25) Entwurfsmuster (Design Patterns) - Eine Einführung

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Achtung: Dieser Foliensatz ist teilweise in Englisch gefasst, weil das Thema in der Englisch-sprachigen Kurs “Design Patterns and Frameworks” wiederkehrt.
Mit der Bitte um Verständnis.

Obligatory Literature

- ST für Einsteiger, Kap. Objektentwurf: Wiederverwendung von Mustern
- also: Chap. 8, Bernd Brügge, Allen H. Dutoit. Objektorientierte Softwaretechnik mit UML, Entwurfsmustern und Java. Pearson.

Recommended Books

- [The GOF (Gang of Four) Book] E. Gamma, R. Johnson, R. Helm, J. Vlissides. Design Patterns. Addison-Wesley.
  - Auf Deutsch: Entwurfsmuster.
- Head First Design Patterns. Eric Freeman & Elisabeth Freeman, mit Kathy Sierra & Bert Bates.O'Reilly, 2004, ISBN 978-0-596-00712-6
  - German Translation: Entwurfsmuster von Kopf bis Fuß. Eric Freeman & Elisabeth Freeman, mit Kathy Sierra & Bert Bates. O'Reilly, 2005, ISBN 978-3-89721-421-7
- There is a lot of free material on the web.
  - http://en.wikipedia.org/wiki/Book:Design_Patterns is a free collection of patterns, available as pdf
  - James W. Cooper. Java™ Design Patterns: A Tutorial. Addison Wesley, 2000, ISBN: 0-201-48539-7
    - http://www.informit.com/store/java-design-patterns-a-tutorial-9780201485394 Section Download
  - Download books at http://www.freebookcentre.net/SpecialCat/Free-Design-Patterns-Books-Download.html

Introductory Papers, Recommended

- A. Tesanovic. What is a pattern? Paper in Design Pattern seminar, IDA, 2001. Available at ST http://www-st.inf.tu-dresden.de/Lehre/WS04-05/dpf/seminar/tesanovic-WhatIsAPattern.pdf
- Brad Appleton. Patterns and Software: Essential Concepts and terminology.
  - http://csis.pace.edu/~grossman/dcs/Patterns%20and%20Software-%20Essential%20Concepts%20and%20Terminology.pdf Compact introduction into patterns.

Other References

- F. Buschmann. N. Meunier, H. Rohnert, P. Sommerlad, M. Stal. Pattern-orientierte Software-Architektur. Addison-Wesley.
  - Design patterns and architectural styles. MVC, Pipes, u.v.m.
- M. Fowler. Refactoring. Addison-Wesley.
- W. Pree. Object-Oriented Software Construction. 1995. Springer.
- Papers:
  - D. Riehle, H. Zülinghoven, Understanding and Using Patterns in Software Development. Theory and Practice of Object Systems 2 (1), 1996. Explains different kinds of patterns. http://citeseer.ist.psu.edu/riehle96understanding.html
  - W. Zimmer. Relationships Between Design Patterns. Pattern Languages of Programming (PLOP) 1995.

- MVC
  - http://exadel.com/tutorial/struts/5.2/guess/strutsintro.html
  - http://www.c2.com/cgi/wiki?ModelViewController
- “Quality without a name” (QWAN principle)
  - http://en.wikipedia.org/wiki/The_Timeless_Way_of_Building

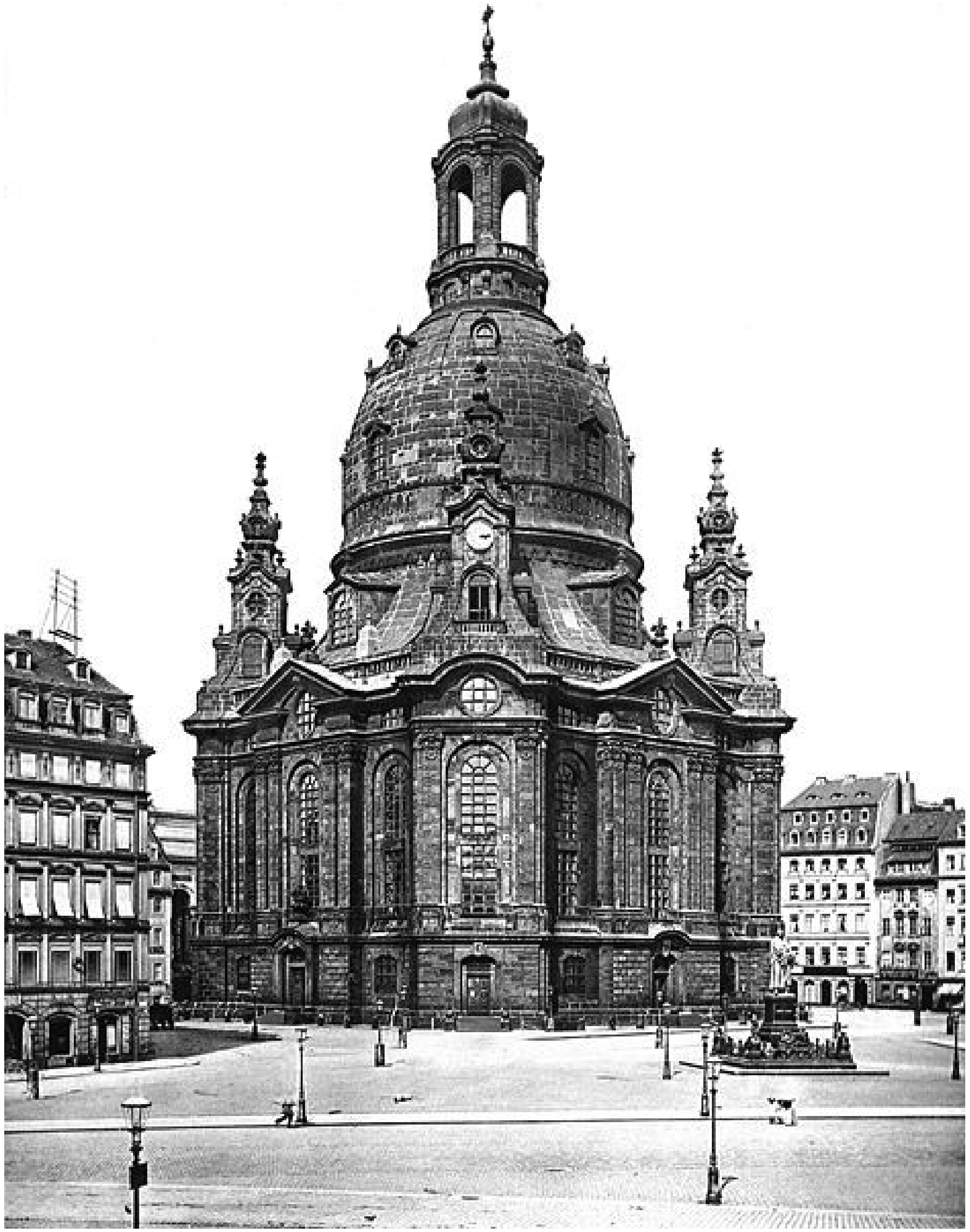
Thus it will be seen that *engineering* is a distinctive and important profession. To some even it is the topmost of all professions. However true that may or may not be to-day, certain it is that some day it will be true, for the reason that engineers serve humanity at every practical turn. Engineers make life easier to live—easier in the living; their work is strictly constructive, sharply exact; the results positive. Not a profession outside of the engineering profession but that has its moments of wabbling and indecision—of faltering on the part of practitioners between the true and the untrue. Engineering knows no such weakness. Two and two make four. Engineers know that. Knowing it, and knowing also the unnumbered possible approach a problem with a certainty of conviction and a confidence in the powers of their working-tools nowhere permitted men outside the profession.

Charles M. Horton. Opportunities of engineering. www.gutenberg.org, eBook #24681; Harper and Brothers, 1922.

Vorsicht

- Wer hat schon ein Java Programm übersetzt?

Why is the Frauenkirche Beautiful?



History: How to Write *Beautiful* Software

- Beginning of the 70s: the window and desktop metaphors (conceptual patterns) are discovered by the Smalltalk group in Xerox Parc, Palo Alto
- 1978/79: Goldberg and Reenskaug develop the MVC pattern for user Smalltalk interfaces at Xerox Parc
  - During porting Smalltalk-78 for the Eureka Software Factory project
- 1979: Alexander's Timeless Way of Building
  - Introduces the notion of a *pattern* and a *pattern language*
- 1987: W. Cunningham, K. Beck OOPSLA paper “Using Pattern Languages for Object-Oriented Programs” discovered Alexander's work for software engineers by applying 5 patterns in Smalltalk
- 1991: Erich Gamma's PhD Thesis about Design Patterns
  - Working with ET++, one of the first window frameworks of C++
  - At the same time, Vlissides works on InterViews (part of Athena)
- 1991: Pattern workshop at OOPSLA 91, organized by B. Anderson
- 1993: E. Gamma, R. Helm, R. Johnson, J. Vlissides. Design Patterns: Abstraction and Reuse of Object-Oriented Design. ECOOP 97, LNCS 707, Springer
- 1995: First PLOP conference (Pattern Languages Of Programming)
- 1995: GOF book

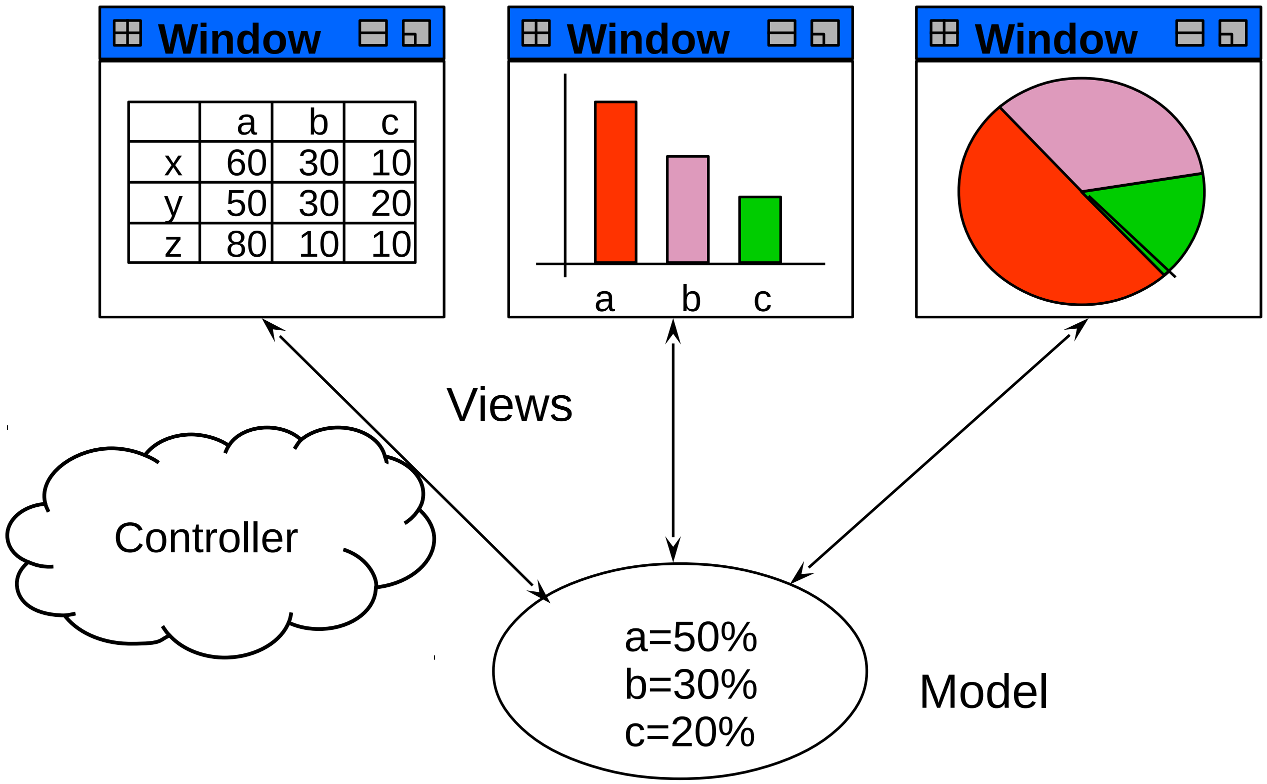
The Most Popular Definition

A **Design Pattern (Entwurfsmuster)** is a *solution pattern,*
- a description of a standard solution for
- a frequent design problem
- in a certain context

- Goal of a Design Pattern: Reuse of design information
  - A pattern must not be “new”!
  - A pattern writer must have a “aggressive disregard for originality”
- Such *solution patterns* are well-known in every engineering discipline
  - Mechanical engineering
  - Electrical engineering
  - Civil engineering and architecture

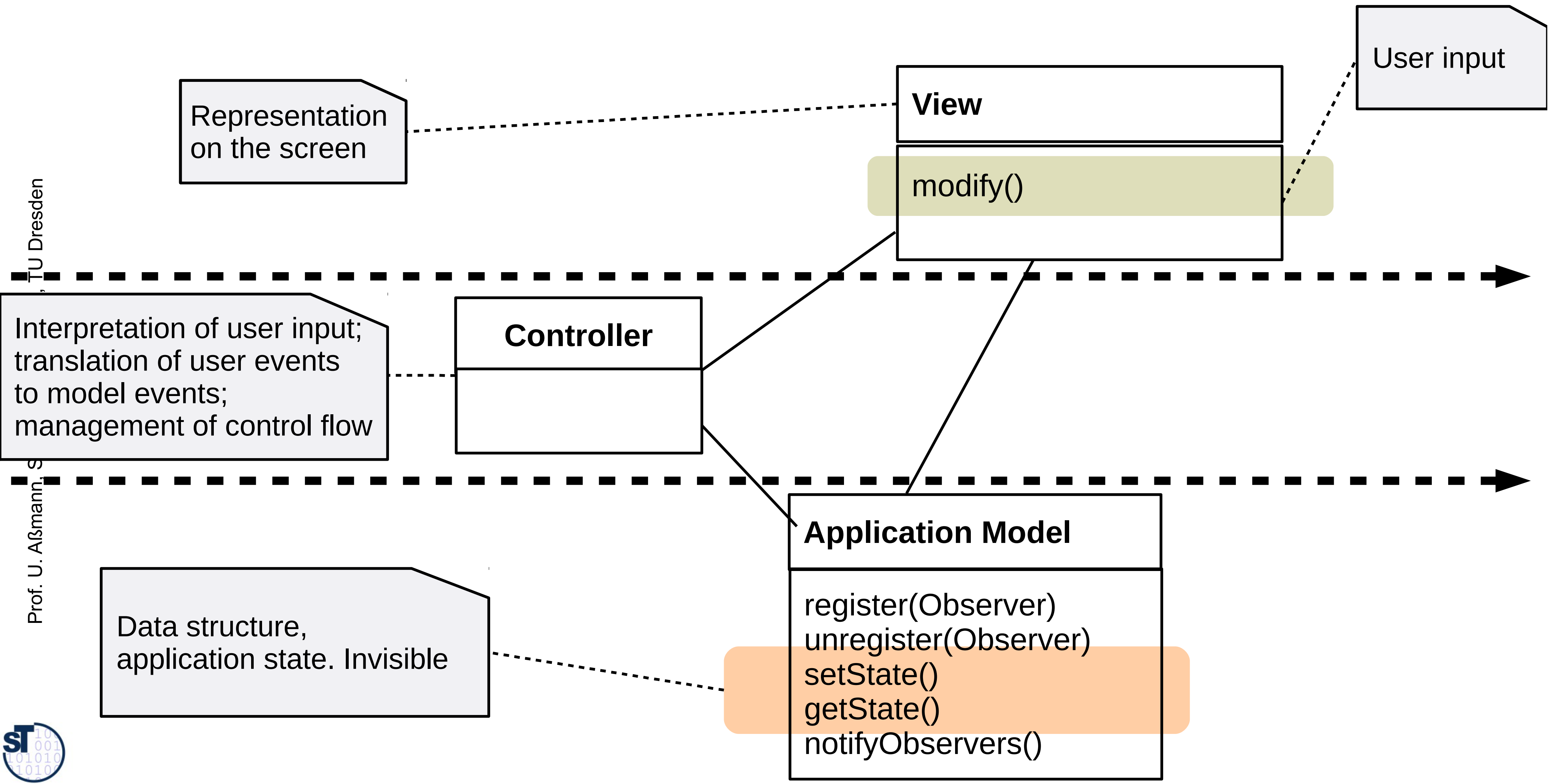
A Problem in Interactive Applications

- How do I display and edit a data structure on the screen?
  - Reaction on user inputs?
  - Maintaining several views
  - Adding and removing new views
- Solution: Model-View-Controller pattern (MVC), a set of classes to control a data structure behind a user interface
  - Developed by Goldberg/Reenskaug in Smalltalk 1978



