Course "Softwaretechnik"

Design: Reuse and Patterns II

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- Design pattern categories
- Proxy
- Command
- Observer
- Strategy
- Abstract Factory
- Builder

Wo sind wir?: Taxonomie "Die Welt der Softwaretechnik"

Welt der Problemstellungen:

- Produkt (Komplexitätsprob.)
  - Anforderungen (Problemraum)
  - **Entwurf (Lösungsraum)**
- Prozess (psycho-soziale P.)
  - Kognitive Beschränkungen
  - Mängel der Urteilskraft
  - Kommunikation, Koordination
  - Gruppendynamik
  - Verborgene Ziele
  - Fehler

Welt der Lösungsansätze:

- Technische Ansätze ("hart")
  - **Abstraktion**
  - **Wiederverwendung**
  - Automatisierung
- Methodische Ansätze ("weich")
  - Anforderungsermittlung
  - **Entwurf**
  - Qualitätssicherung
  - Projektmanagement

Wo sind wir?: Entwurf

- Einsicht: Man sollte *vor* dem Kodieren über eine günstige Struktur der Software nachdenken
  - und diese als Koordinationsgrundlage schriftlich festhalten

- Prinzipien:
  - **Trennung von Belangen**
  - **Architektur**: Globale Struktur festlegen (Grobentwurf), insbes. für das Erreichen der nichtfunktionalen Anforderungen
  - **Modularisierung**: Trennung von Belangen durch Modularisierung, Kombination der Teile durch Schnittstellen (information hiding, Lokalität)
  - ***Wiederverwendung***: Erfinde Architekturen und Entwurfsmuster nicht immer wieder neu
  - **Dokumentation**: Halte sowohl Schnittstellen als auch zu Grunde liegende Entwurfsentscheidungen und deren Begründungen fest

Outline of the lecture

- Review of design pattern concepts
  - What is a design pattern?
  - Modifiable designs
- Categories of design patterns
- More patterns:
  - Abstract Factory: Provide manufacturer independence
  - Builder: Hide a complex creation process
  - Proxy: Provide transparency
  - Command: Encapsulate control flow
  - Observer: Provide publisher/subscribe mechanism
  - Strategy: Support family of algorithms,
    separate policy from mechanism

Review: design pattern

A design pattern is...

- ...a template solution to a recurring design problem
  - Consider them before re-inventing the wheel
- ...reusable design knowledge
  - Higher level than classes or common data structures
  - Lower level than application frameworks
- ...an example of good design
  - Learning to design starts by studying other designs
- ...generalized from existing systems
  - i.e., realistic (rather than armchair philosophy)
- ...powerful shared vocabulary for designers

The patterns we consider here focus on modifiable designs

Modifiable designs

A modifiable design enables...

- ...an iterative and incremental development cycle
  - concurrent development
  - risk management
  - flexibility to change
- ...to minimize the introduction of new problems when fixing old ones
- ...to deliver more functionality after initial delivery

What makes a design modifiable?

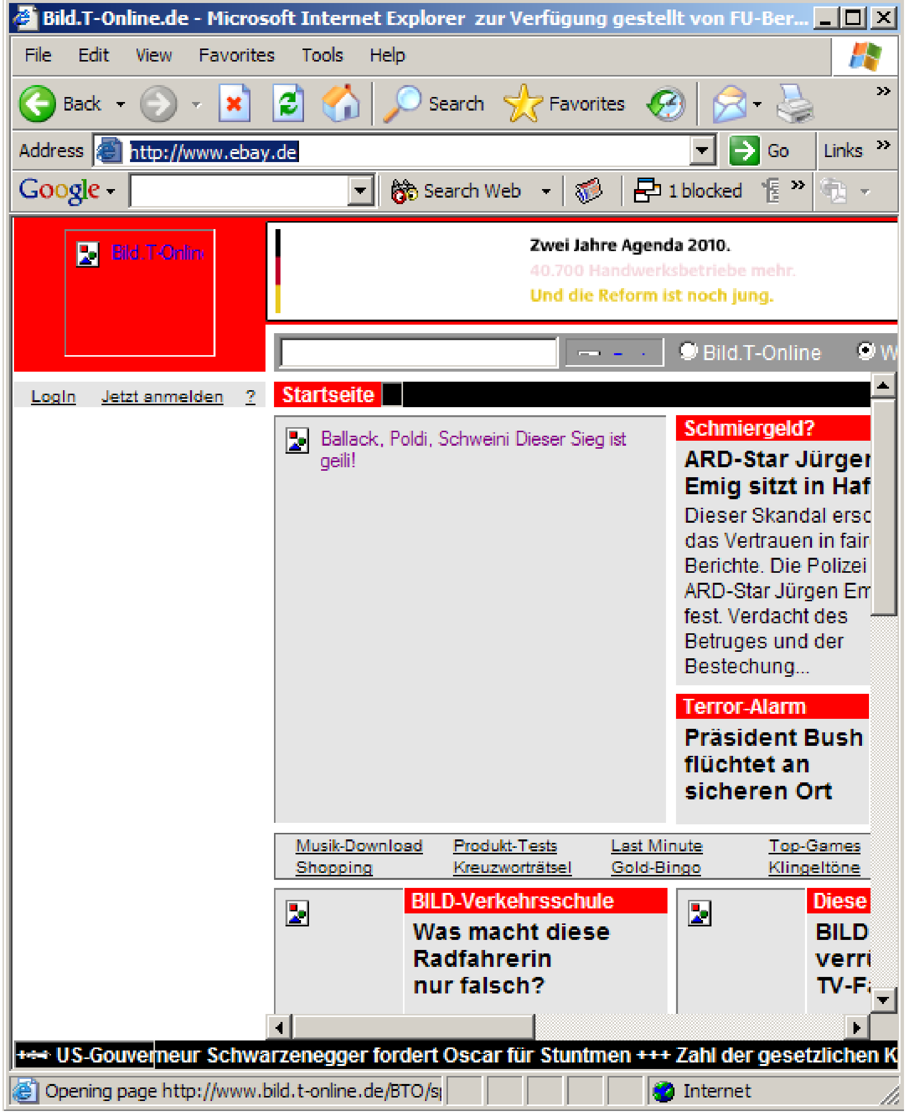
- Encapsulated design decisions
  - Clear dependencies
  - Explicit assumptions
- Reduced coupling

On to more patterns!

Structural Pattern	(Strukturmuster)
Composite, Adapter, Bridge, and Façade all also belong into this category	
Proxy	Stellvertreter
Creational Patterns	(Erzeugungsmuster)
Abstract Factory	Abstrakte Fabrik
Builder	Erbauer
Behavioral Patterns	(Verhaltensmuster)
Command	Kommando
Observer	Beobachter
Strategy	Strategie

Proxy Pattern: motivation

- I want to access an image-intensive webpage
  - slooowww mobile connection
- Can my browser help?
- Solution ideas:
  1. Display only image placeholders.
     Retrieve images one-by-one only upon click
  2. Cache images



Zwei Jahre Agenda 2010.
40.700 Handwerksbetriebe mehr.
Und die Reform ist noch jung.

Ballack, Poldi, Schweini Dieser Sieg ist geili!

Schmiergeld?
ARD-Star Jürger Emig sitzt in Haf
Dieser Skandal ersc das Vertrauen in fair Berichte. Die Polizei ARD-Star Jürgen Em fest. Verdacht des Betruges und der Bestechung...

Terror-Alarm
Präsident Bush flüchtet an sicheren Ort

BILD-Verkehrsschule
Was macht diese Radfahrerin nur falsch?

Diese
BILD verri TV-F

+++ US-Gouverneur Schwarzenegger fordert Oscar für Stuntmen +++ Zahl der gesetzlichen K

