals("odt")) {  
            result = new TextDocument();  
        } else if (fileType.equals("ods")) {  
            result = new Spreadsheet();  
        } else if (fileType.equals("odp")) {  
            result = new Presentation();  
        }  
  
        ...  
        return result;  
    }  
  
    ...  
}
```

Switch / Case Evaluated

- Advantages
 - Easy to read
 - Easy to understand
 - Easy to change
- Disadvantages
 - Hard to extend
- Additional notes
 - May require use of initialization method

Scenario 2: Application → Document

- Client is run-time environment, e.g. desktop
- Wants to create document for given application

Factory Method Applied

```
public abstract class Application {  
    public abstract Document createDocument();  
    ...  
}
```

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

```
public class Calc extends Application {  
    public Document createDocument() { return new Spreadsheet(); }  
    ...  
}
```

```
public class Impress extends Application {  
    public Document createDocument() { return new Presentation(); }  
    ...  
}
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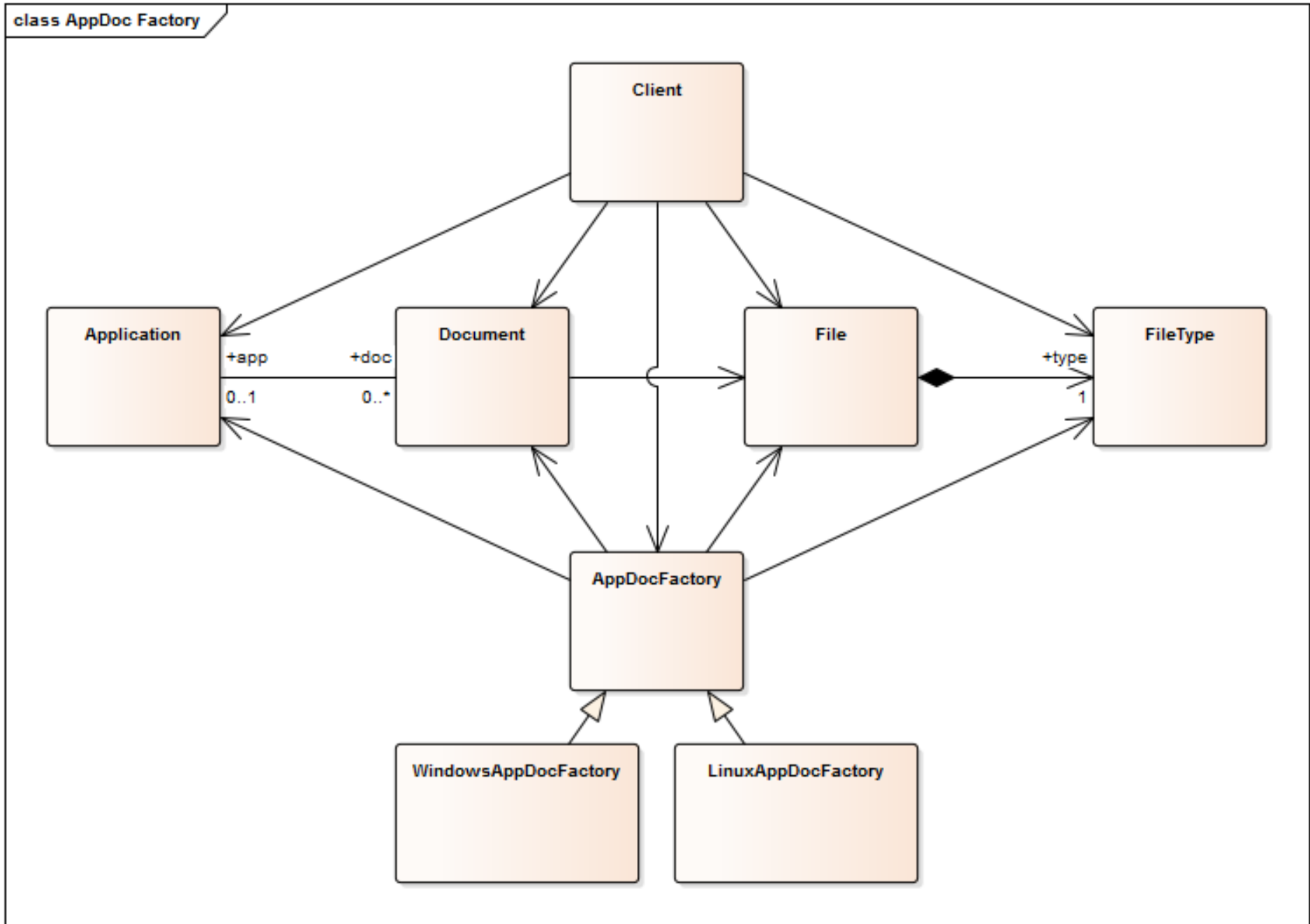
Factory Method Evaluated