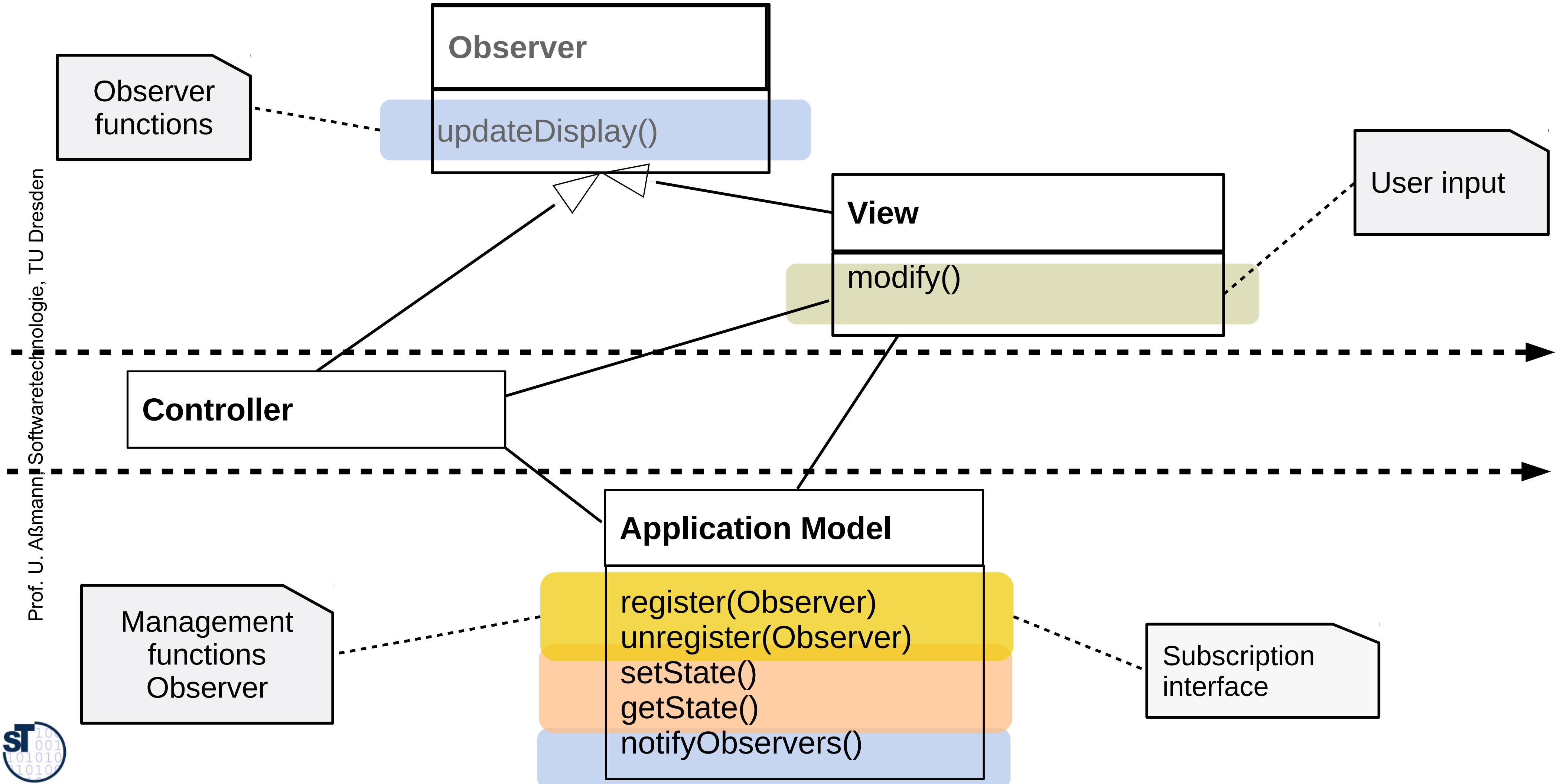
Design Pattern Model/View/Controller (MVC)

- MVC is a set of classes to control a data structure behind a user interface
- Layered structure of View, Controller and ApplicationModel


Representation on the screen
View
modify()
User input
Interpretation of user input; translation of user events to model events; management of control flow
Controller
Application Model
register(Observer)
unregister(Observer)
setState()
getState()
notifyObservers()
Data structure, application state. Invisible

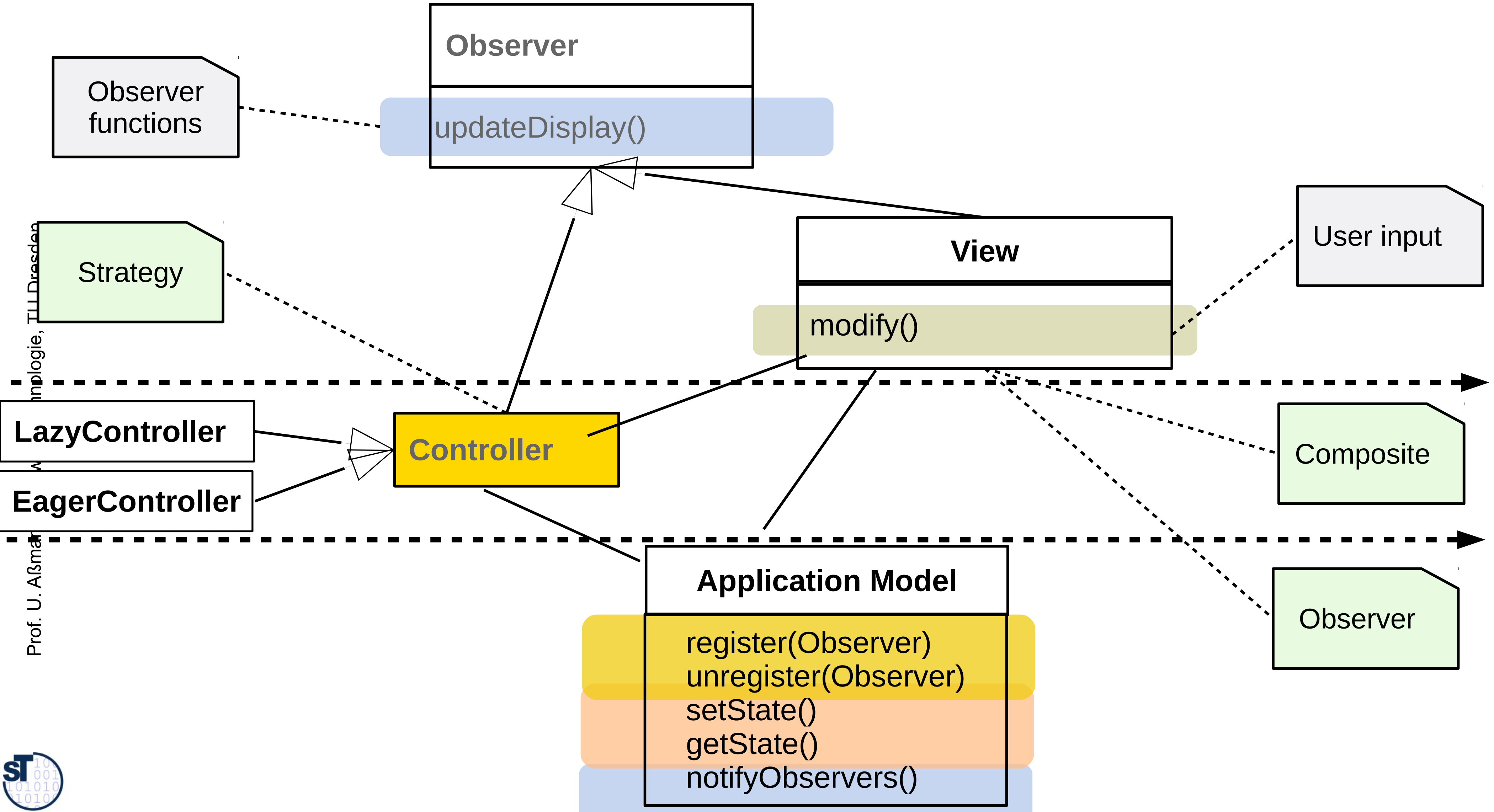
Design Pattern Model/View/Controller (MVC)

- The MVC is a complex design pattern. The layers are connected by the simpler patterns Observer, Composite, Strategy.
  - The Controller interpretes the input of the user and transmits them into actions on the model
  - Controller and View play Listener role from *Observer* (asynchronous communication)
  - Model plays Subject role



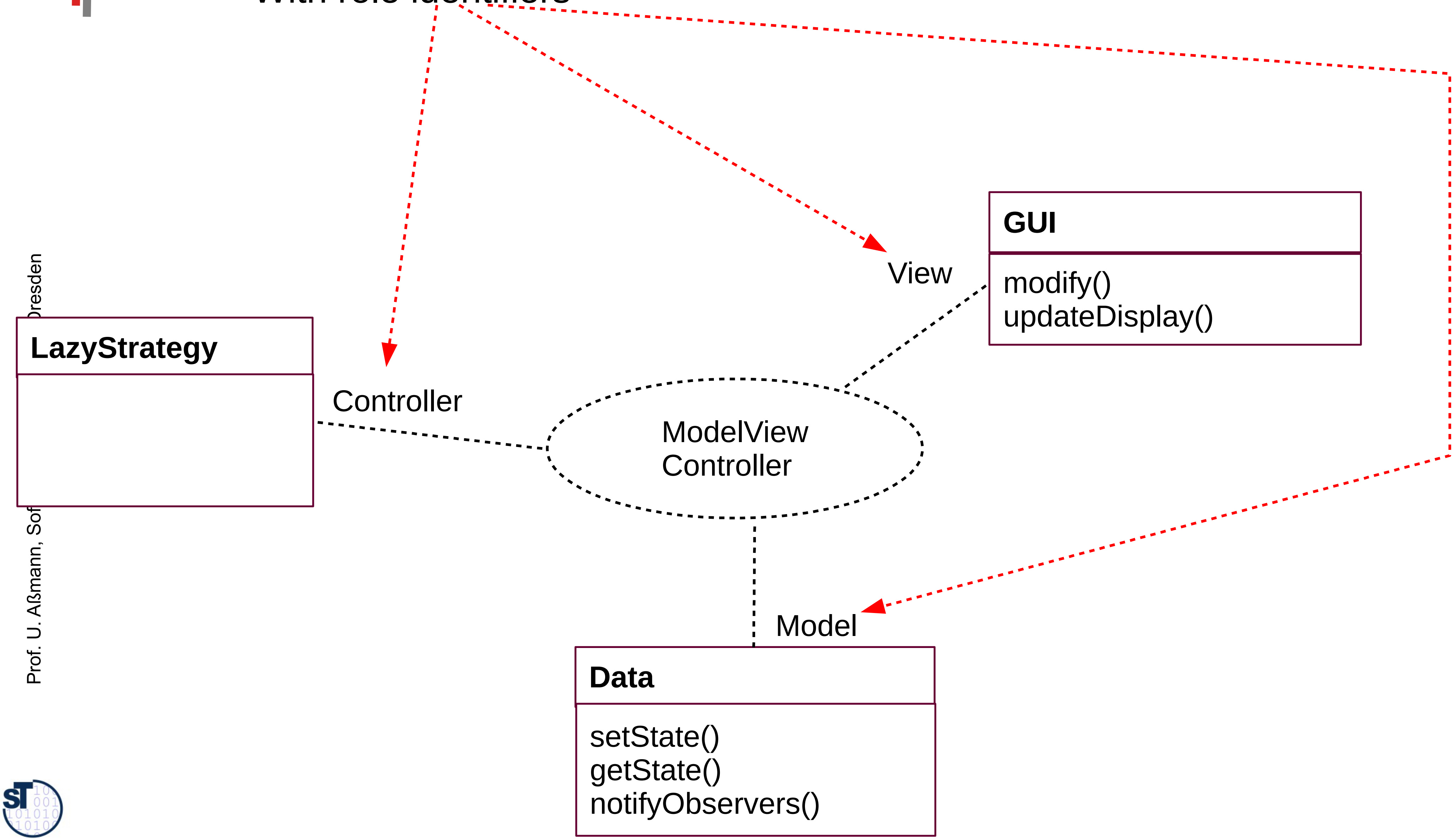
Design Pattern Model/View/Controller (MVC)

- Controller follows Strategy pattern (variation of updating the screen)
- Relation within Views by Composite (tree-formed views)