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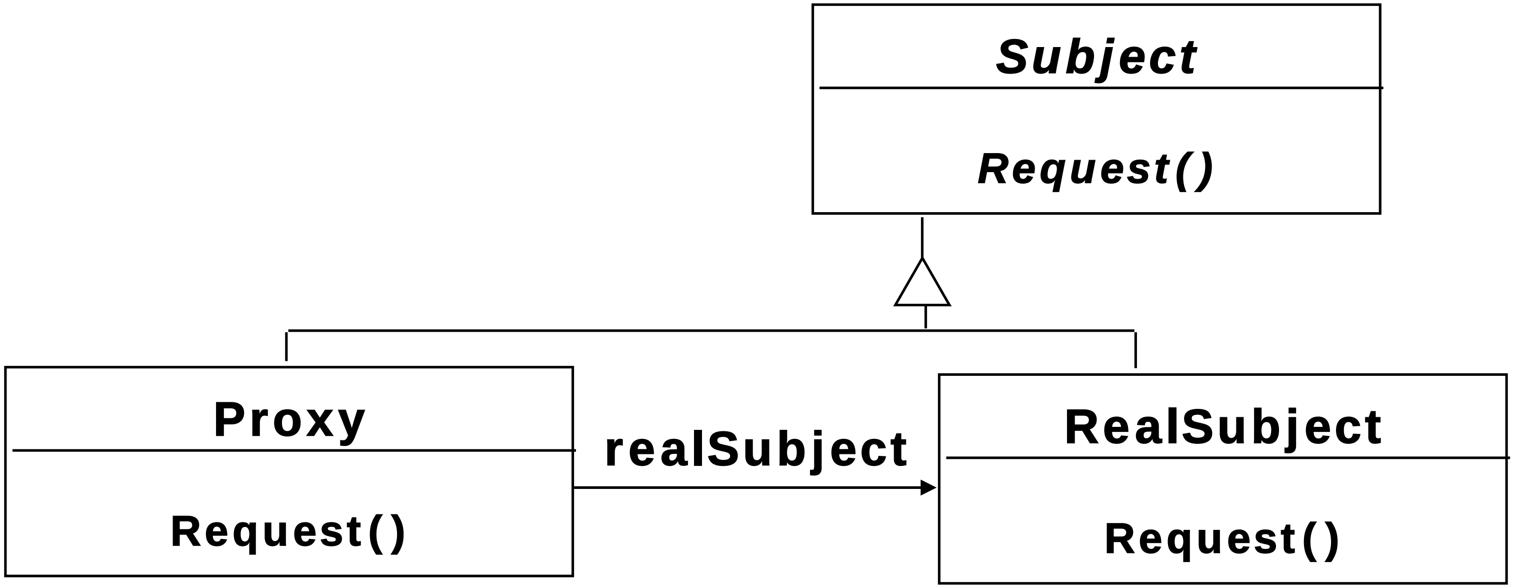
Proxy Pattern (Stellvertreter)

Also known as *Surrogate*

- Problem:
  I need access to a certain object but I cannot (or do not want to) access it directly
- Solution idea:
  Provide a replacement object (with the same interface as the original object) that performs the access for me
- http://c2.com/cgi/wiki?ProxyPattern

Proxy Pattern

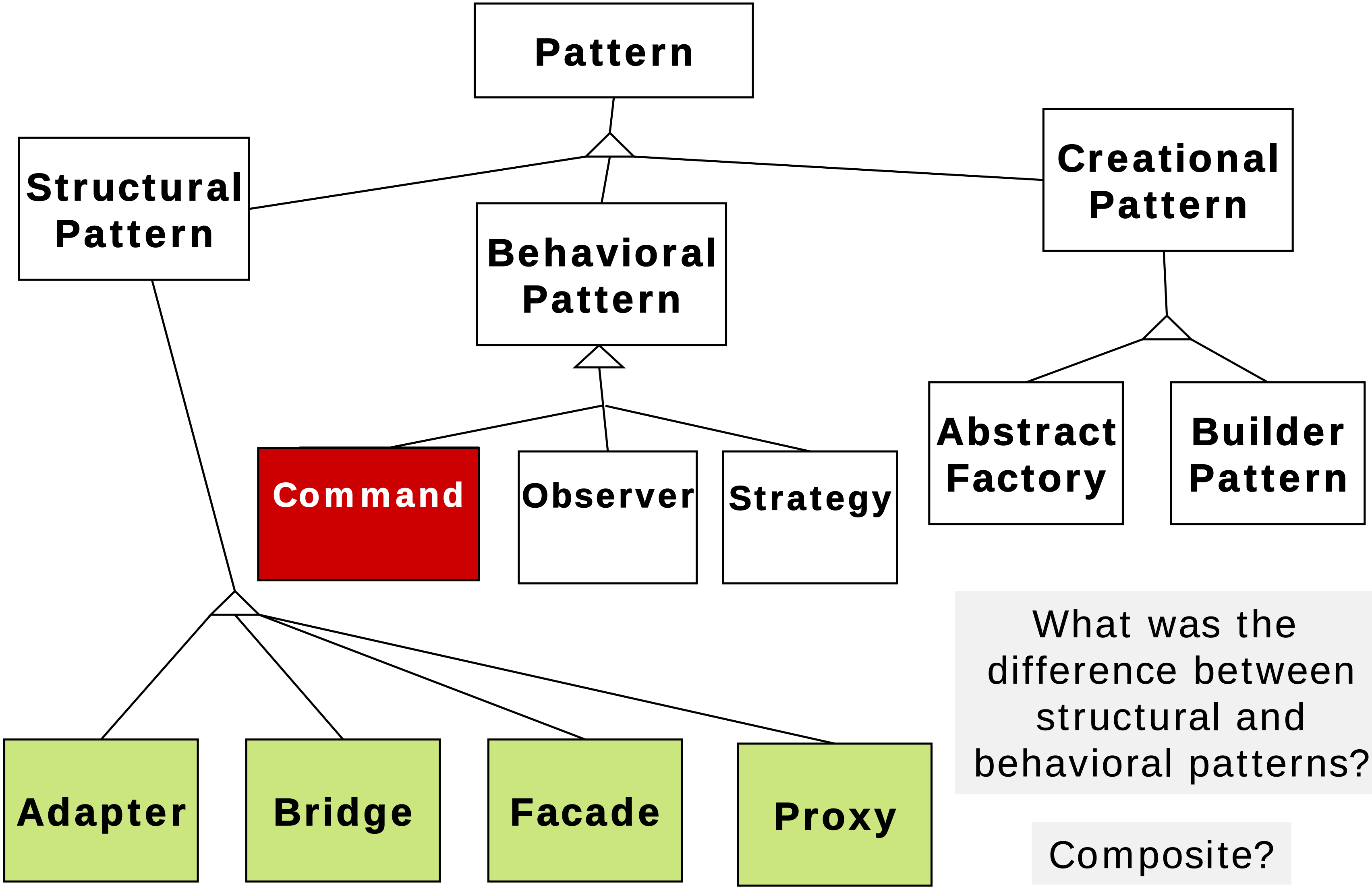


- Interface inheritance is used to specify the interface shared by Proxy and RealSubject
- Delegation is used to catch and forward any accesses to the RealSubject (if and when desired)
  - Client accesses Proxy only
- Proxy patterns can be implemented with a Java interface

Proxy applications

- Remote Proxy: Local representative for a remote object
  - Provides location transparency
    - Client need not know where the object lives
  - Provides access transparency
    - Client need not know the access mechanisms
  - May provide caching of information
- Decorator: Invisibly add some functionality
  - e.g. add a scrollbar to a text pane so it can fit in less space
- Virtual Proxy: Stand-in object
  - When creating the object is expensive
- Protection Proxy: Access control object
  - Proxy object encapsulates the access rules
  - Different proxies can be used for different clients

A pattern taxonomy



What was the difference between structural and behavioral patterns?

Composite?

Pattern taxonomy

- Structural Patterns ("Strukturmuster")
  - Composite, Adapter, Bridge, Facade, and Proxy are variations on a single theme:
    - They reduce the coupling between two or more classes
    - They introduce abstract classes to enable future extensions
    - They encapsulate complex structures
- Behavioral Patterns ("Verhaltensmuster")
  - Here we are concerned with algorithms and the assignment of responsibilies between objects: Who does what?
  - Behavioral patterns allow us to characterize complex control flows that are difficult to follow at runtime
- Creational Patterns ("Erzeugungsmuster")
  - Here we our goal is to provide an abstraction for a (possibly complex) instantiation process
  - We want to make the system independent from the way its objects are created, composed, and represented