- Advantages
 - Easy to change
 - Easy to extend
- Disadvantages
 - Creation code is not centralized any longer

Scenario 3: File-type → Document (v2)

- Client is run-time environment, e.g. desktop
- Wants to create document for given file
- Wants to add new Document types in one place

Application Document Factory



Abstract Factory Applied

```
public interface AppDocFactory {  
    public Application createFrom(Document doc);  
    public Document createFrom(File file);  
    ...  
}
```

```
public class DefaultAppDocFactory implements AppDocFactory {  
    ...  
  
    public Document createFrom(File file) {  
        String fileType = file.getFileType();  
        if (fileType.equals("odt")) {  
            result = new TextDocument();  
        } else if ...  
  
        return result;  
    }  
    ...  
}
```

Abstract Factory Evaluated

- Advantages
 - Easy to read
 - Easy to change
 - Easier to extend (than v1)
- Disadvantages
 - Harder to understand
- Additional notes
 - Factories are versatile, advantages and disadvantages depend on further choices like how to implement the creation methods

Scenario 4: Document → Application

- Client is run-time environment, e.g. desktop
- Wants to create application for given document
- Wants to add new Application types in one place

Product Trader Applied 1 / 2

```
public interface AppDocFactory {  
    public void registerApplicationClass(Class dc, Class ac);  
    public Application createFrom(Document doc);  
    ...  
}
```

```
public class DefaultAppDocFactory implements AppDocFactory {  
  
    Map<Class, Class> appClasses = new HashMap<Class, Class>();  
    static {  
        appClasses.put(TextDocument.class, Writer.class);  
        appClasses.put(Spreadsheet.class, Calc.class);  
        appClasses.put(Presentation.class, Impress.class);  
    }  
  
    ...  
}
```

Product Trader Applied 2 / 2

```
public class DefaultAppDocFactory implements AppDocFactory {

    Map<Class, Class> appClasses = new HashMap<Class, Class>();

    public void registerApplicationClass(Class dc, Class ac) {
        assert (dc != null) && (ac != null);
        appClasses.put(dc, ac);
    }

    public Application createFrom(Document doc) {
        Class appClass = appClasses.get(doc.getClass());
        assert appClass != null;
        return createInstance(appClass);
    }

    protected Application createInstance(Class ac) {
        ...
    }

    ...
}
```

Product Trader Evaluated

- Advantages
 - Easy to read
 - Easy to change
 - Easy to extend
- Disadvantages
 - Hard to understand
 - Hard to debug
- Additional notes
 - Product Trader delays everything until runtime
 - May be viewed as just a complex (abstract) factory

Scenario 5: File-type → Document (v3)

- Client is run-time environment, e.g. desktop
- Wants to create document for given file type
- Wants to add new Document types in one place
- Wants to initialize complex but default document

Prototype Applied 1 / 2

```
public interface AppDocFactory {  
    public void registerDocumentPrototype(FileType ft, Document doc);  
    public Document createFrom(FileType ft);  
    ...  
}
```