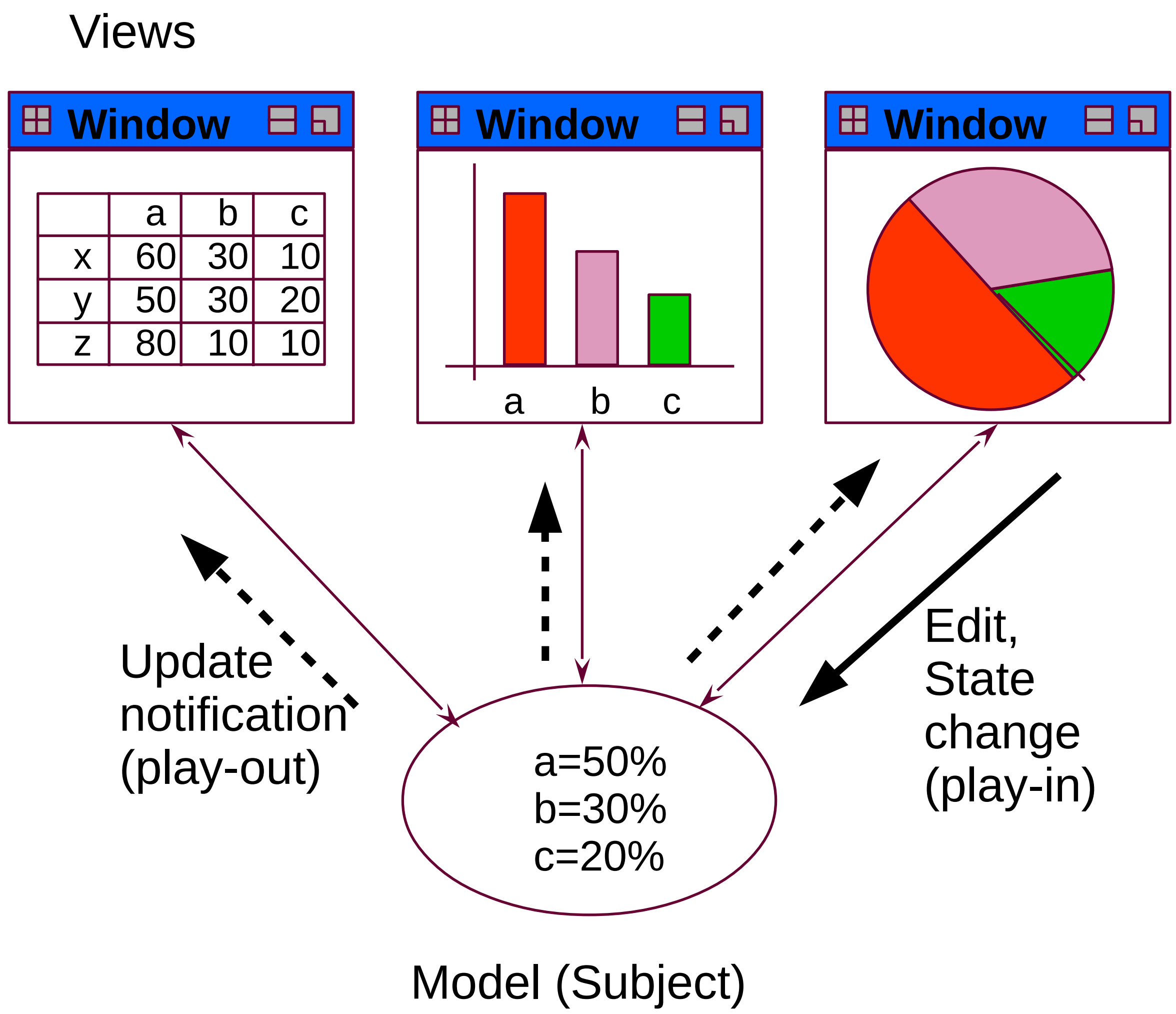
Design Pattern Model/View/Controller (MVC)

- UML has a specific notation for patterns (**collaboration classes**)
  - With role identifiers



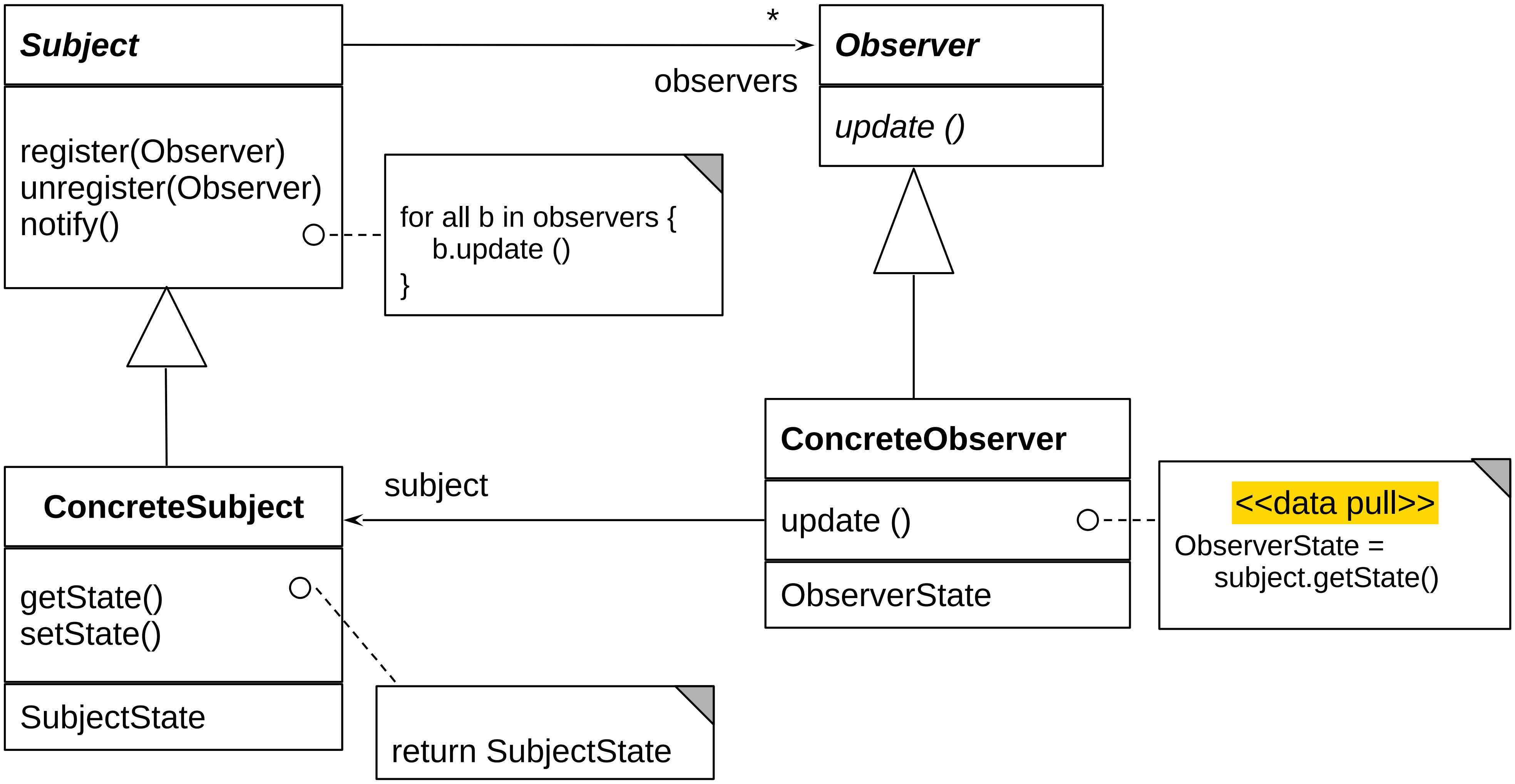
Pattern 1: Observer

- Views may register as Observer at the model (Subject)
  - They become *passive* observers of the model
  - They are notified if the model changes.
  - Then, every view updates itself by accessing the data of the model.
- Views are independent of each other
  - The model does not know how views visualize it
  - Observer decouples views strongly



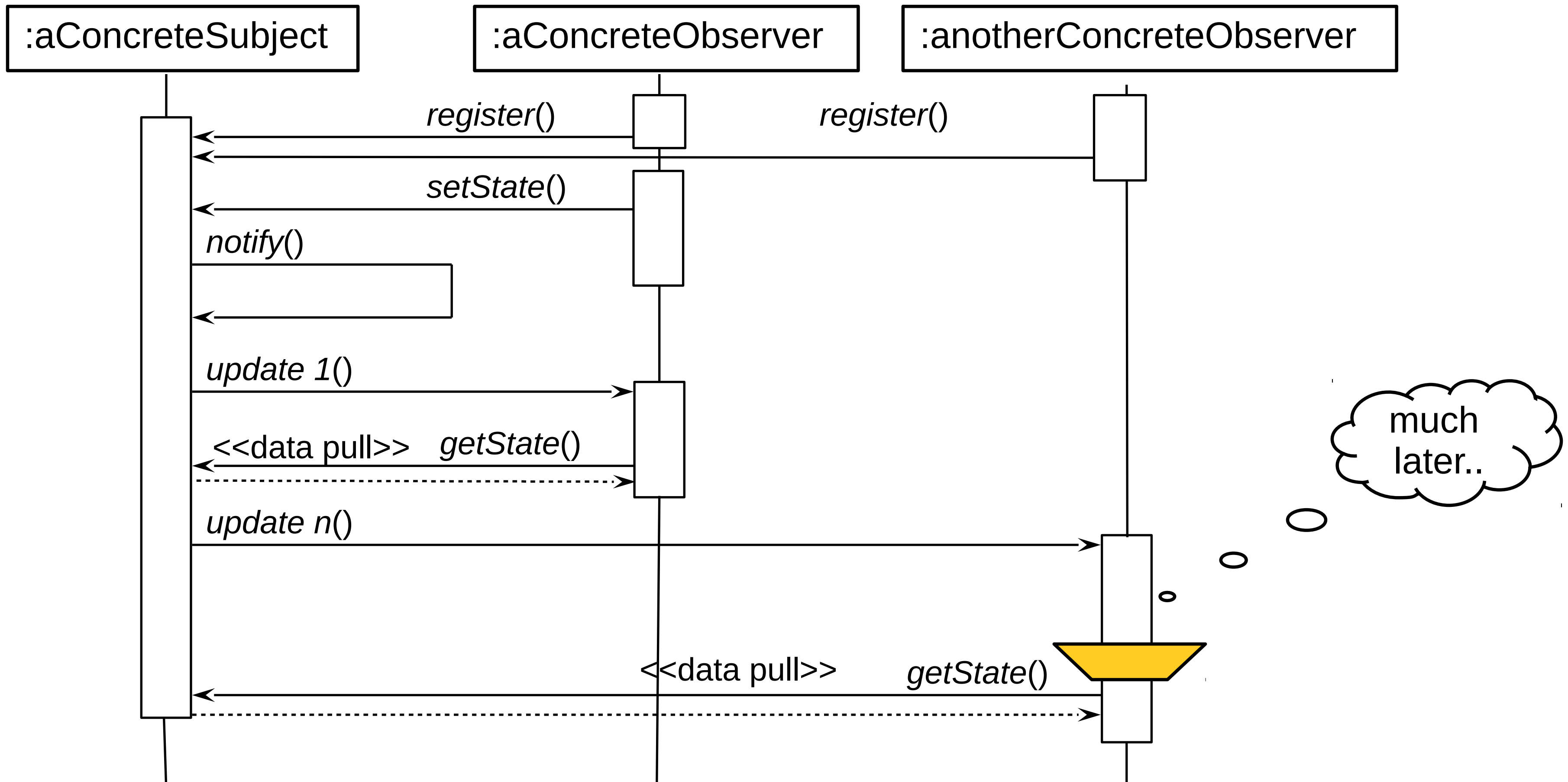
Structure Observer (pull-Variant)

- Aka Publisher/Subscriber
- Subject does not care nor know, which observers are involved: subject independent of observer



Sequence Diagram pull-Observer

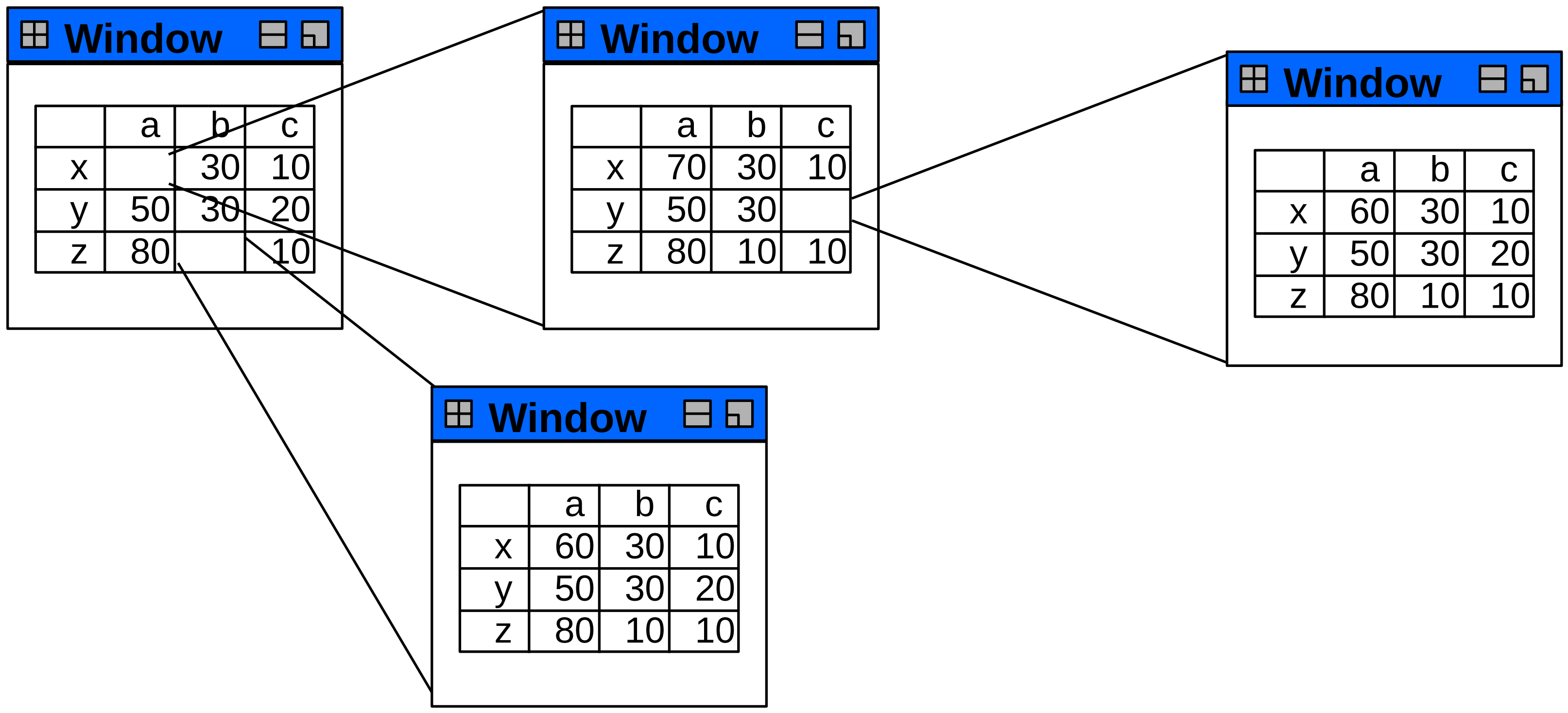
- Observer.update() does not transfer data, only announces an event
  - Anonymous communication possible
- Observer *pulls* data out itself
  - In the context of MVC, Controller or View pull data out of the application model themselves



Pattern 2: Composite (Rpt.)