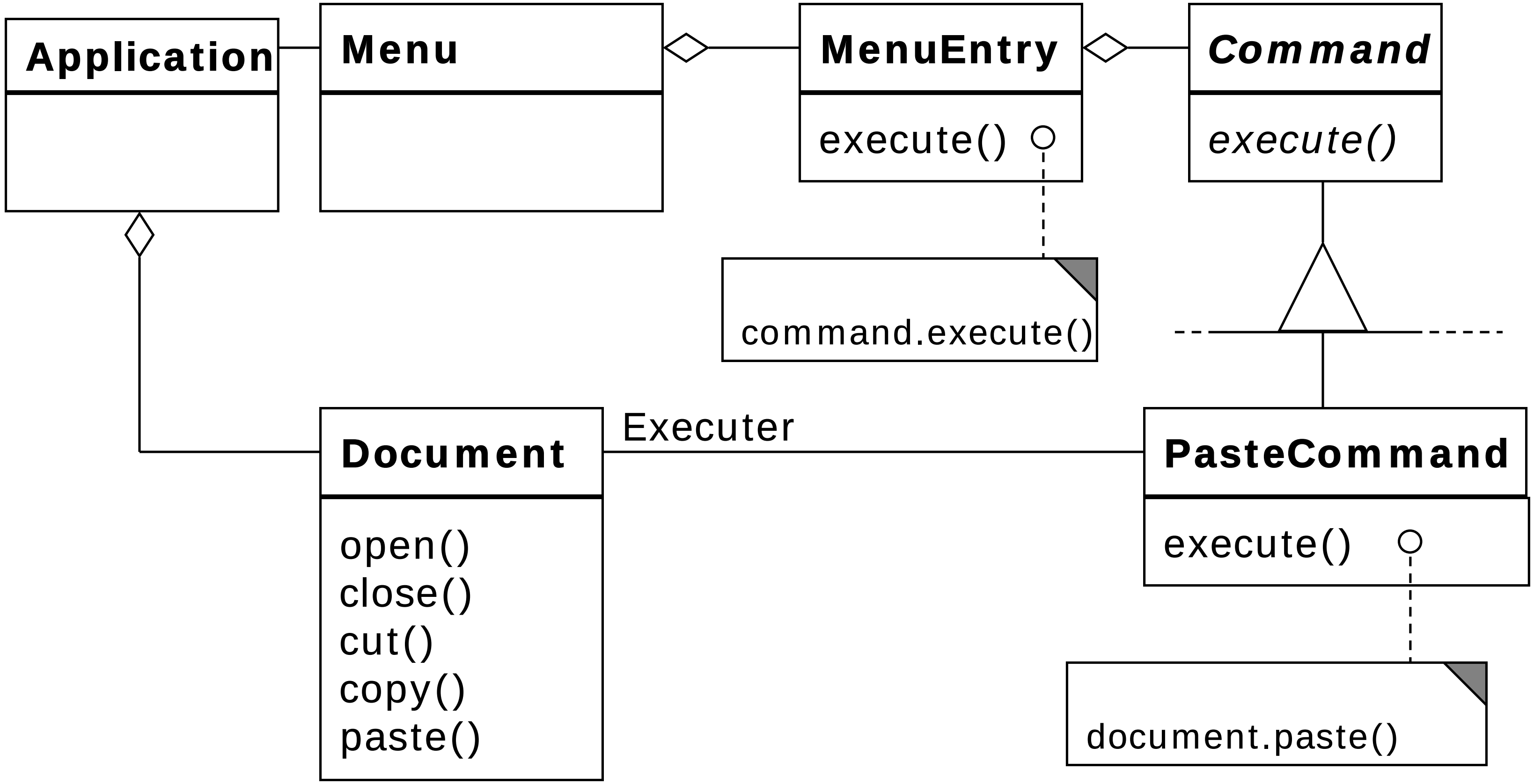
Command Pattern: motivation

- You want to build a user interface
  - including menus

- You want to make the user interface reusable across many applications and reconfigurable within each
  - You cannot hard-code the meanings of the menus for the various applications
    - A Menu object should be just a container for MenuEntry objects
  - So the operation called by the application when a menu entry is selected must be the same for any MenuEntry

- Such a menu can be implemented with the Command Pattern
  - MenuEntries are (or contain) Command objects

Command example: menu entries



Command Pattern (Kommando)

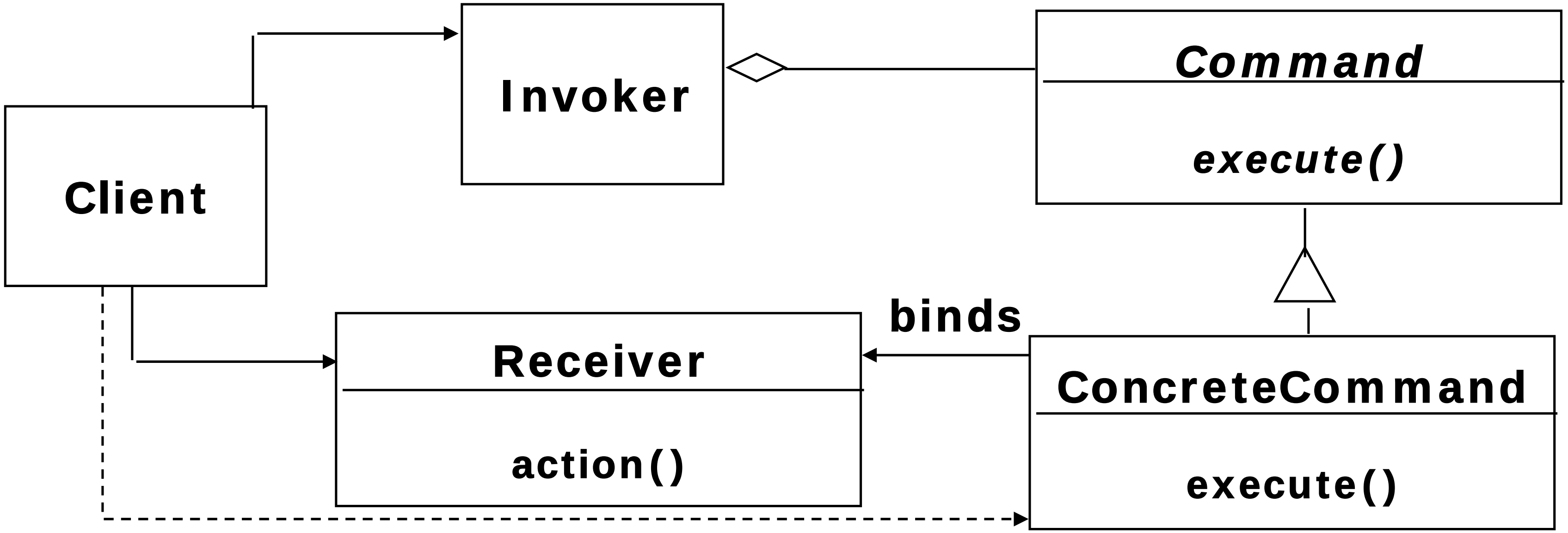
Also known as *Action* or *Transaction*

- Problem: We need to handle actions just like data
  - move them around, store them, copy them, pass them as parameters, etc.

- Solution idea: Package different actions into objects with a fixed interface

  so you can:
  - parameterize clients with different requests,
  - queue requests,
  - log requests,
  - support undoable operations
    - Upon 'execute', the command object stores all information required for the 'undo' operation, e.g. the data deleted by the 'execute'
  - collect and combine requests.

Command Pattern



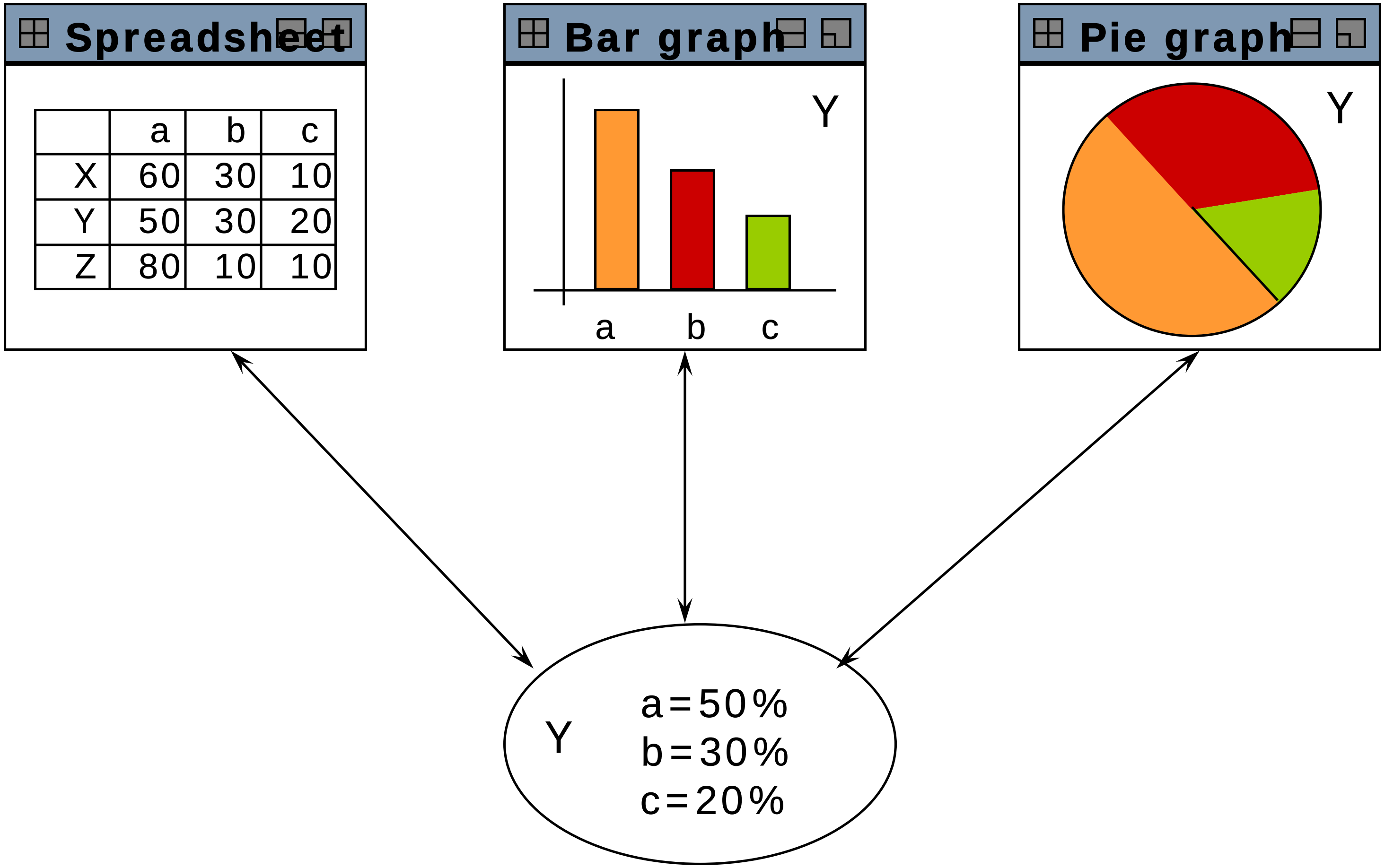
- Client creates a ConcreteCommand and binds it with a Receiver
- Client hands the ConcreteCommand over to the Invoker which stores it
- The Invoker has the responsibility to perform the command ("execute" or "undo")