Prototype Applied 2 / 2

```
public class DefaultAppDocFactory implements AppDocFactory {

    Map<String, Document> docProtos = new HashMap<String, Document>();

    public void registerDocumentPrototype(FileType ft, Document doc) {
        assert (ft != null) && (doc != null);
        docProtos.put(ft, doc);
    }

    public Document createFrom(FileType ft) {
        Document prototype = docProtos.get(ft);
        assert (prototype != null) && (prototype.isCloneable());
        return prototype.clone();
    }

    ...
}
```

Prototype Evaluated

- Advantages
 - Easy to read
 - Easy to change
 - Easy to extend
- Disadvantages
 - Hard to understand

Problems with Using Design Patterns

- Many design patterns address multiple issues at once, e.g.
 - Factory method: Creation method and subclassing for configuration
 - Abstract factory: Factory object and subclassing for configuration
 - Prototype: Creation configuration and complex object structures

Design Process for Object Creation

- Use your experience
- Use a pattern language
- Choose from design space
 - Delegation (of object creation)
 - Selection (of concrete class)
 - Configuration (of class mapping)
 - Instantiation (of concrete class)
 - Initialization (of new object)
 - Building (of object structure)

Design Space for Object Creation

- 1. Delegation** of object creation
- 2. Selection** of concrete class
- 3. Configuration** of class mapping
- 4. Instantiation** of concrete class
- 5. Initialization** of new object
- 6. Building** of object structure

Details of Design Space for Object Creation

- **Delegation** (Who gets to create the object?)
 - on-the-spot, this-object, separate-object
- **Selection** (How is the concrete class selected?)
 - on-the-spot, by-switch-case, by-subclassing, by-colocating, by-mapping
- **Configuration** (How is a class mapping configured?)
 - in-code, by-annotation, by-configuration-file
- **Instantiation** (How is the concrete class instantiated?)
 - in-code, by-class-object, by-prototype, by-function-object
- **Initialization** (How is the new object initialized?)
 - default, by-cloning, by-fixed-signature, by-key-value-pairs, in-second-step
- **Building** (How is the object structure built?)
 - default, by-cloning, by-building

1. Delegation of Object Creation

- **On-the-spot**
 - Definition: Hard-code in client code
 - Use: If product class is unlikely to change, ever
- By delegating to **this-object**
 - Definition: Delegate to separate (creation) method
 - Use: If this class has multiple places that need this type of new object
- By delegating to a **separate-object**
 - Definition: Delegate to a separate (factory) object
 - Use: If many places in the system need to create new objects of this type

2. Selection of Concrete Class

- **On-the-spot**

- Definition: Hard-code in place (whether this method, this class or factory)
- Use: If there is no need for varying the concrete class, ever

- **By-switch-case** statement

- Definition: Hard-code in place using switch/case statement
- Use: If there are multiple options, none of which changes, ever

- **By-subclassing**

- Definition: Select concrete class by delegating to subclass
- Use: If you need a family and dual hierarchies need to be satisfied

- **By-colocating**

- Definition: Select concrete class as part of a family selection
- Use: If your concrete class is part of a family of co-dependent classes

- **By-mapping**

- Definition: Look-up concrete class as part of some spec → class mapping
- Use: If your concrete class needs to be configurable at runtime

3. Configuration of Class Mapping

- **In-code**

- Definition: Hard-code mapping in configuration method
- Use: If you need a mapping, but it is unlikely to change, ever

- **By-annotation**

- Definition: Use annotations to (incrementally) configure mapping
- Use: If your mapping is small and does not need to be centralized

- **By-configuration-file**

- Definition: Read mapping from configuration file
- Use: If you need to manage large and changing mappings

4. Instantiation of Concrete Class

- **In-code**

- Definition: Call constructor (new) directly
- Use: If there is no need for configuration

- **By-class-object**

- Definition: Represent each concrete class using its class object
- Use: If you don't need specialized initialization

- **By-prototype**

- Definition: Represent each concrete class using a prototype (object)
- Use: If you don't need specialized initialization and don't have class objects