Views may be *nested* (*Composite*)

- Composite represents trees
- For a client class, Compositum unifies the access to root, inner nodes, and leaves
- In MVC, views can be organized as Composite



	a	b	c
x		30	10
y	50	30	20
z	80		10

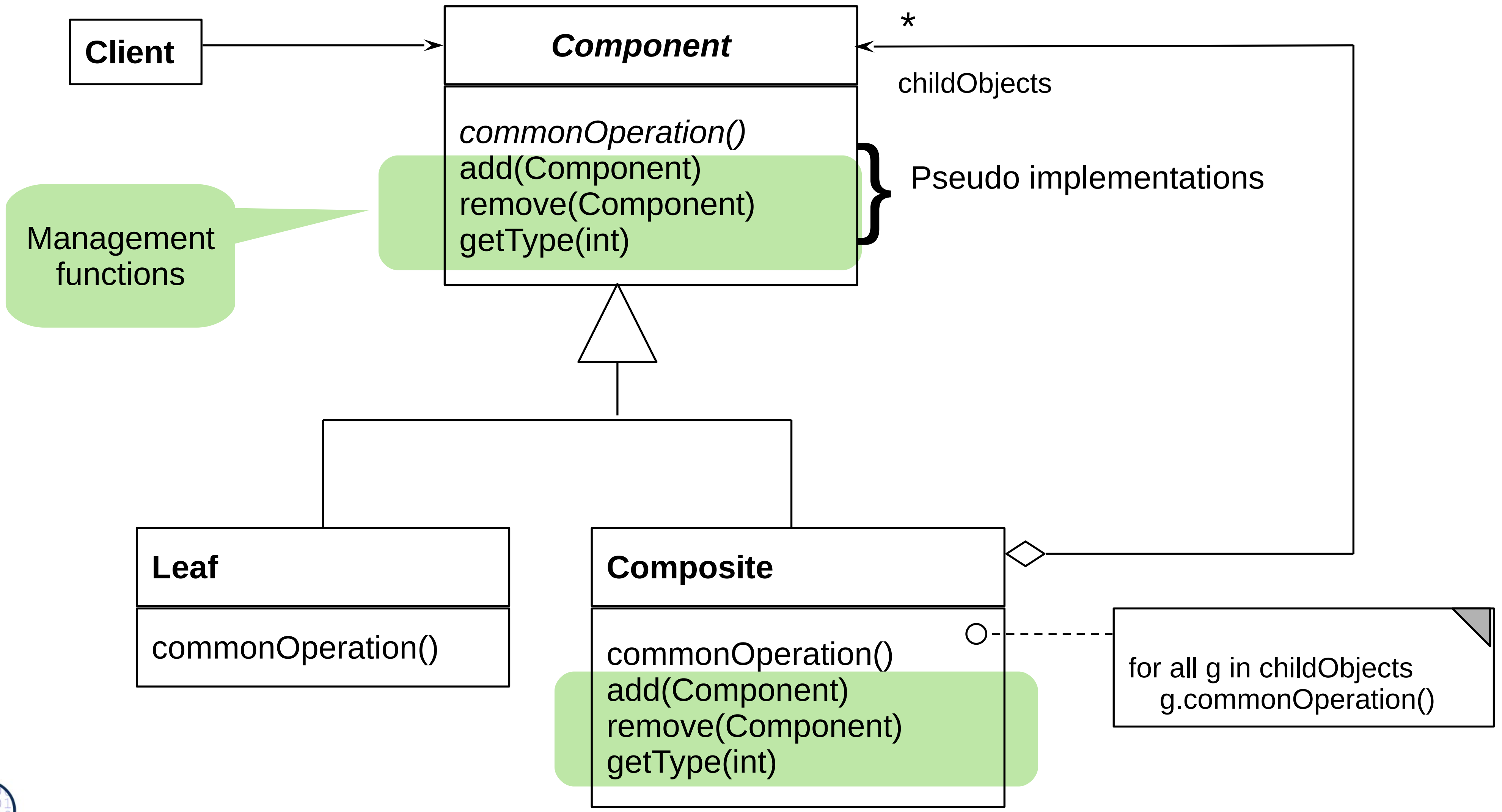
	a	b	c
x	70	30	10
y	50	30	
z	80	10	10

	a	b	c
x	60	30	10
y	50	30	20
z	80	10	10

	a	b	c
x	60	30	10
y	50	30	20
z	80	10	10

Structure Composite (Rpt.)

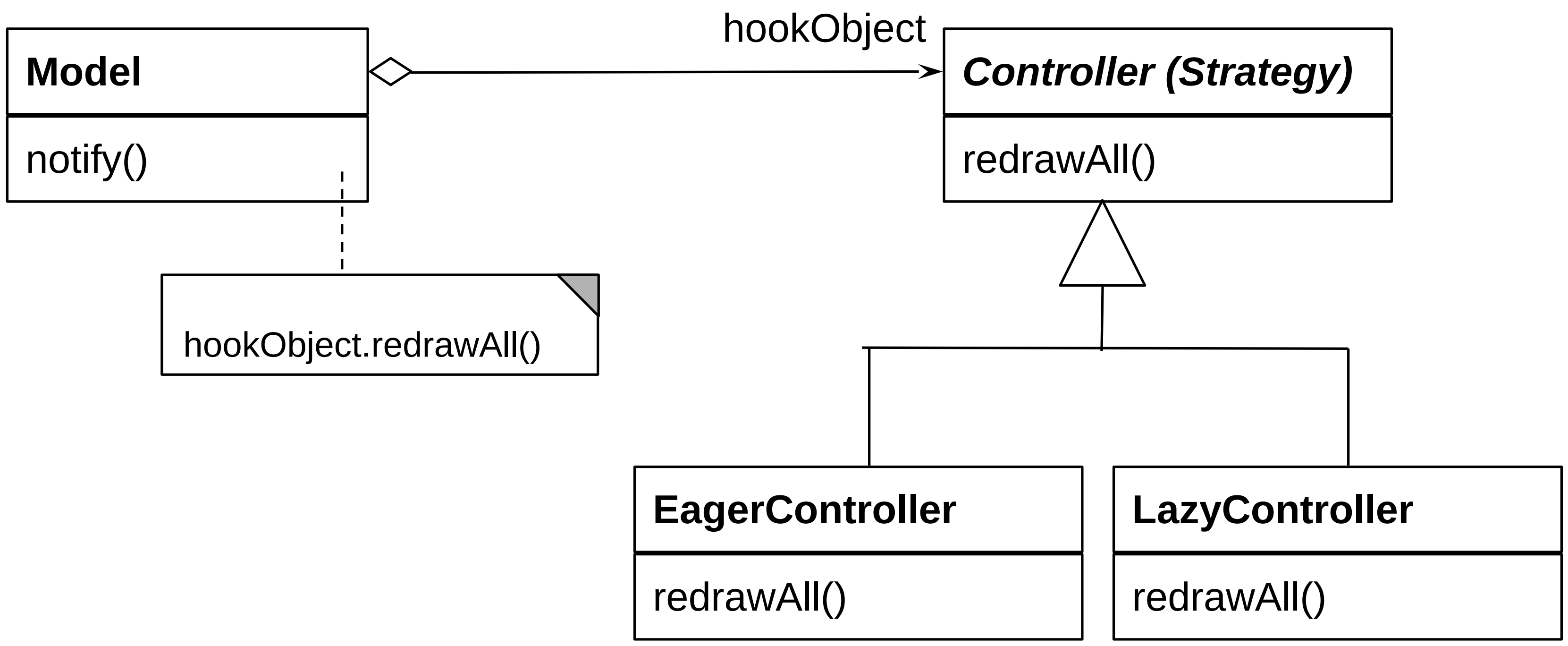
- Composite has an recursive n-aggregation to the superclass



Pattern 3: Strategy

The relation between *application model* and *controller* is a *Strategy* pattern.

- There may be different control strategies
  - Lazy or eager update of views
  - Menu or keyboard input
- A view may select subclasses of *Controller,* even dynamically
- No other class changes

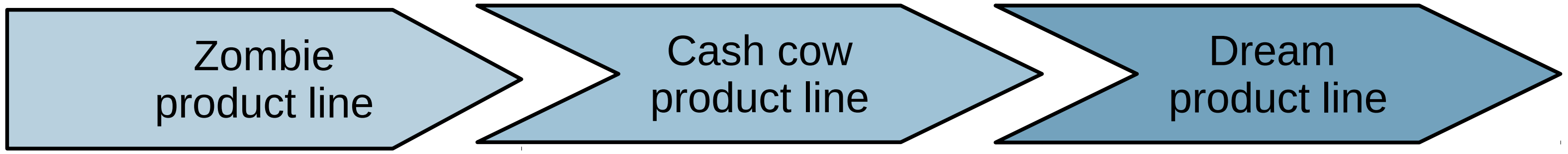


Purposes of Design Patterns

- Design patterns improve **communication** in teams
  - Between clients and programmers
  - Between designers, implementers and testers
  - For designers, to understand good design concepts
- Design patterns create a **glossary** for software engineering (an "ontology of software design")
  - A "software engineer" without the knowledge of patterns is a programmer
- Design patterns **document** abstract design concepts
  - Patterns are "mini-frameworks"
  - Documentation: in particular frameworks are documented by design patterns
  - Prevent re-invention of well-known solutions
  - Design patterns capture information in reverse engineering
  - Improve code structure and hence, code quality

Standard Problems to Be Solved By *Product Line Patterns*

- **Product Line Patterns** are specific design patterns about:
- **Variability**
  - Exchanging parts easily
  - Variation, variability, complex parameterization
  - Static and dynamic
  - For product lines, framework-based development
- **Extensibility**
  - Software must change
- **Glue** (adaptation overcoming architectural mismatches)
  - Coupling software that was not built for each other



25.1) Patterns for Variability

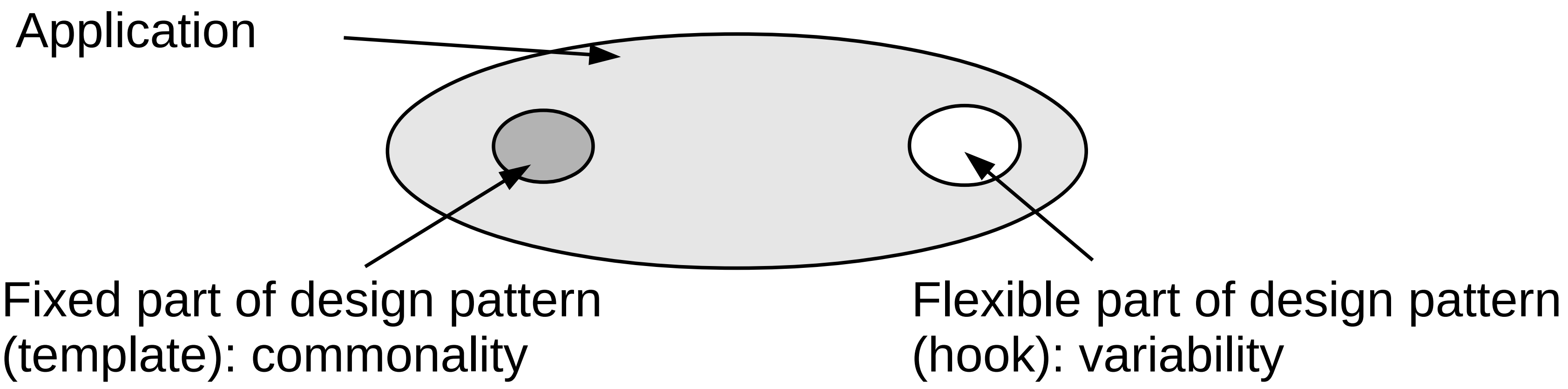
Programming complex objects in variants

Generating product families

Variability Pattern	# Run-time objects	Key feature
TemplateMethod	1	
FactoryMethod	1	
TemplateClass	2	Complex object
Strategy	2	Complex algorithm object
FactoryClass	3	Complex allocation of a family of objects
Bridge (DimensionalClass Hierarchy)	2	Complex object

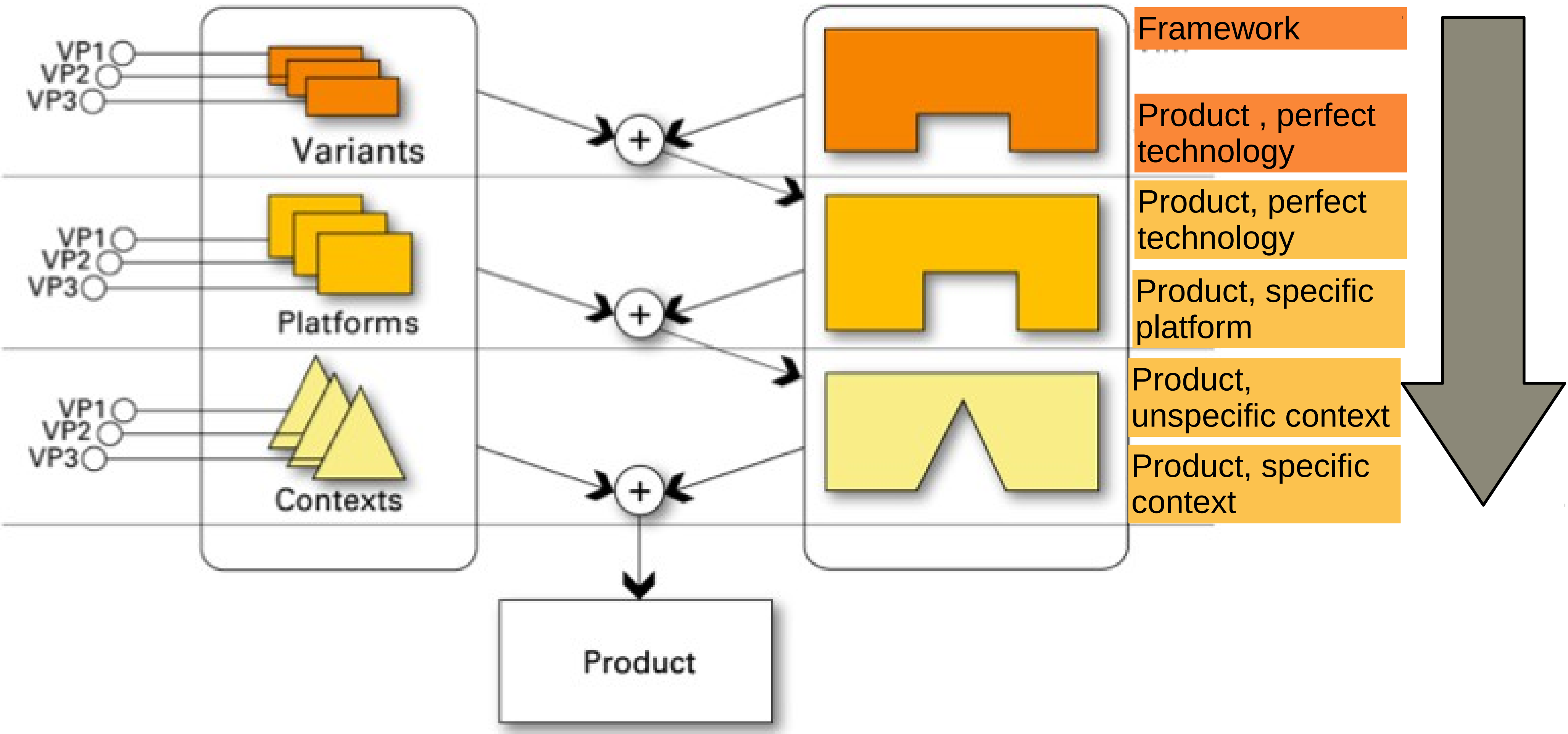
Commonalities and Variabilities

- A variability design pattern describes
  - Things that are *common* to several applications
    - Commonalities lead to *frameworks* or *product lines*
  - Things that are *different or variable* from application to application
    - Variabilities to *products* of a product line
- For capturing the communality/variability knowledge in variability design patterns, Pree invented the *template-and-hook (T&H) concept*
  - *Templates* contain skeleton code (commonality), common for the entire product line
  - *Hooks (hot spots)* are placeholders for the instance-specific code (variability)



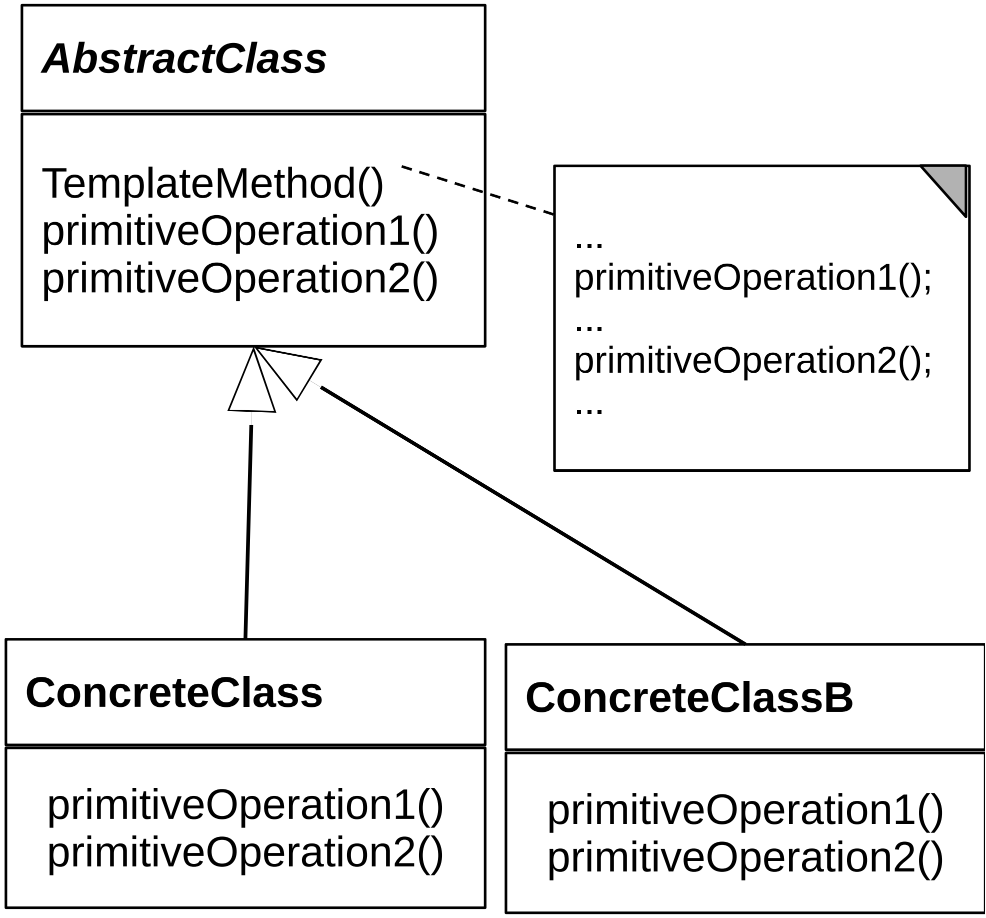
Why Do We Need Variability?