Observer Pattern (Beobachter)

Also known as *Publish/Subscribe* or *Listener* pattern

- Problem:
  Whenever one particular object changes state,
  several dependent objects must be modified
  - The number and identity of the dependent objects is not known statically
- Solution idea:
  All dependents provide the same notification interface and register with the state object
  - All state objects (called *subjects*) provide the same registration interface

Observer Pattern example



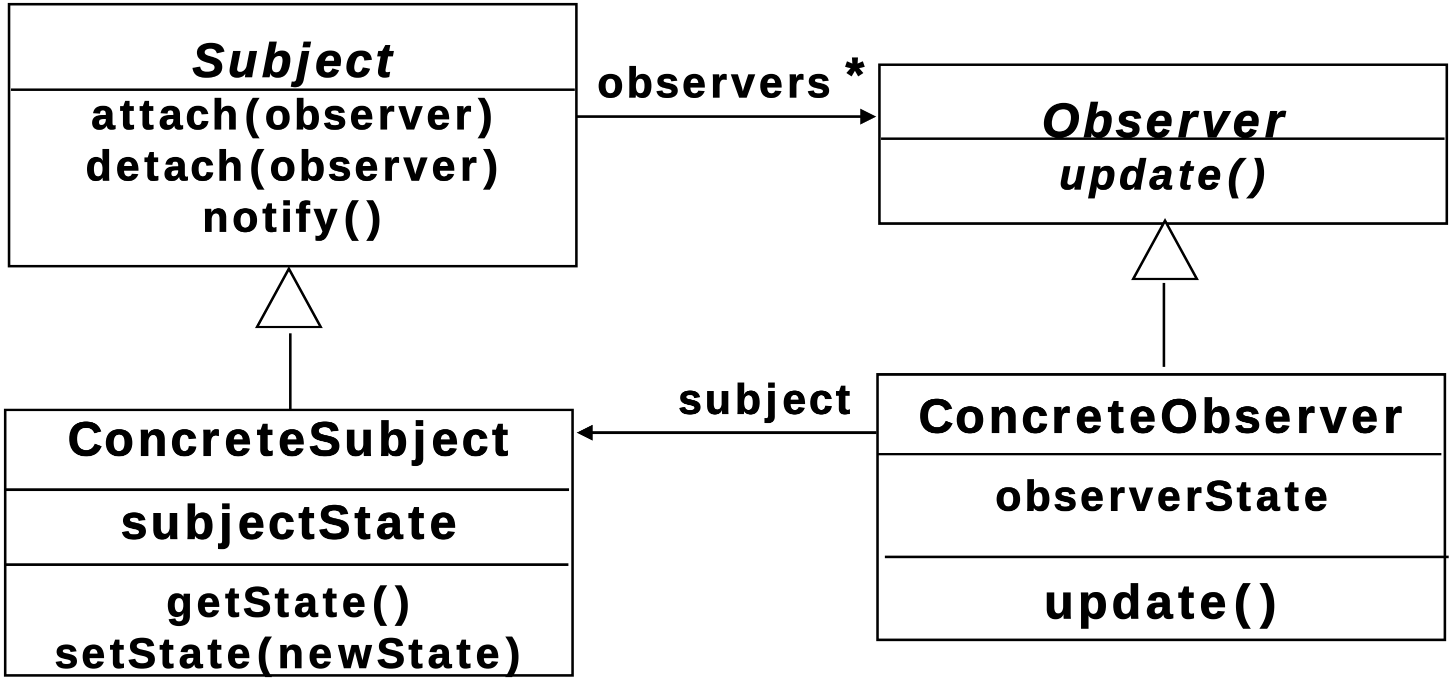
	a	b	c
X	60	30	10
Y	50	30	20
Z	80	10	10

Y

a=50%
b=30%
c=20%

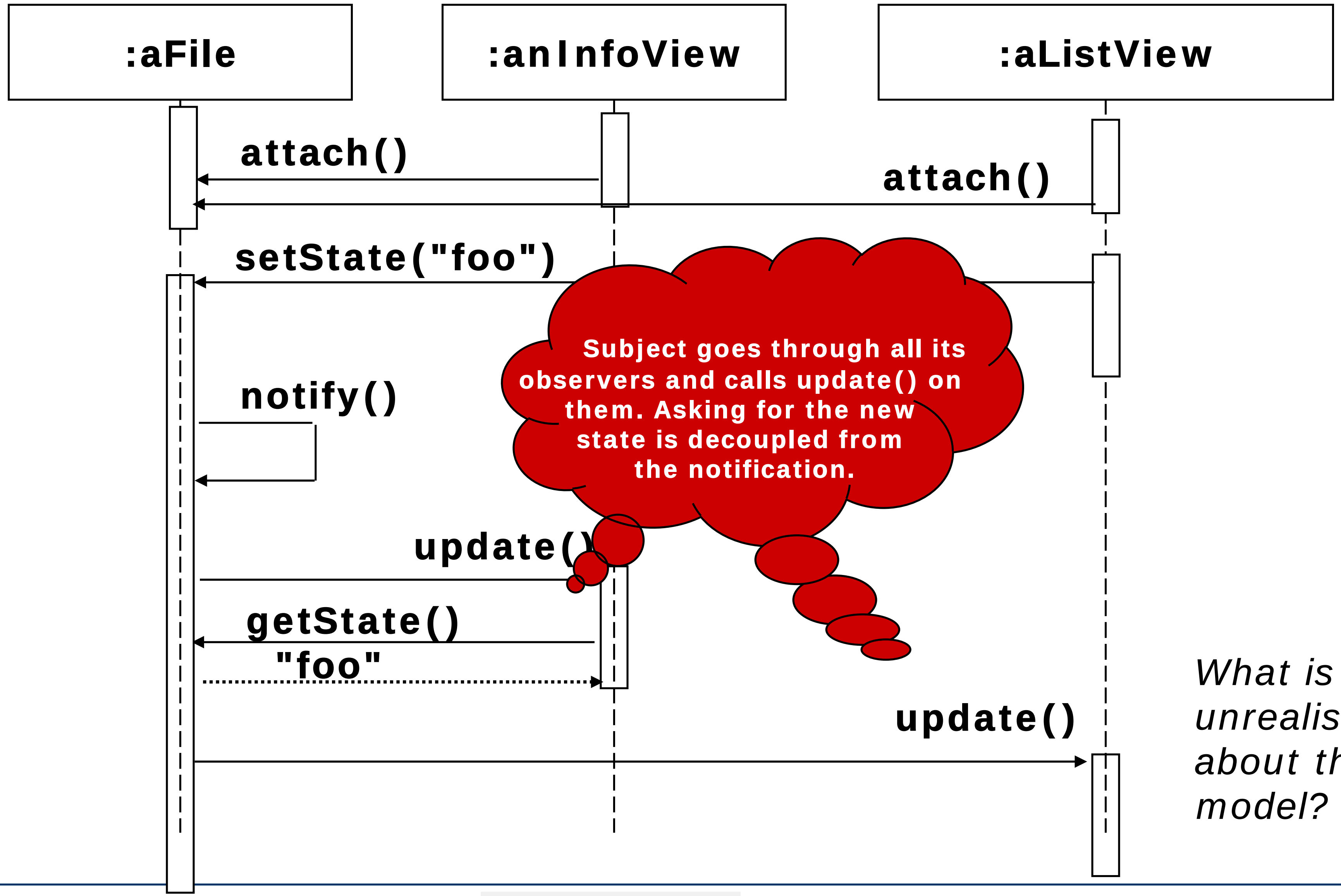
State object

Observer Pattern (continued)



- The *Subject* represents the actual state, *Observers* show views of the state or react to state changes
- *Observer* can be implemented as a Java interface
- *Subject* is an abstract class, not usually an interface
  - needs to manage the list of Observers and perform notification

Sequence diagram for scenario: change filename to "foo"



Subject goes through all its observers and calls update() on them. Asking for the new state is decoupled from the notification.

What is unrealistic about this model?