- **By-function-object**

- Definition: Represent each concrete class using a function object
- Use: If you need specialized initialization or don't have class objects

5. Initialization of New Object

- **Default**

- Definition: Provide a fixed (default) field assignment in constructor
- Use: If there is no need for client-specific initialization (or it can be done later)

- **By-cloning**

- Definition: Provide a fixed field assignment by cloning a prototype
- Use: If there is no need for a client-specific initialization

- **By-fixed-signature**

- Definition: Provide a field assignment using a fixed method signature
- Use: If you can channel everything through a fixed method signature

- **By-key-value-pair list**

- Definition: Provide a field assignment using a variable argument list
- Use: If considerable variation is possible and needed in object initialization

- **In-second-step**

- Definition: Push back object initialization to client until after creation finished
- Use: If there is too much variation in the initialization arguments

6. Building of Object Structure

- **Default**

- Definition: Let the new object create any dependent object structure
- Use: If the client wants no say in creating any dependent objects

- **By-cloning**

- Definition: Create the desired object structure by cloning a prototype
- Use: If someone else needs to define the object structure for the client

- **By-building**

- Definition: Create the desired object structure by building it piece-by-piece
- Use: If the client needs to direct the building of a complex object structure

Design Patterns and Design Space

	Factory Method	Abstract Factory	Product Trader	Prototype	Builder
1. Delegation	• this-object	• separate-object	• separate-object	• separate-object	• separate-object
2. Selection	• by-subclassing	• all possible	• by-mapping	• by-subclassing	• all possible
3. Configuration	• N/A	• all possible	• all possible	• N/A	• all possible
4. Instantiation	• in-code	• in-code	• by-class-object • by-prototype • by-function-object	• by-prototype	• all possible
5. Initialization	• all possible	• all possible	• all possible	• all possible	• all possible
6. Building	• N/A	• default • by-cloning	• default • by-cloning	• default • by-cloning	• by-building

Green background indicates characteristic property
 Orange background indicates unnecessary constraint
 all possible = all options are valid options
 N/A = not applicable

Review / Summary of Session

- Object creation patterns
 - Several patterns, definitions, examples
 - Switch / case
 - Factory method
 - Abstract factory
 - Product trader
 - Prototype
 - Builder
 - Constituting a design space

Thanks! Questions?

dirk.riehle@fau.de – <http://osr.cs.fau.de>

dirk@riehle.org – <http://dirkriehle.com> – [@dirkriehle](#)

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- Contributions
 - ...