- Functional features
  - Payed vs free use
- Platforms
- Dynamic contexts (personalization, time and location)


VP1
VP2
VP3
Variants
VP1
VP2
VP3
Platforms
VP1
VP2
VP3
Contexts
+
+
+
Product
Framework
Product , perfect technology
Product, perfect technology
Product, specific platform
Product, unspecific context
Product, specific context

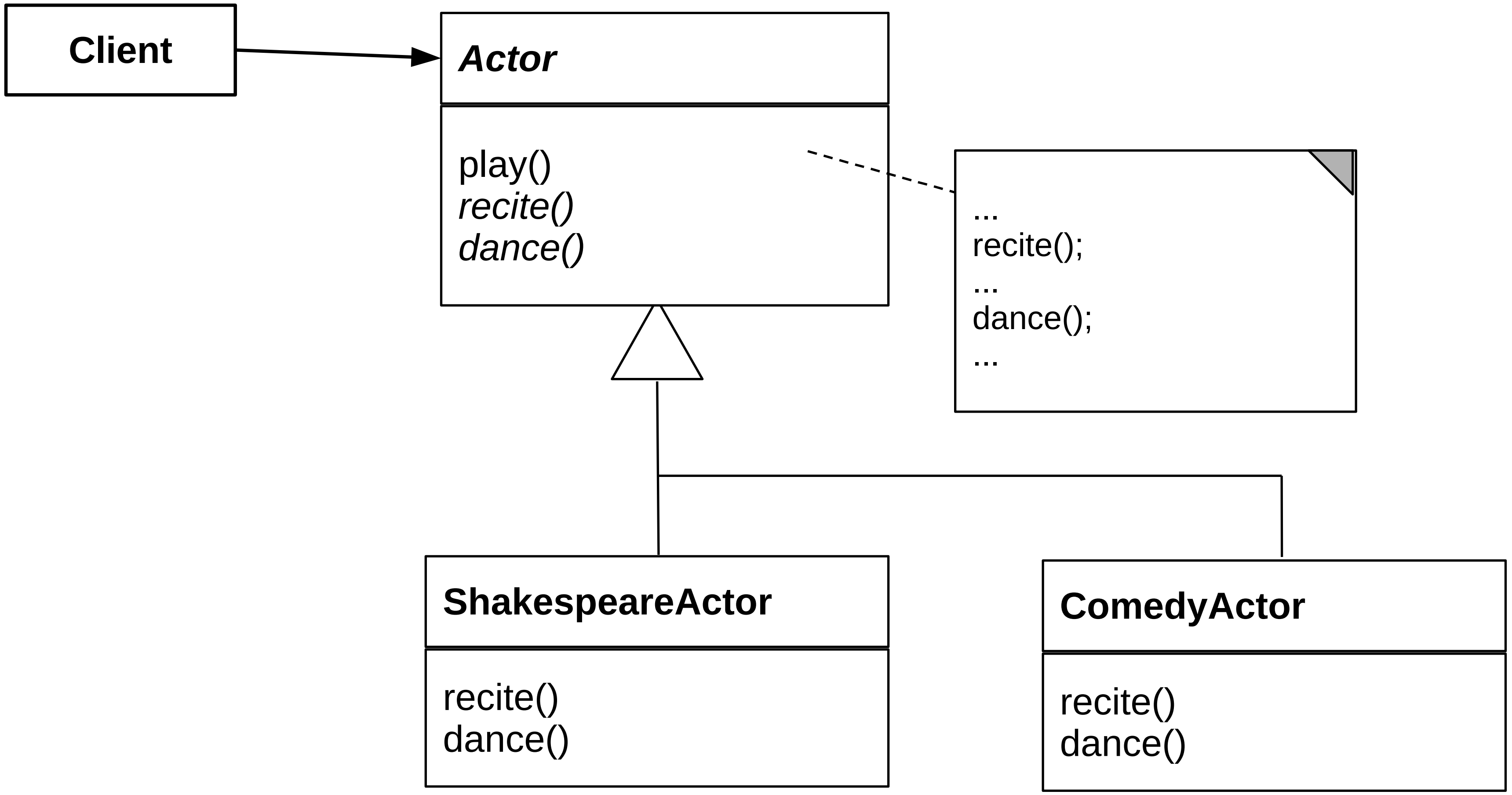
25.1.1 TemplateMethod Pattern is a Variability Design Pattern (Rpt.)

- Define the skeleton of an algorithm (template method)
  - The template method is concrete
- Delegate parts to abstract *hook methods* that are filled by subclasses
- Implements template and hook with the same class, but different methods
- Allows for varying behavior
  - Separate invariant from variant parts of an algorithm
- Example: TestCase in JUnit



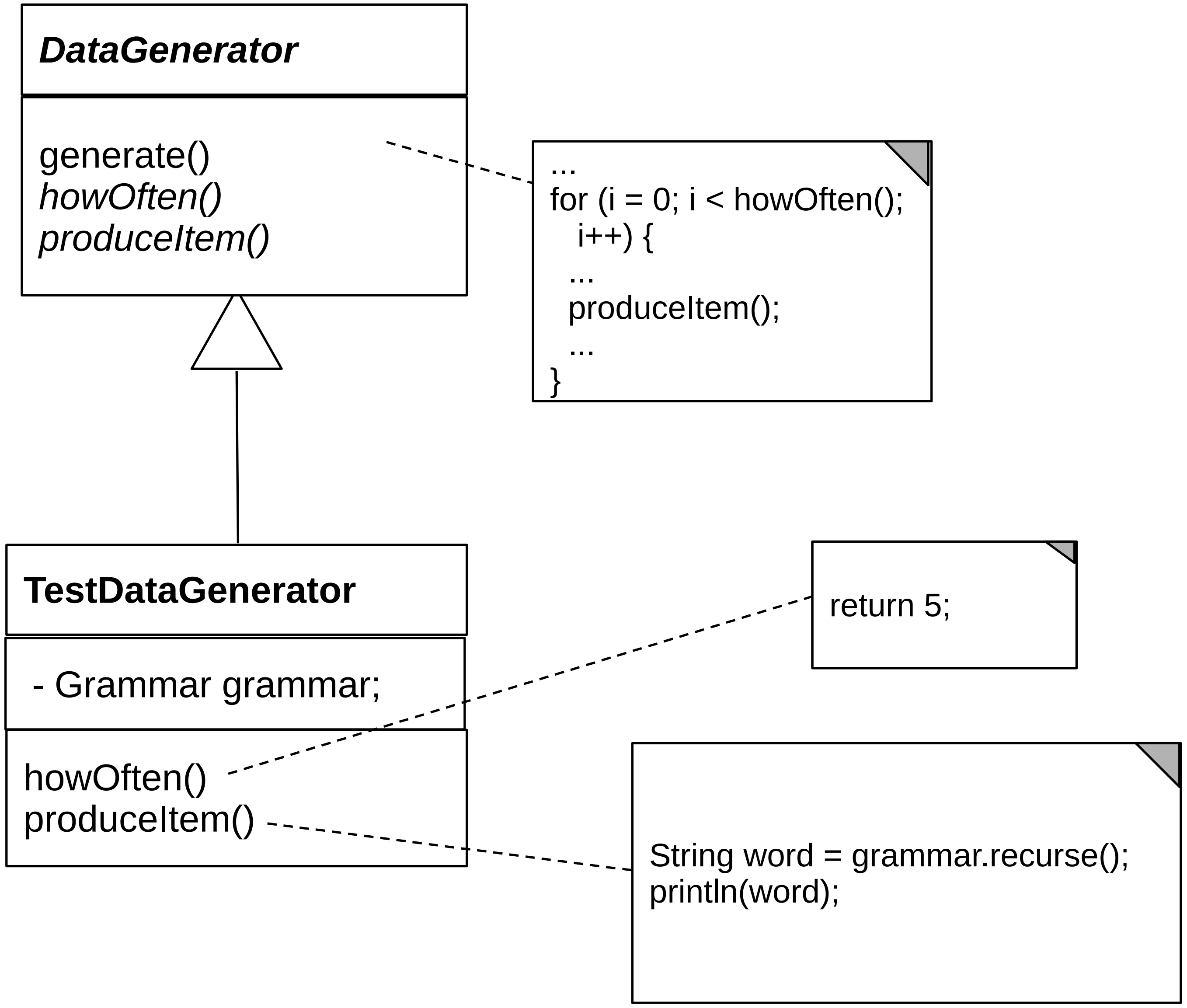
Actors and Genres as Template Method

- Binding an Actor's hook to be a ShakespeareActor *or* a Comedy Actor
- The behavior visible to a client will differ in two aspects, reciting and dancing



Running Example: A Data Generator

- Parameterizing a data generator by frequency and kind of production
-



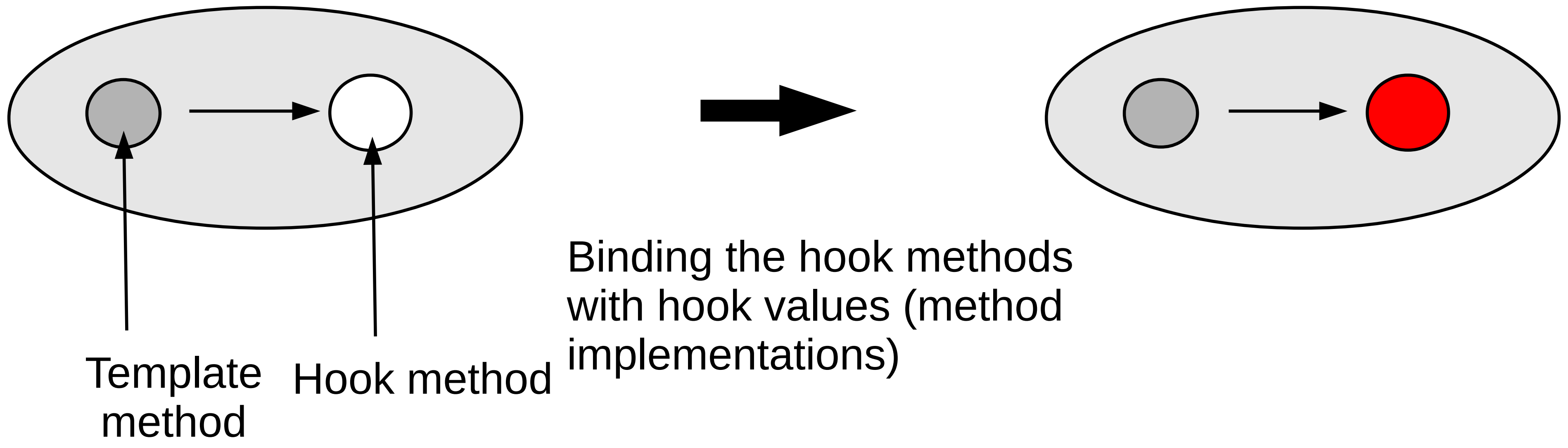
```
...
for (i = 0; i < howOften();
   i++) {
  ...
  produceItem();
  ...
}
```

```
return 5;
```

```
String word = grammar.recurse();
println(word);
```

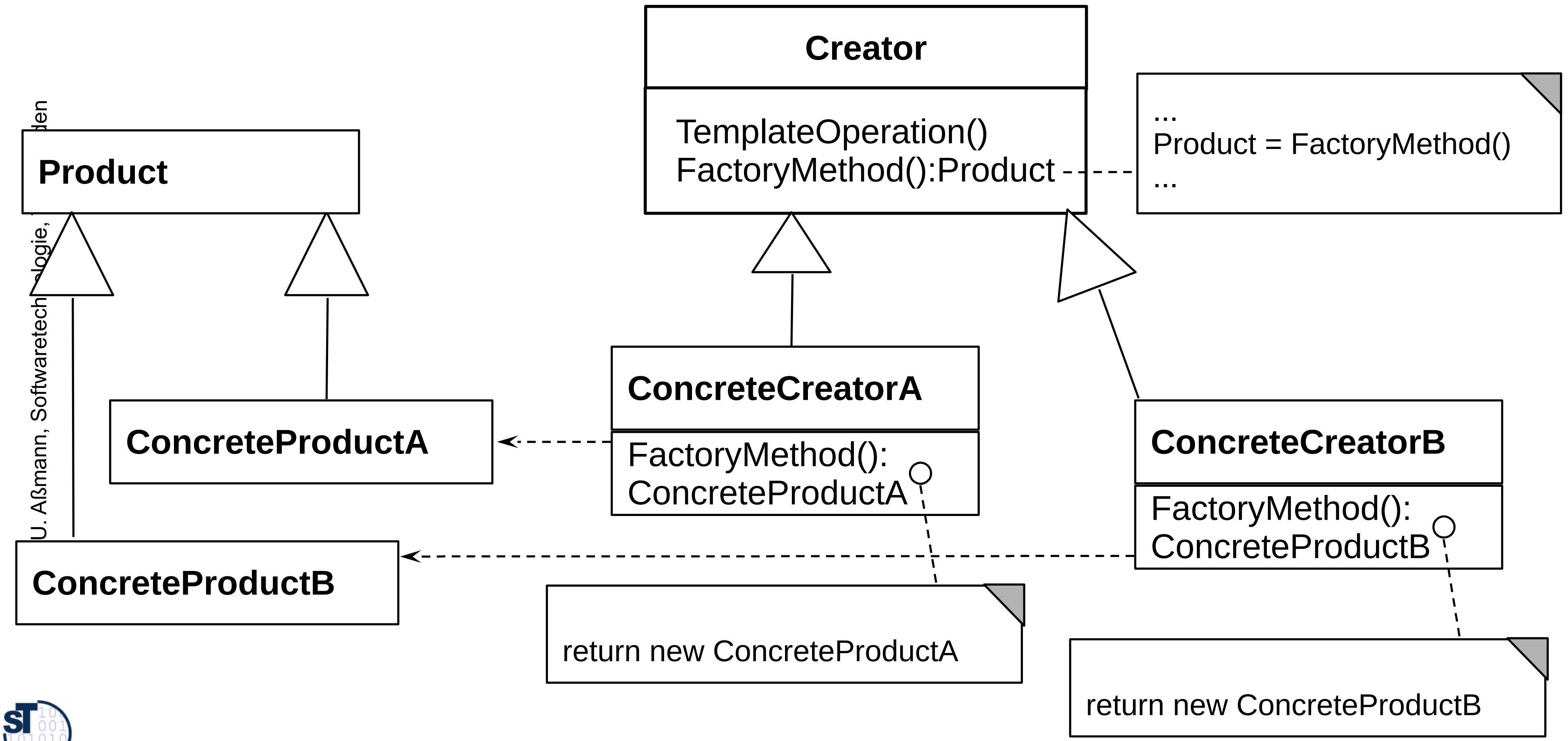
Variability with TemplateMethod

- **Binding the hook method** means to
  - Derive a concrete subclass from the abstract superclass, providing the implementation of the hook method
- **Controlled variability** by only allowing for binding hook methods, but not overriding template methods