Observer Pattern implementation in Java

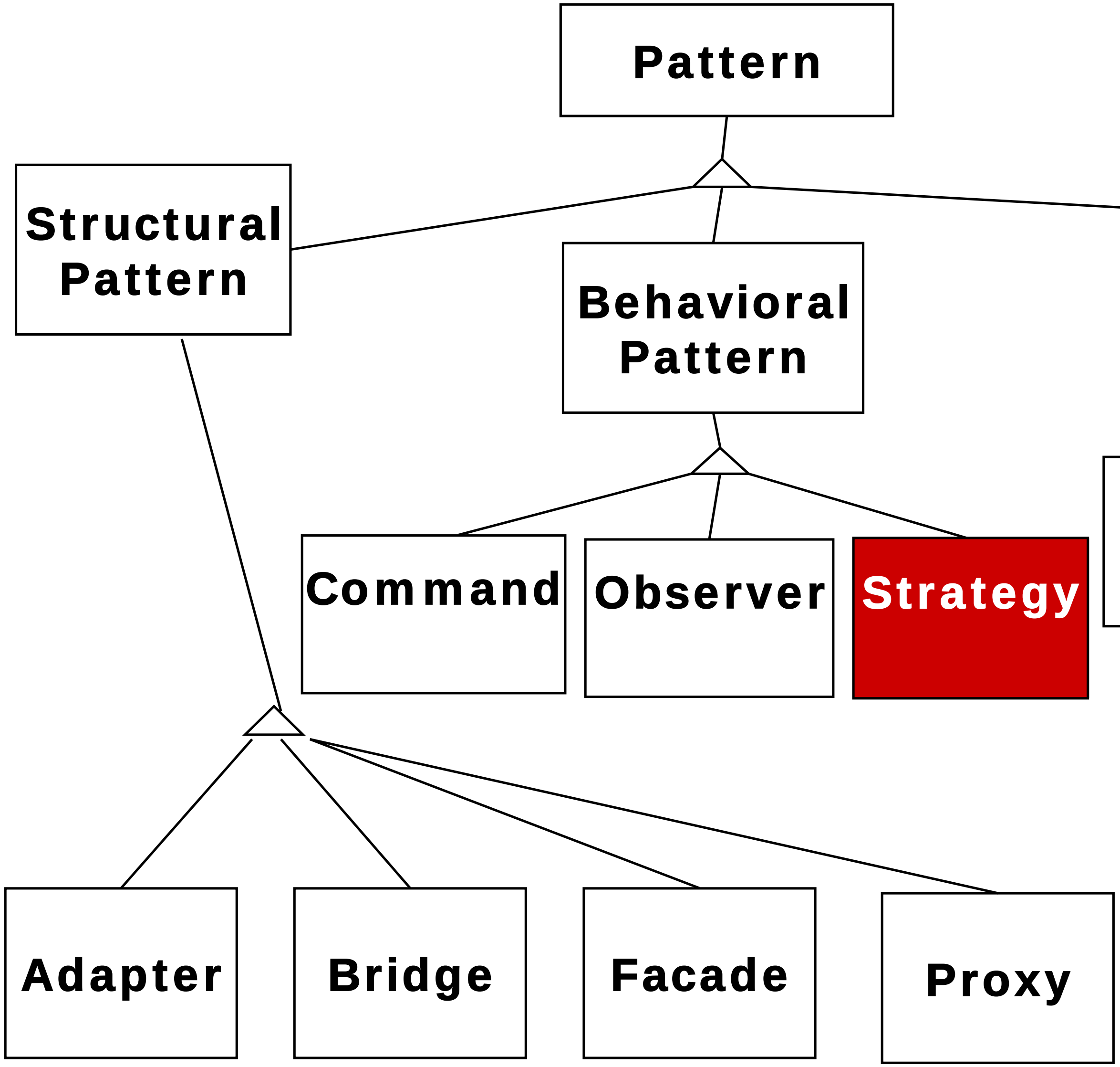
```
package java.util;
public class Observable<T> {  // subject superclass
   public void     addObserver(Observer<T> o) {…}
   public void     deleteObserver(Observer<T> o) {…}
   public boolean  hasChanged() {…}
   public void     setChanged() {…}
   public void     notifyObservers() {…}
   public void     notifyObservers(T arg) {…}
}
public interface Observer<T> { // observer interface
   public void     update(Observable<T> o, T arg);
}
```

Observers are similar to the Event Channel architectural style.
Event Channels allow registering for certain *types of* events.
Observers could do so, too.
Advantage? Disadvantage?

Observer Pattern example

```
package mypackage; // a subject
public class File extends Observable<String> {
  …
  public void setFilename(String filename) {
    …
    if (!this.filename.equals(filename)){
      …
      setChanged();
    }
    …
    notifyObservers(filename);
  }
  public String getFilename() {…}
}
```

A pattern taxonomy

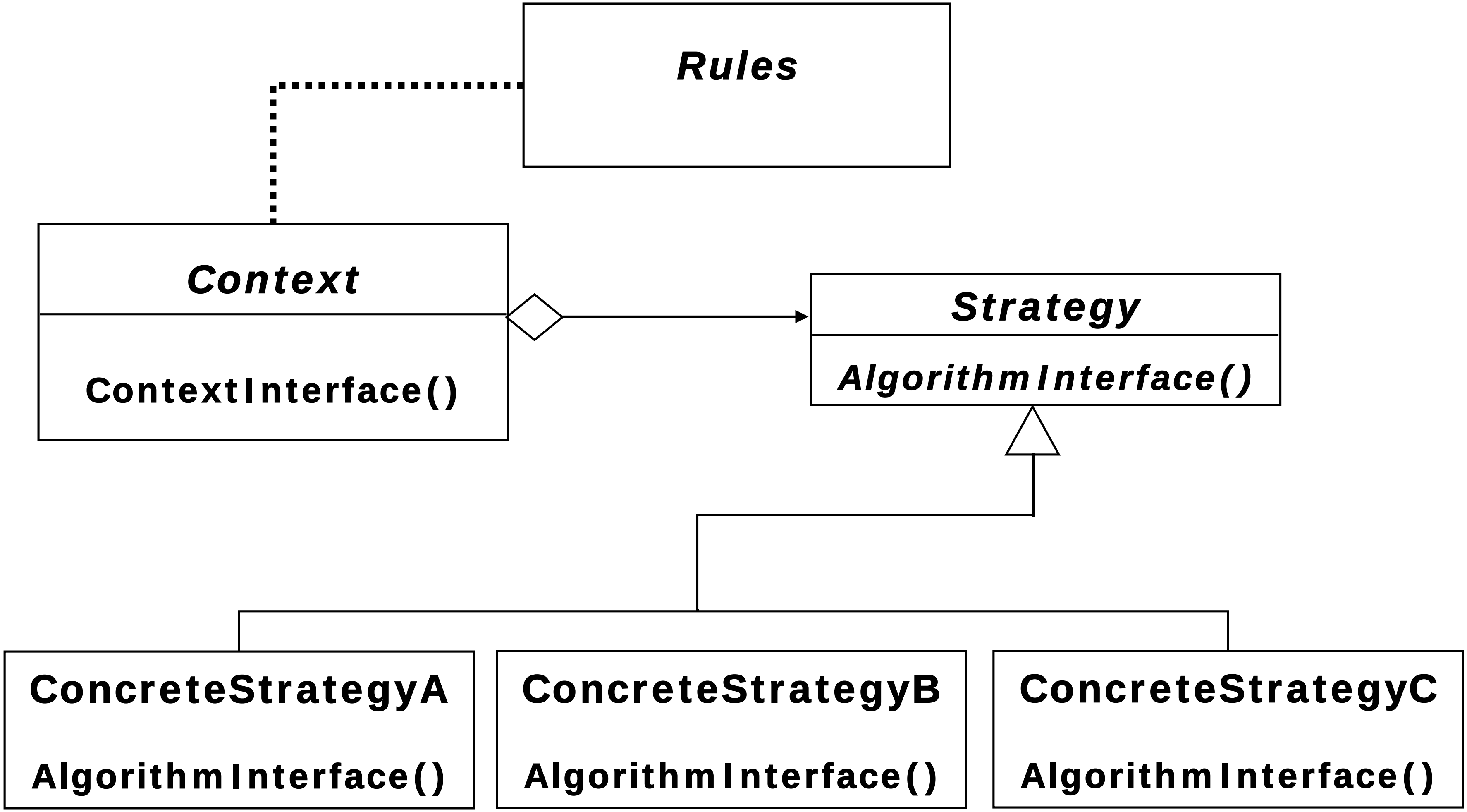


Strategy Pattern (Strategie)