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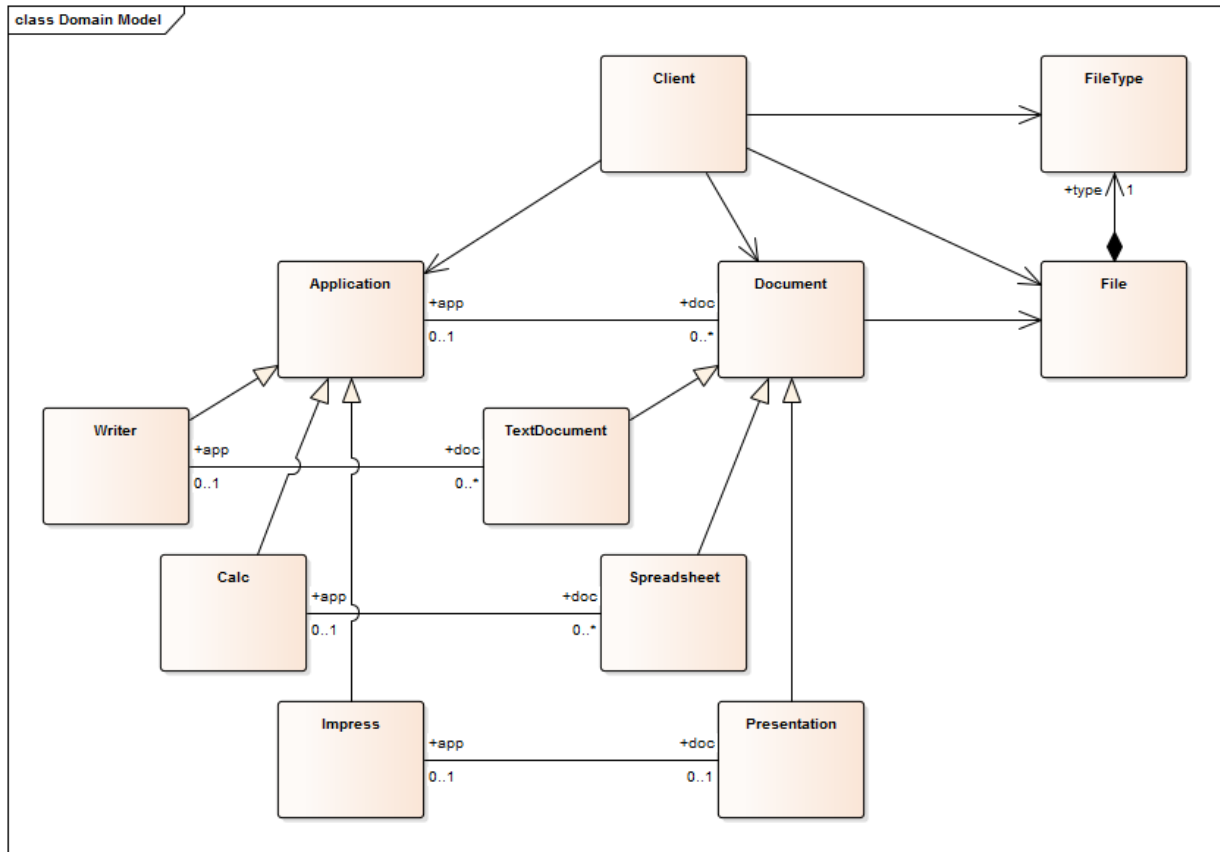
It is Friedrich-Alexander University Erlangen-Nürnberg – FAU, in short.
Corporate identity wants us to say “Friedrich-Alexander University”.

- 1. Switch / Case**
- 2. Factory Method**
- 3. (Abstract) Factory**
- 4. Product Trader**
- 5. Prototype**

Object Creation Example

- Create a document from its file type (extension)
- Create an application for the document

Application Document Model



Ease of

- 1. Reading code**
- 2. Understanding code**
- 3. Changing code**
- 4. Extending code**

Scenario 1: File-type → Document

- Client is run-time environment, e.g. desktop
- Wants to create document for given file

Switch / Case Applied

```
public class Client {  
  
    public Document createDocument(File file) {  
        String fileType = file.getFileType();  
        Document result = null;  
  
        if (fileType.equals("odt")) {  
            result = new TextDocument();  
        } else if (fileType.equals("ods")) {  
            result = new Spreadsheet();  
        } else if (fileType.equals("odp")) {  
            result = new Presentation();  
        }  
  
        ...  
        return result;  
    }  
  
    ...  
}
```

Switch / Case Evaluated

- Advantages
 - Easy to read
 - Easy to understand
 - Easy to change
- Disadvantages
 - Hard to extend
- Additional notes
 - May require use of initialization method

Scenario 2: Application → Document

- Client is run-time environment, e.g. desktop
- Wants to create document for given application

Factory Method Applied

```
public abstract class Application {  
    public abstract Document createDocument();  
    ...  
}
```