Template method
Hook method
Binding the hook methods with hook values (method implementations)

25.1.2 FactoryMethod (Rpt.)

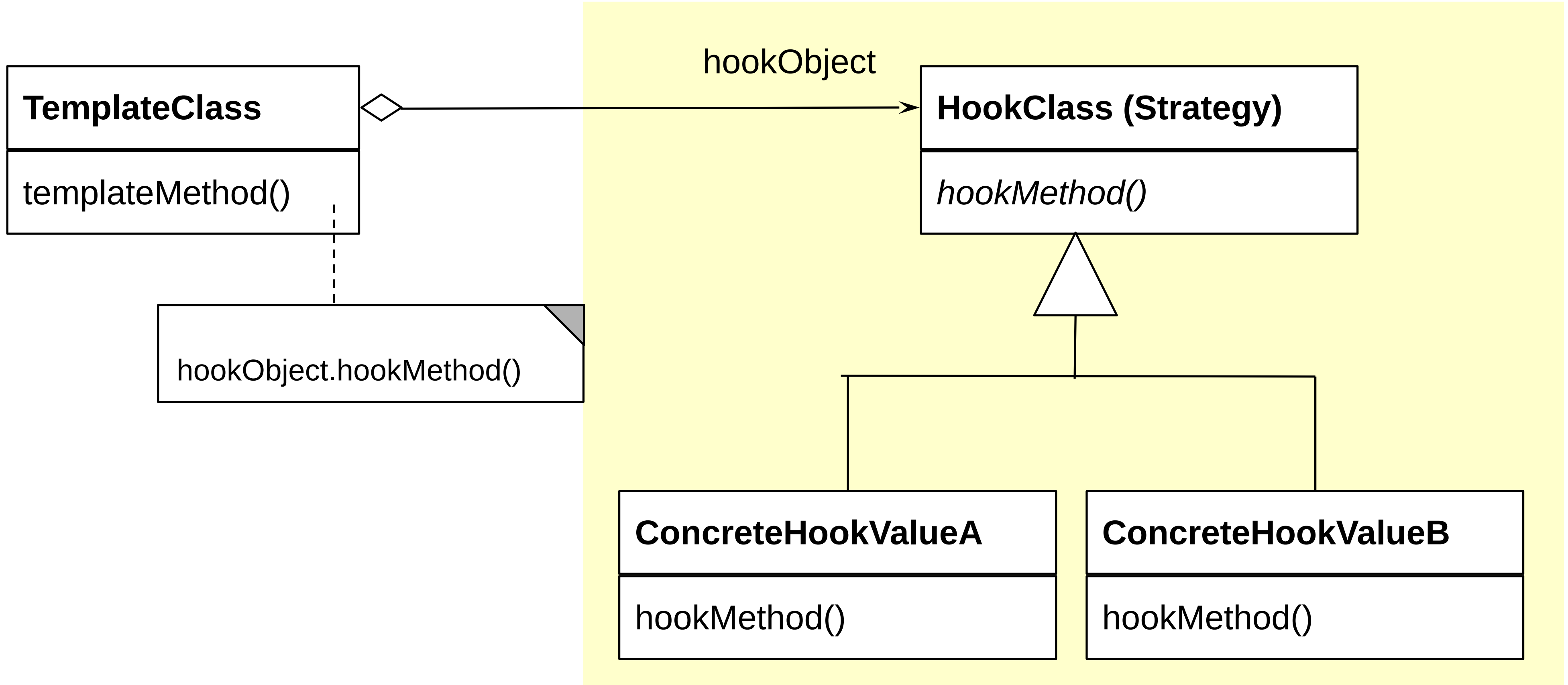
- FactoryMethod is a variant of TemplateMethod
- A FactoryMethod is a polymorphic constructor



25.1.3 Strategy (Template Class)

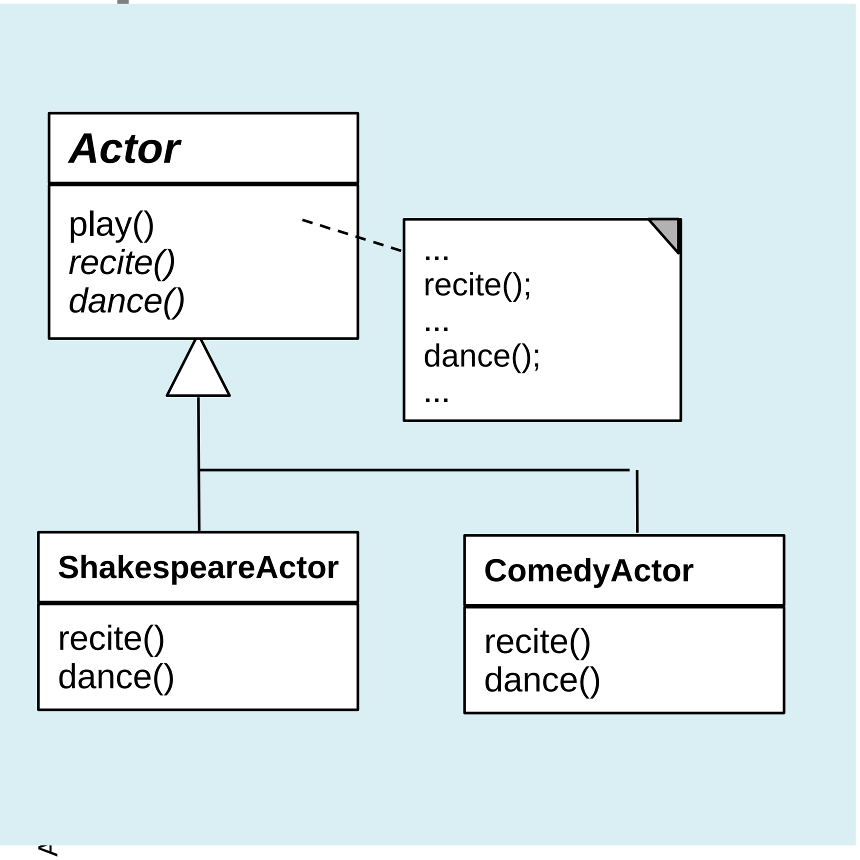
Strategy (also called Template Class)

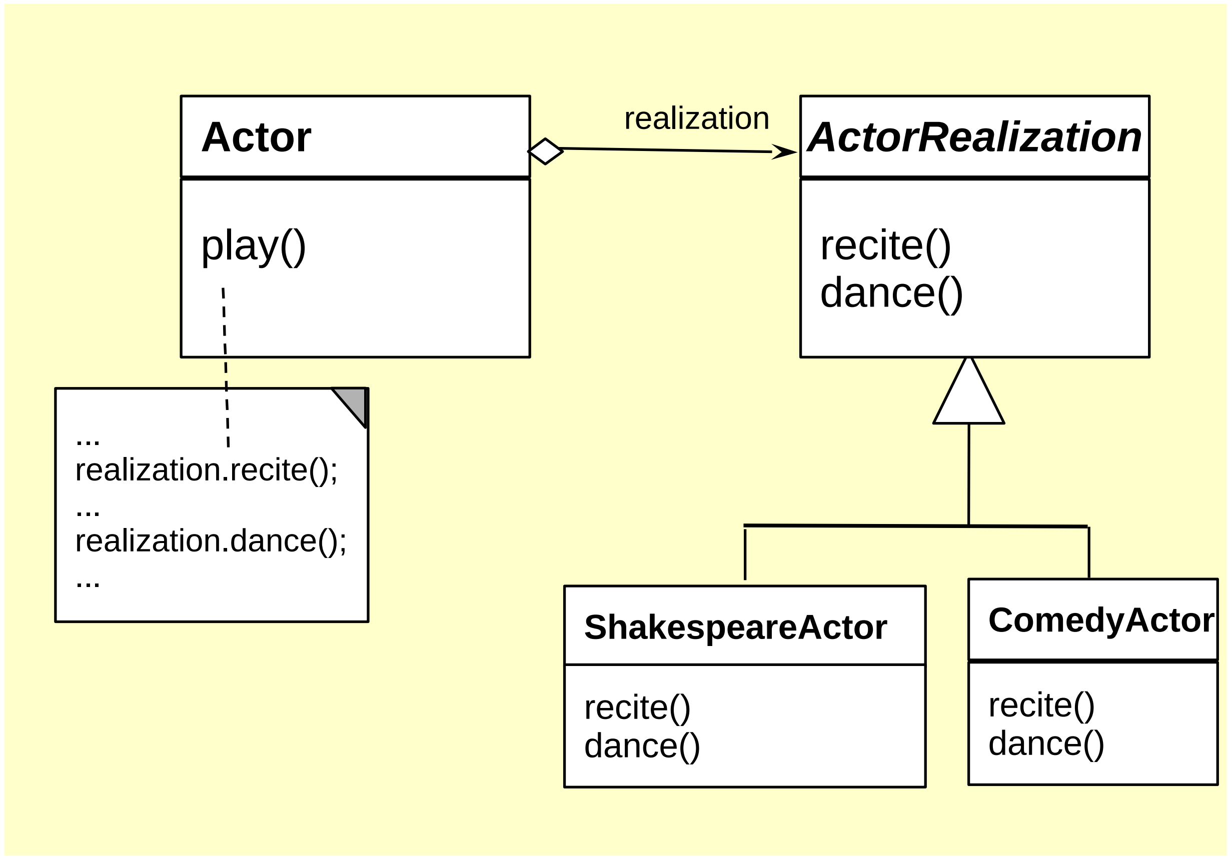
- The template method and the hook method are found in different classes
- Similar to TemplateMethod, but
  - Hook objects and their hook methods can be exchanged at run time
  - Exchanging several methods (a set of methods) at the same time
  - Consistent exchange of several parts of an algorithm, not only one method
- This pattern is basis of Bridge, Builder, Command, Iterator, Observer, Visitor.



Actors as Template Method

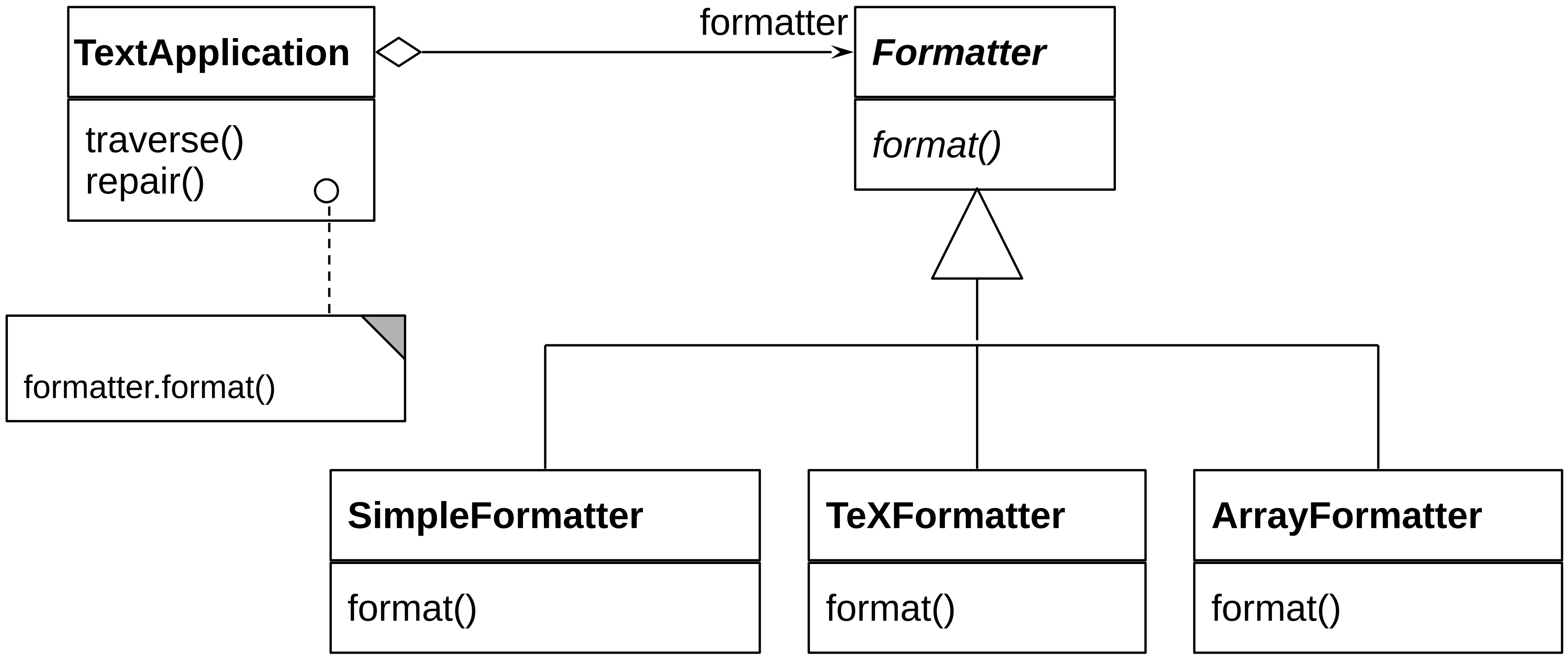
- TemplateMethod creates *one* run-time object; TemplateClass creates *two physical objects belonging to one logical object*