Also known as *Policy* pattern

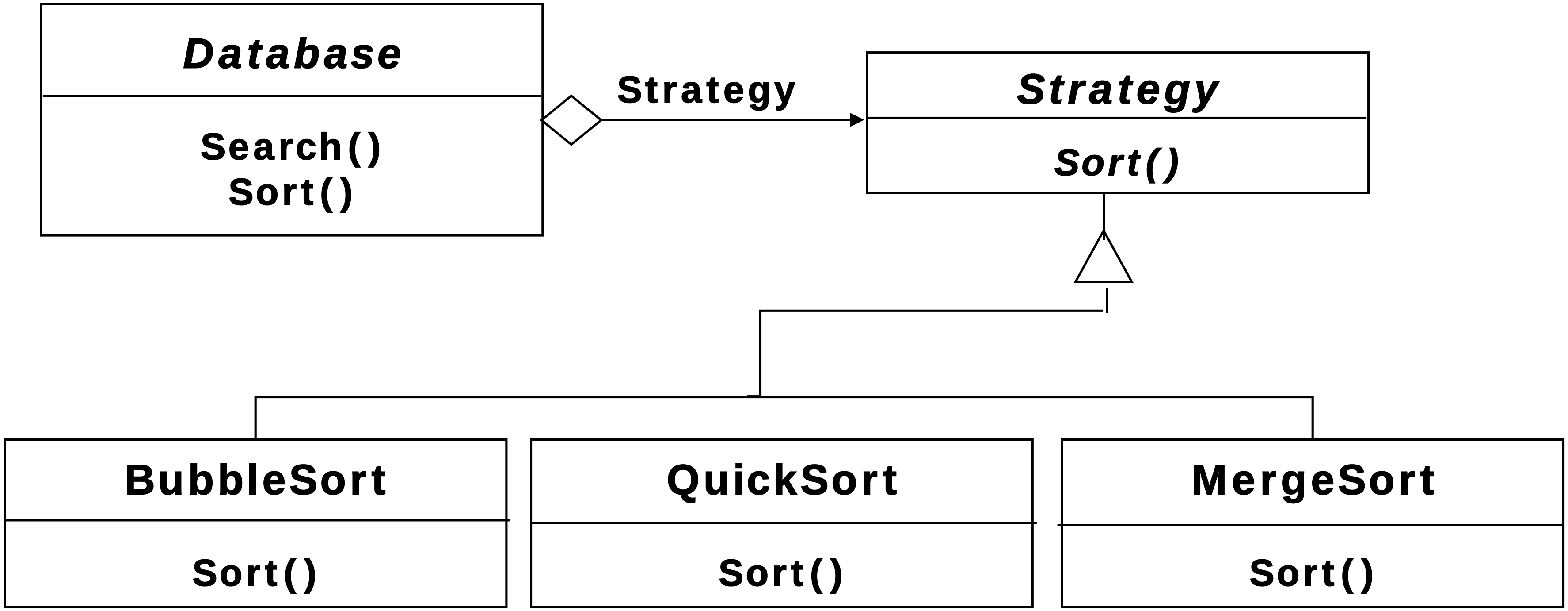
- Problem:
  There are multiple ways of doing something.
  We want to add, use, and exchange them freely (perhaps even dynamically), depending on context:
  - Different algorithms for identical results (e.g. sorting)
  - Different variants of equivalent results (e.g. codecs, file formats)
  - Different purposes (e.g. access control policies)
- Solution idea:
  Dynamically associate an object whose interface is the same for all variants.

Strategy Pattern

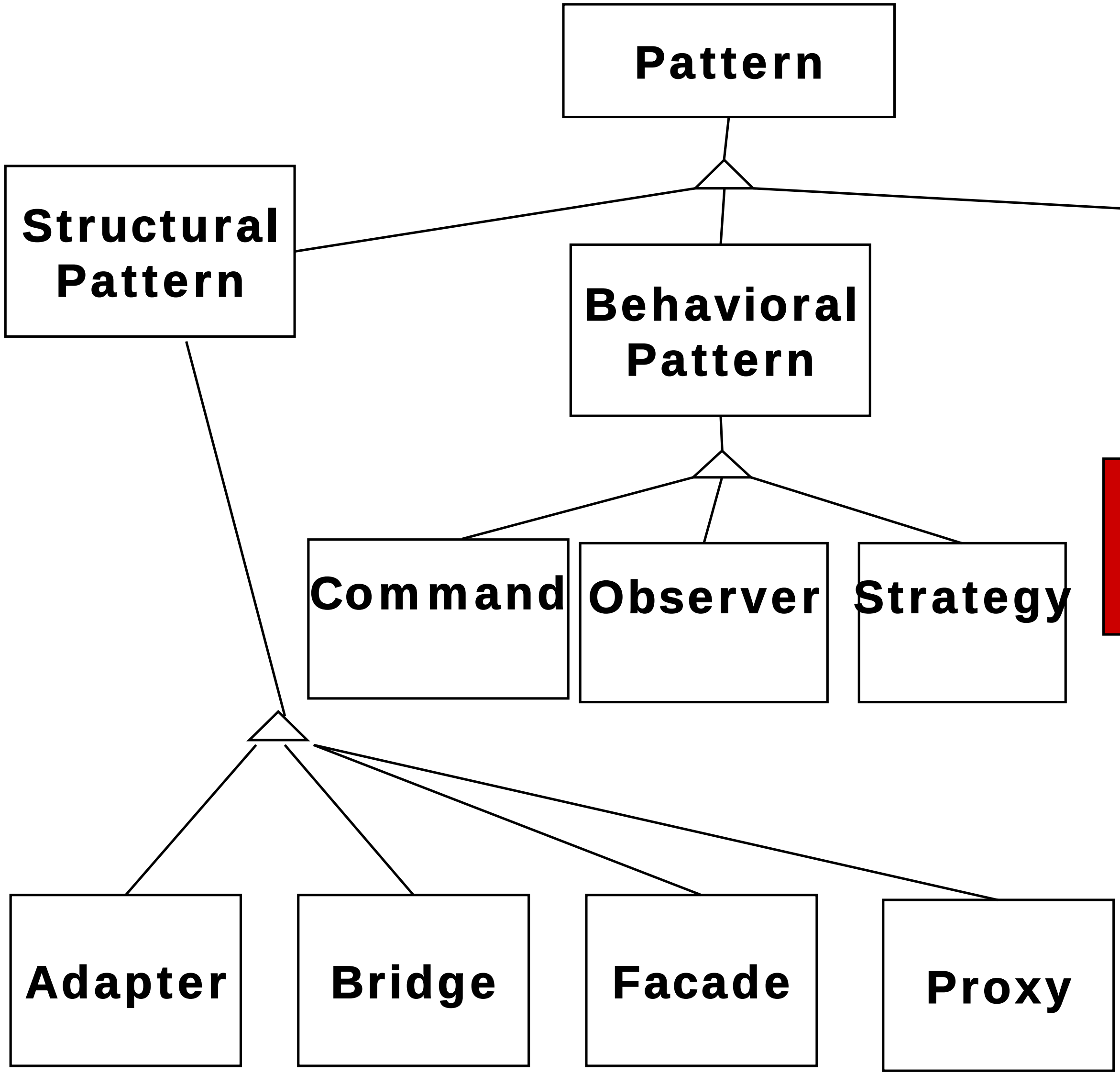


Rules may decide which Strategy is best in the current Context

Applying a Strategy Pattern in a database application



A pattern taxonomy



Abstract Factory: motivation

Examples:

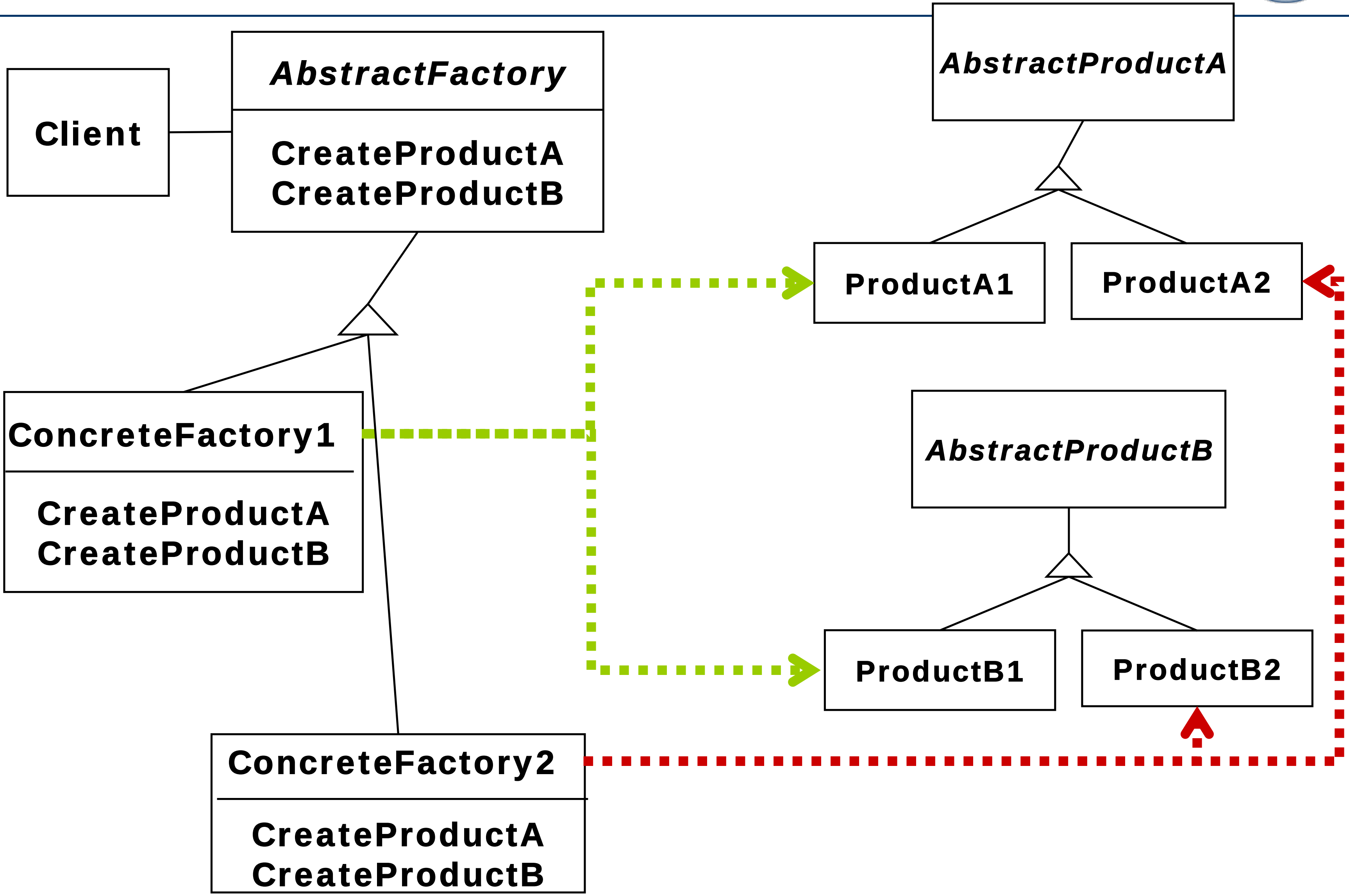
- Consider a user interface toolkit that supports multiple Look-and-Feel standards such as KDE, Windows or Mac OS X
  - How can you write a single user interface and make it portable across the different window managers? ➔ Bridge Pattern
  - When using the Bridge pattern, how do we switch between implementations?

Abstract Factory Pattern

Also known as *Kit* pattern

- Problem:
  - We create many objects from a family of related classes
  - There are several implementation variants of that family
  - But for any one program run, all objects created must be from the same family variant
  - We want to create objects without caring which family variant is currently active
- Solution idea:
  - For each family *member*, all variants share the same interface
  - We create objects by calling a factory method, not a constructor
  - The factory methods are grouped in a factory class
  - There is an abstract interface for the factory class
  - and one implementation of the factory class per family variant
- Note how complex this description is!

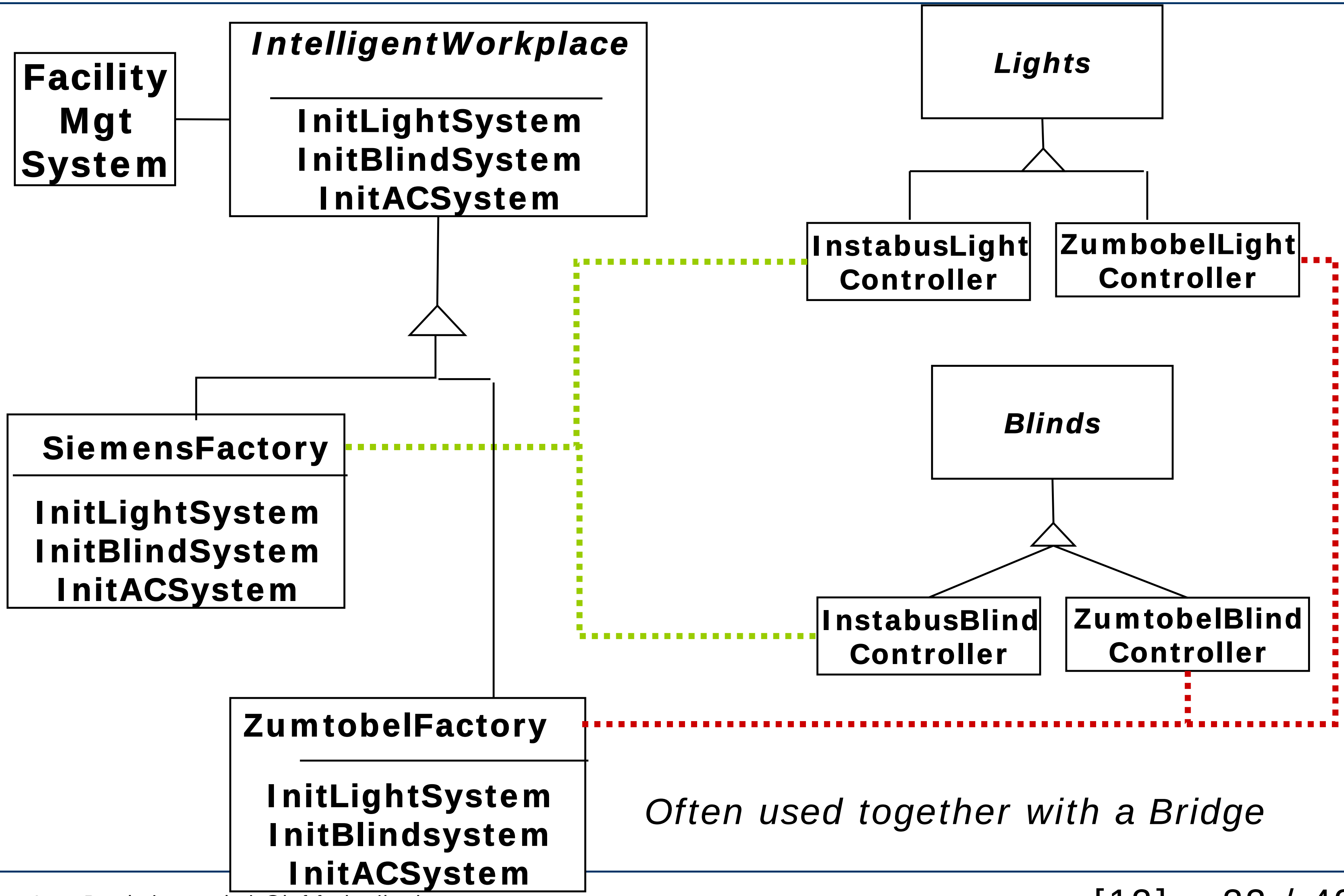
Abstract Factory



Applicability for Abstract Factory Pattern

- Manufacturer Independence:
  - A system should be configured with one family of products, where one has a choice from many different families
  - You want to provide a class library for a customer ("facility management library"), but you don't want to reveal what particular product you are using
    - Used in many places in the Java API for instance with XML libs
- Constraints on related products
  - A family of related products is designed to be used together and you need to enforce this constraint
- Independence from Initialization or Representation:
  - The system should be independent of how its products are created, composed or represented
- Cope with upcoming change:
  - You use one particular product family, but you expect that the underlying technology will change soon