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

```
public class Calc extends Application {  
    public Document createDocument() { return new Spreadsheet(); }  
    ...  
}
```

```
public class Impress extends Application {  
    public Document createDocument() { return new Presentation(); }  
    ...  
}
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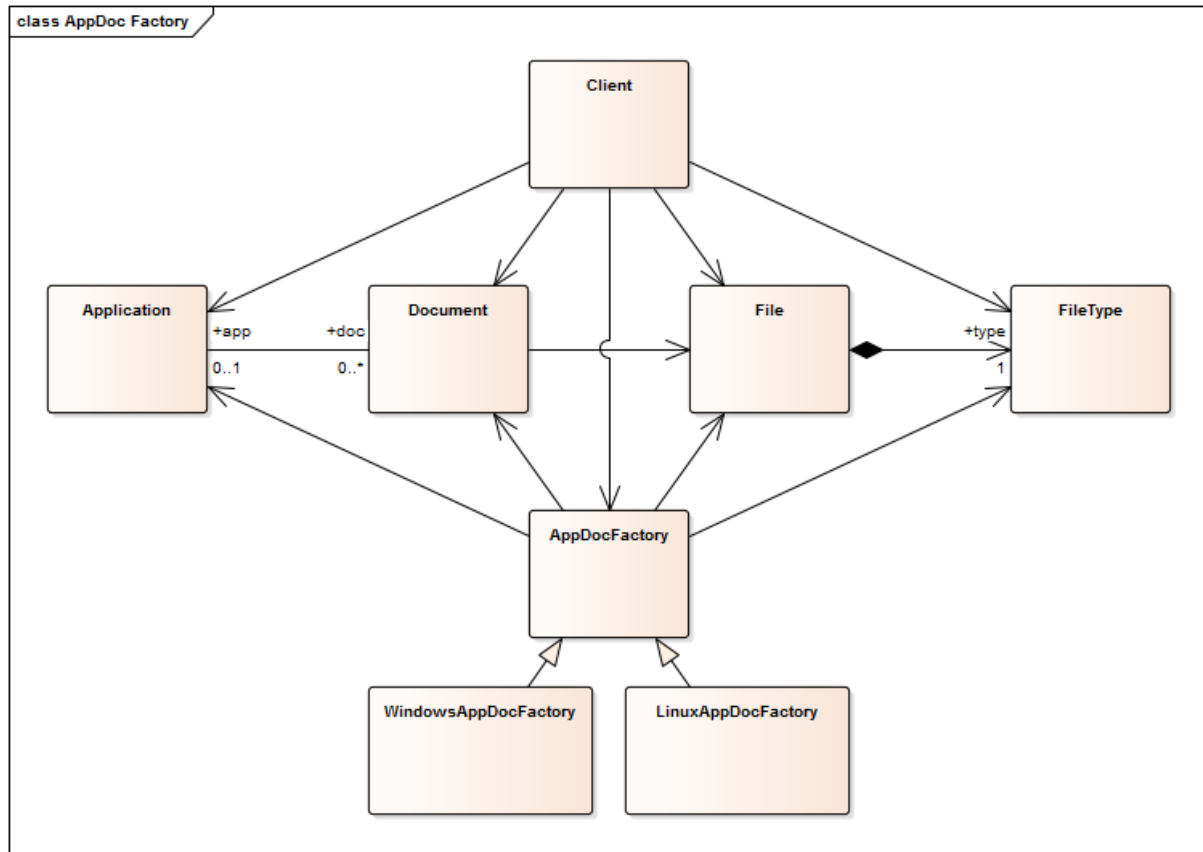
Factory Method Evaluated

- Advantages
 - Easy to change
 - Easy to extend
- Disadvantages
 - Creation code is not centralized any longer

Scenario 3: File-type → Document (v2)

- Client is run-time environment, e.g. desktop
- Wants to create document for given file
- Wants to add new Document types in one place

Application Document Factory



Abstract Factory Applied

```
public interface AppDocFactory {  
    public Application createFrom(Document doc);  
    public Document createFrom(File file);  
    ...  
}
```

```
public class DefaultAppDocFactory implements AppDocFactory {  
    ...  
  
    public Document createFrom(File file) {  
        String fileType = file.getFileType();  
        if (fileType.equals("odt")) {  
            result = new TextDocument();  
        } else if ...  
  