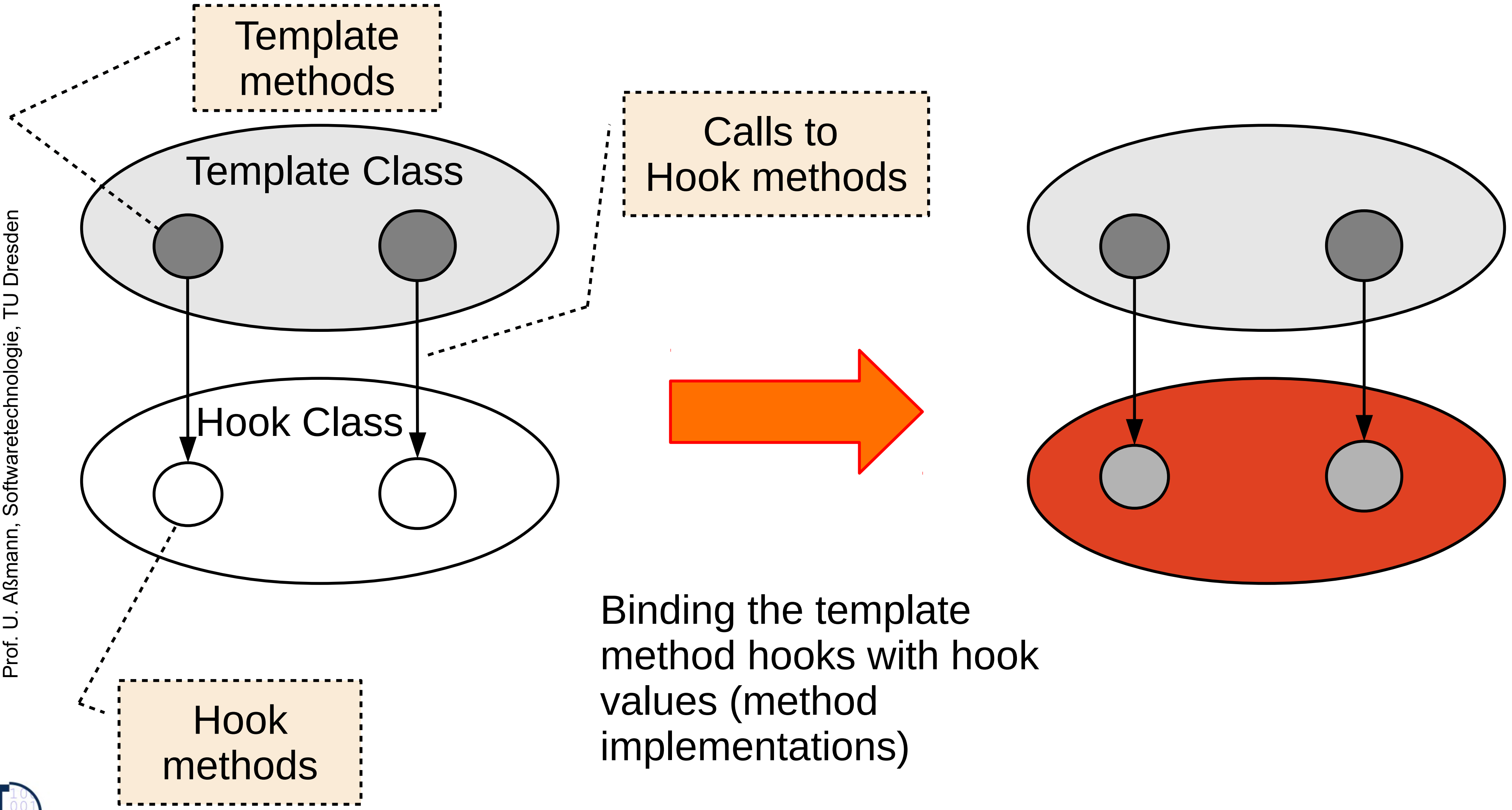
Example for Strategy

- Also algorithms can be represented as objects
- Ex.: complex formatting algorithm



Variability with Strategy

- Binding the hook class of a Strategy means to derive a concrete subclass from the **abstract hook superclass,** providing the implementation of the hook method

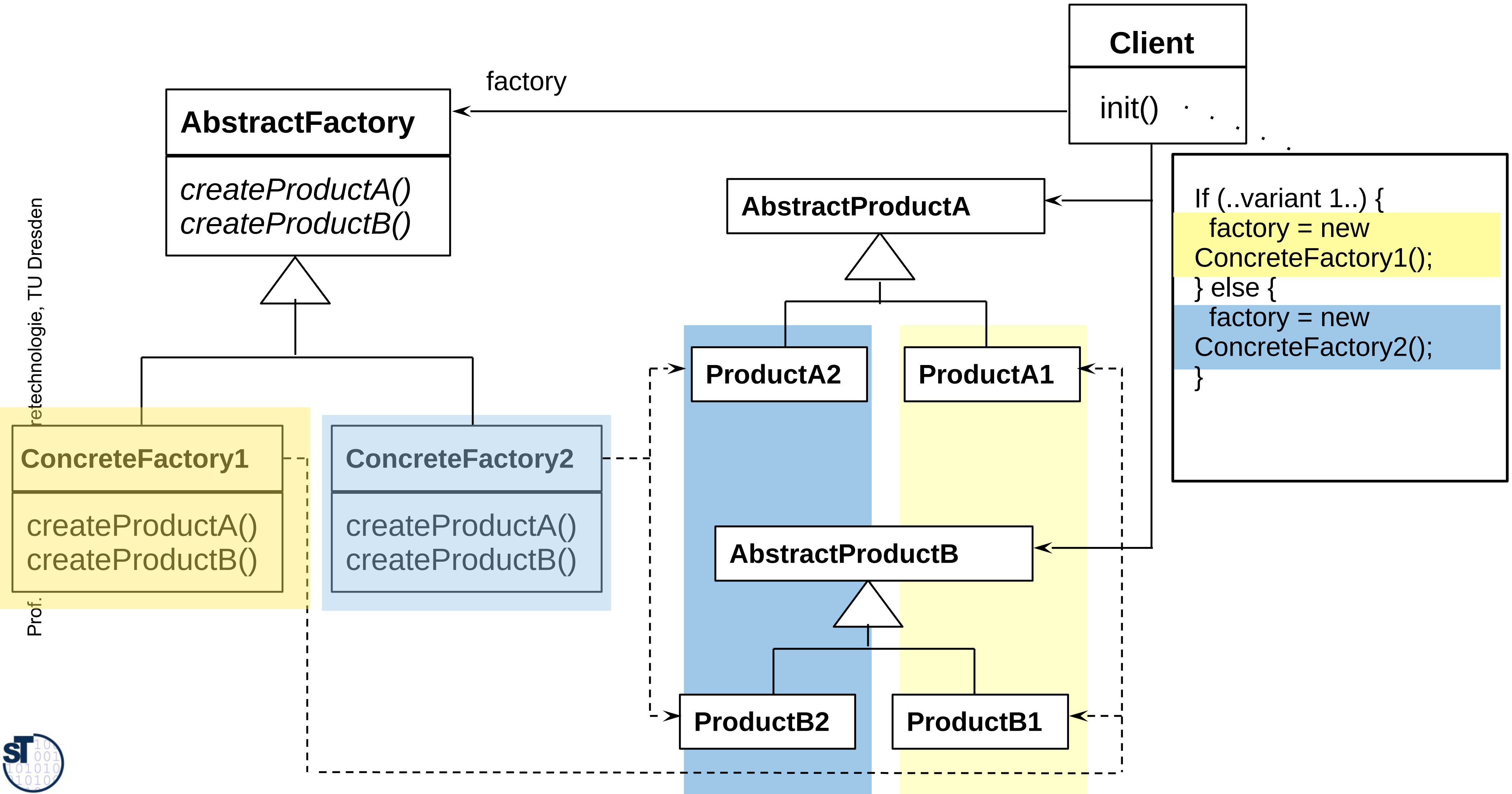


Binding the template method hooks with hook values (method implementations)

25.1.4. Factory Class

25.1.4 Factory Class (Abstract Factory)

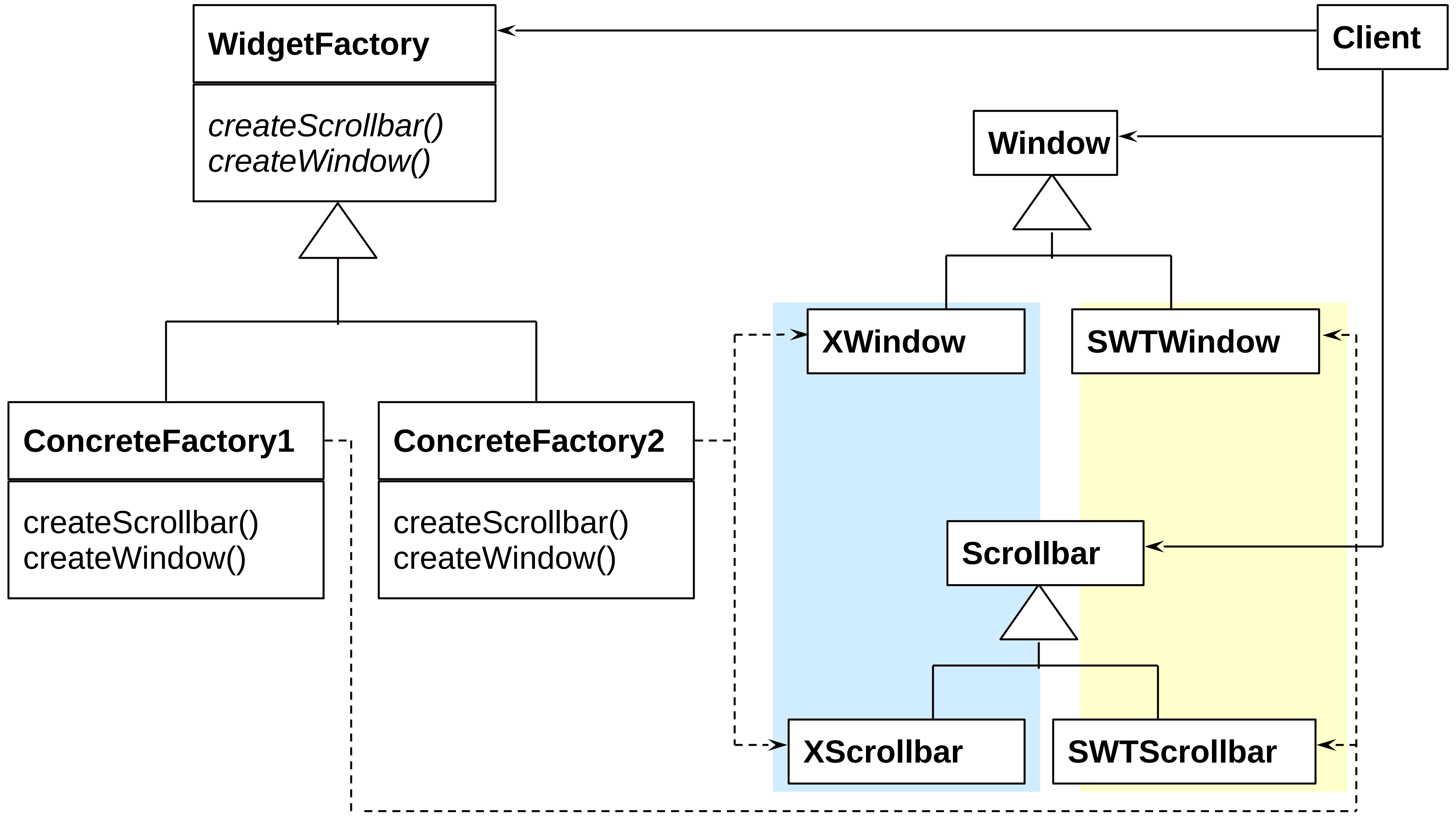
- Allocate a family of products {Ai, Bi, ..} in different “flavors” or “colors” {1, 2, ..}
- Vary consistently by exchange of factory and object families



```
If (..variant 1..) {
  factory = new
ConcreteFactory1();
} else {
  factory = new
ConcreteFactory2();
}
```

Example for Factory Class

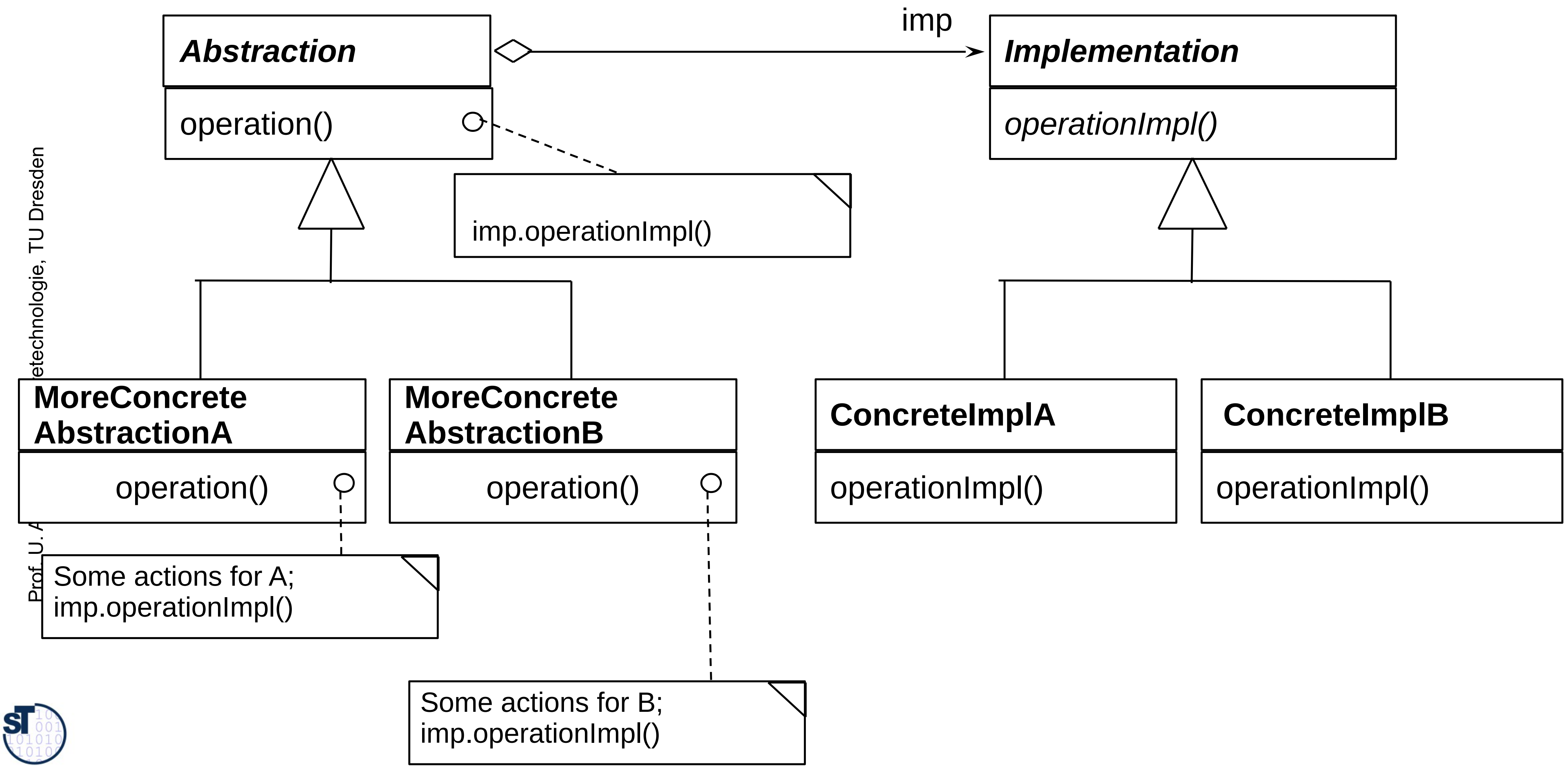
- Consistently varying a family of widgets