Example: A Facility Management System for the Intelligent Workplace



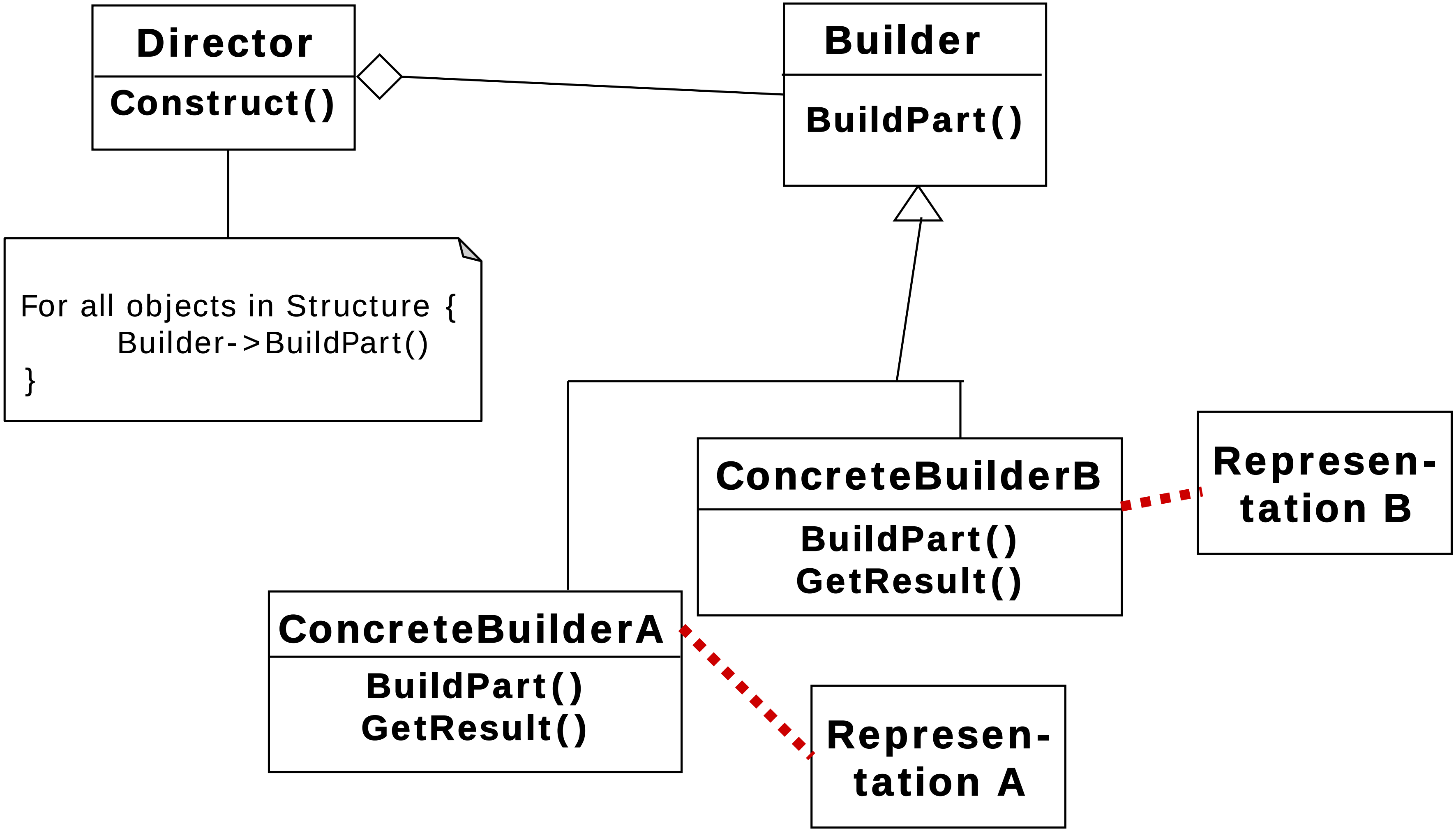
Often used together with a Bridge

Builder Pattern: Motivation

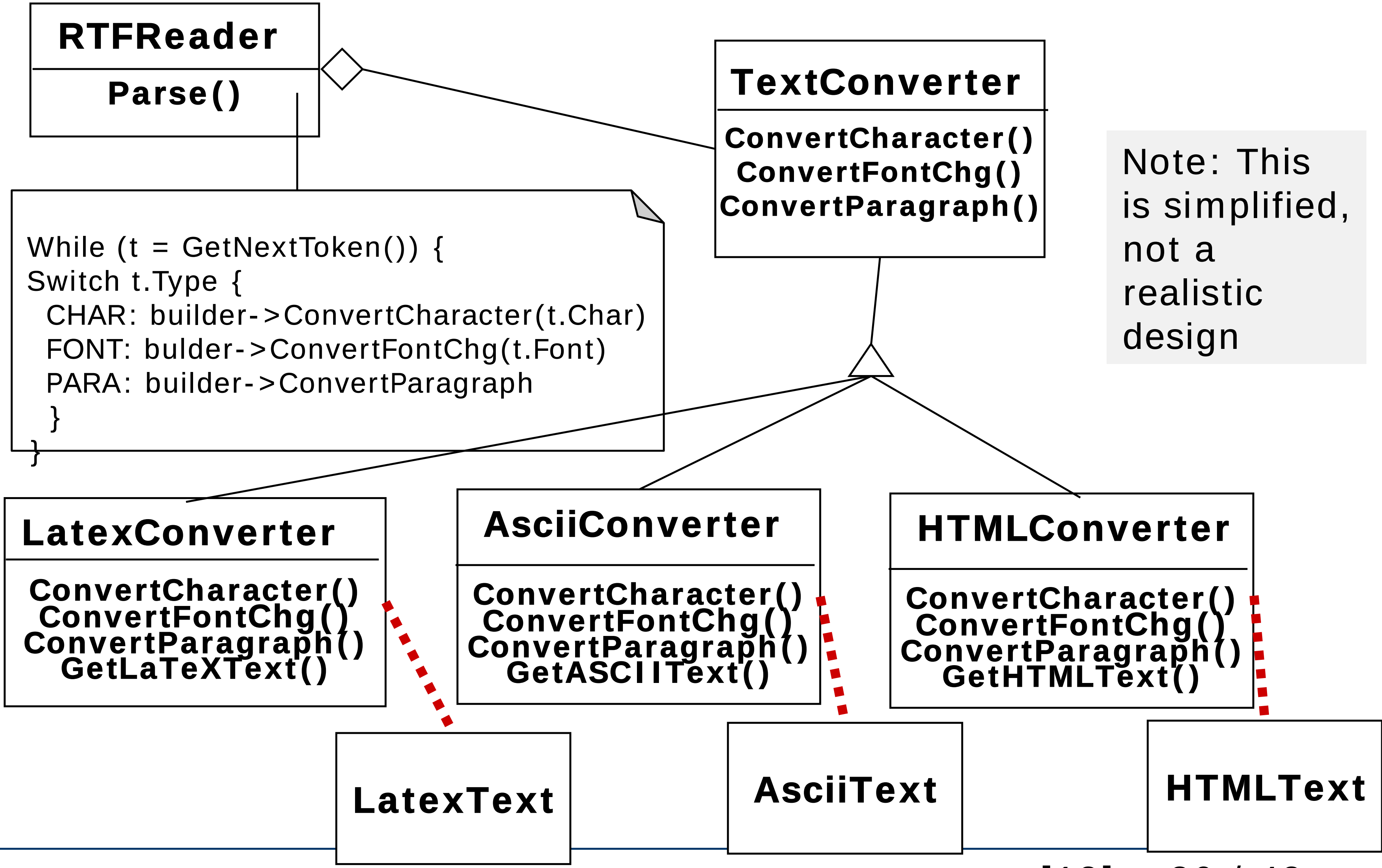
- Problem: Must create documents in many formats
  - Some software companies make their money by introducing new formats, forcing users to upgrades
  - You want to isolate the changes needed when this happens
- Idea: A reader for RTF format
  - Convert RTF to many text formats (Framemaker 4.0, Framemaker 5.0, Framemaker 5.5, LaTeX, HTML, SGML, WordPerfect 3.5, WordPerfect 7.0, ….)
    - Problem: The number of conversions is open-ended
- Solution
  - Configure the RTF Reader with a "builder" object.
  - A Builder subclass specializes in converting to one known format.
    - It has one method for each "build event" to be handled.
  - New Builder classes can easily be added to deal with any new format appearing on the market

Note: This is simplified, not a realistic scenario

Builder Pattern (Erbauer)



Builder Pattern Example



```
While (t = GetNextToken()) {
Switch t.Type {
  CHAR: builder->ConvertCharacter(t.Char)
  FONT: bulder->ConvertFontChg(t.Font)
  PARA: builder->ConvertParagraph
  }
}
```

Note: This is simplified, not a realistic design

When do you use the Builder Pattern?

Three cases:

1. The creator of a complex product must not know which of several different variant forms of the product is being built
   - The production process must look exactly the same although the products do not

2. We need a simplified view of the creation process for a complex product
   - Creator should not need to know how the parts are put together to make up the product

3. The creation process must allow different descriptions for the object that is constructed
   - Different build processes can lead to the same product
   - The Builder class API provides alternative abstractions

Comparison: Abstract Factory vs. Builder

- Abstract Factory
  - Focuses on product family
    - The products can be simple ("light bulb") or complex ("engine")
  - The creation process takes only one step
    - The complete product is returned

- Builder
  - Creates only one type of product
  - The creation process is complex: many separate steps
    - and those steps can vary a lot

- Abstract Factory and Builder work well together for a family of multiple complex products
  - One or more of the factory methods may yield a Builder rather than directly a product object

Summary

- Structural Patterns Composite, Adapter, Bridge, Façade, Proxy
  - Focus: How objects are composed to form larger structures
  - Problems solved:
    - Provide flexibility and extensibility
- Behavioral Patterns Command, Observer, Strategy, Proxy
  - Focus: Algorithms and the assignment of responsibilities to objects
  - Problem solved:
    - Reduce coupling to a particular algorithm
- Creational Patterns Abstract Factory, Builder
  - Focus: Creation of complex objects
  - Problems solved:
    - Hide how complex objects are created and put together

Conclusion

Design patterns...

- provide reusable solution ideas for recurring problems
- lead to extensible models and code
- simplify talking about a design
  - Because they provide powerful abstractions
- are examples of change-resistant design
  - using interface inheritance and delegation
- apply the same principles to structure and to behavior

Konventionelle vs. Agile Prozesse

"Entwurfsmuster sind super!"

"Entwurfsmuster sind super!"

Thank you!