        return result;  
    }  
    ...  
}
```

Abstract Factory Evaluated

- Advantages
 - Easy to read
 - Easy to change
 - Easier to extend (than v1)
- Disadvantages
 - Harder to understand
- Additional notes
 - Factories are versatile, advantages and disadvantages depend on further choices like how to implement the creation methods

Scenario 4: Document → Application

- Client is run-time environment, e.g. desktop
- Wants to create application for given document
- Wants to add new Application types in one place

Product Trader Applied 1 / 2

```
public interface AppDocFactory {  
    public void registerApplicationClass(Class dc, Class ac);  
    public Application createFrom(Document doc);  
    ...  
}
```

```
public class DefaultAppDocFactory implements AppDocFactory {  
  
    Map<Class, Class> appClasses = new HashMap<Class, Class>();  
    static {  
        appClasses.put(TextDocument.class, Writer.class);  
        appClasses.put(Spreadsheet.class, Calc.class);  
        appClasses.put(Presentation.class, Impress.class);  
    }  
  
    ...  
}
```

Product Trader Applied 2 / 2

```
public class DefaultAppDocFactory implements AppDocFactory {

    Map<Class, Class> appClasses = new HashMap<Class, Class>();
    public void registerApplicationClass(Class dc, Class ac) {
        assert (dc != null) && (ac != null);
        appClasses.put(dc, ac);
    }

    public Application createFrom(Document doc) {
        Class appClass = appClasses.get(doc.getClass());
        assert appClass != null;
        return createInstance(appClass);
    }

    protected Application createInstance(Class ac) {
        ...
    }

    ...
}
```

Product Trader Evaluated

- Advantages
 - Easy to read
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 - Easy to extend
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 - Hard to understand
 - Hard to debug
- Additional notes
 - Product Trader delays everything until runtime
 - May be viewed as just a complex (abstract) factory

Scenario 5: File-type → Document (v3)

- Client is run-time environment, e.g. desktop
- Wants to create document for given file type
- Wants to add new Document types in one place
- Wants to initialize complex but default document

Prototype Applied 1 / 2

```
public interface AppDocFactory {  
    public void registerDocumentPrototype(FileType ft, Document doc);  
    public Document createFrom(FileType ft);  
    ...  
}
```

Prototype Applied 2 / 2

```
public class DefaultAppDocFactory implements AppDocFactory {

    Map<String, Document> docProtos = new HashMap<String, Document>();
    public void registerDocumentPrototype(FileType ft, Document doc) {
        assert (ft != null) && (doc != null);
        docProtos.put(ft, doc);
    }

    public Document createFrom(FileType ft) {
        Document prototype = docProtos.get(ft);
        assert (prototype != null) && (prototype.isCloneable());
        return prototype.clone();
    }

    ...
}
```

Prototype Evaluated

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 - Easy to read
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- Many design patterns address multiple issues at once, e.g.
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 - Configuration (of class mapping)
 - Instantiation (of concrete class)
 - Initialization (of new object)
 - Building (of object structure)

1. **Delegation** of object creation
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5. **Initialization** of new object
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1. Delegation of Object Creation

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2. Selection of Concrete Class

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- Use: If you need to manage large and changing mappings

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- **In-code**
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 - Definition: Represent each concrete class using its class object
 - Use: If you don't need specialized initialization
- **By-prototype**
 - Definition: Represent each concrete class using a prototype (object)
 - Use: If you don't need specialized initialization and don't have class objects
- **By-function-object**
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5. Initialization of New Object

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3. Configuration	• N/A	• all possible	• all possible	• N/A	• all possible
4. Instantiation	• in-code	• in-code	• by-class-object • by-prototype • by-function-object	• by-prototype	• all possible
5. Initialization	• all possible	• all possible	• all possible	• all possible	• all possible
6. Building	• N/A	• default • by-cloning	• default • by-cloning	• default • by-cloning	• by-building

Green background indicates characteristic property
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dirk.riehle@fau.de – <http://osr.cs.fau.de>

dirk@riehle.org – <http://dirkriehle.com> – [@dirkriehle](#)

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