25.1.5 Bridge (Dimensional Class Hierarchies)

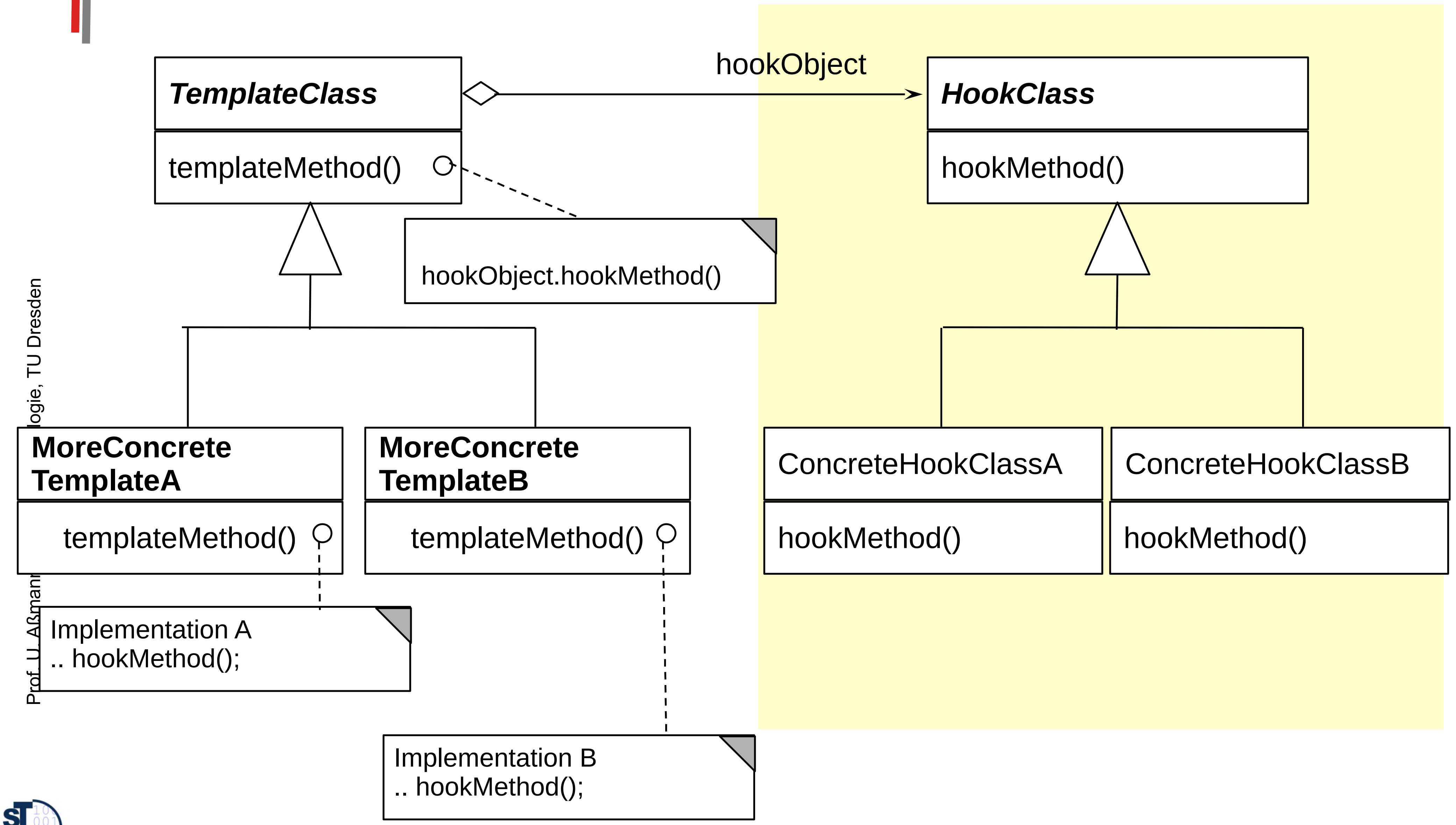
Bridge, GOF-Version

- A **Bridge** represents a *complex object* with two layers
- The left hierarchy (upper layer) is called *abstraction hierarchy,* the right hierarchy (lower layer) is called *implementation*

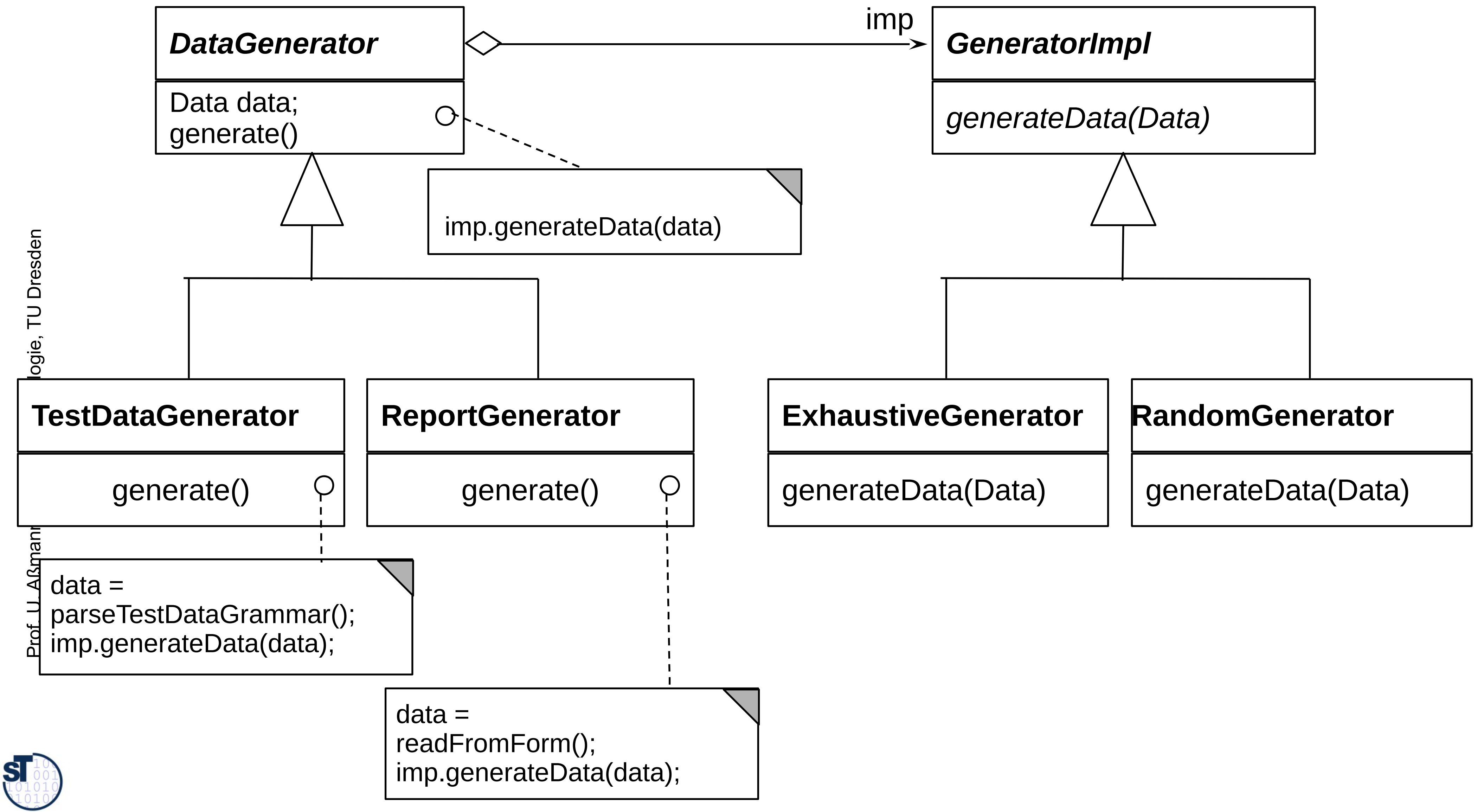


Bridge as Dimensional Class Hierarchies

- Bridge is an extension of TemplateClass

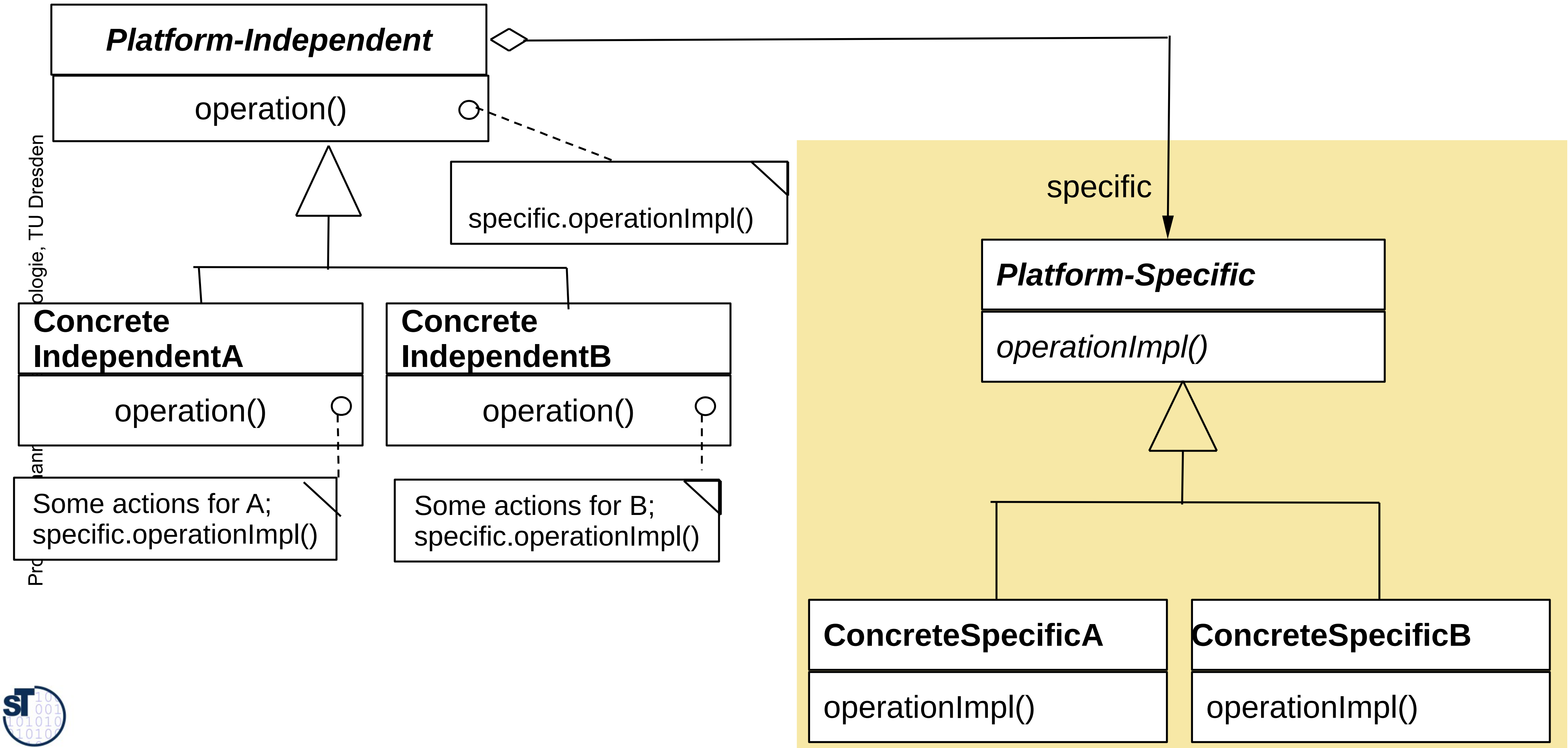


Ex. Complex Object *DataGenerator* as Bridge



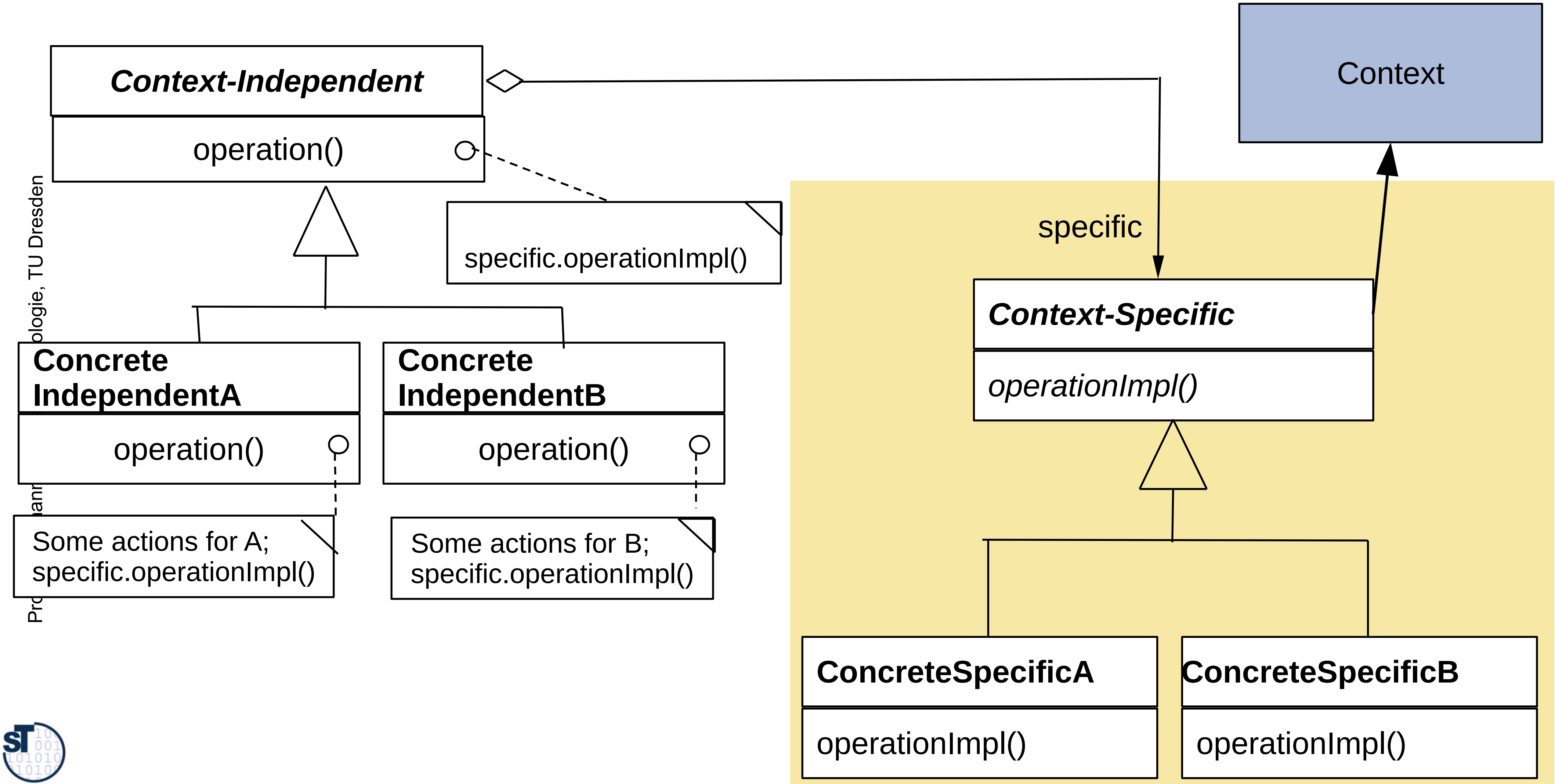
Use of Bridge for Separation of Platform-Independent from Platform-Dependent Code

- Bridge can be used to implement an object with *platform-independent (left/upper hierarchy)* and platform-specific part (lower/right hierarchy)
- For every type of platform, there must be one Bridge



Use of Bridge for Separation of Context-Independent from Context-Dependent Code

- Bridge can be used to implement an object with *context-independent (left/upper hierarchy)* and context-specific part (lower/right hierarchy)
- For every type of context, there must be one Bridge



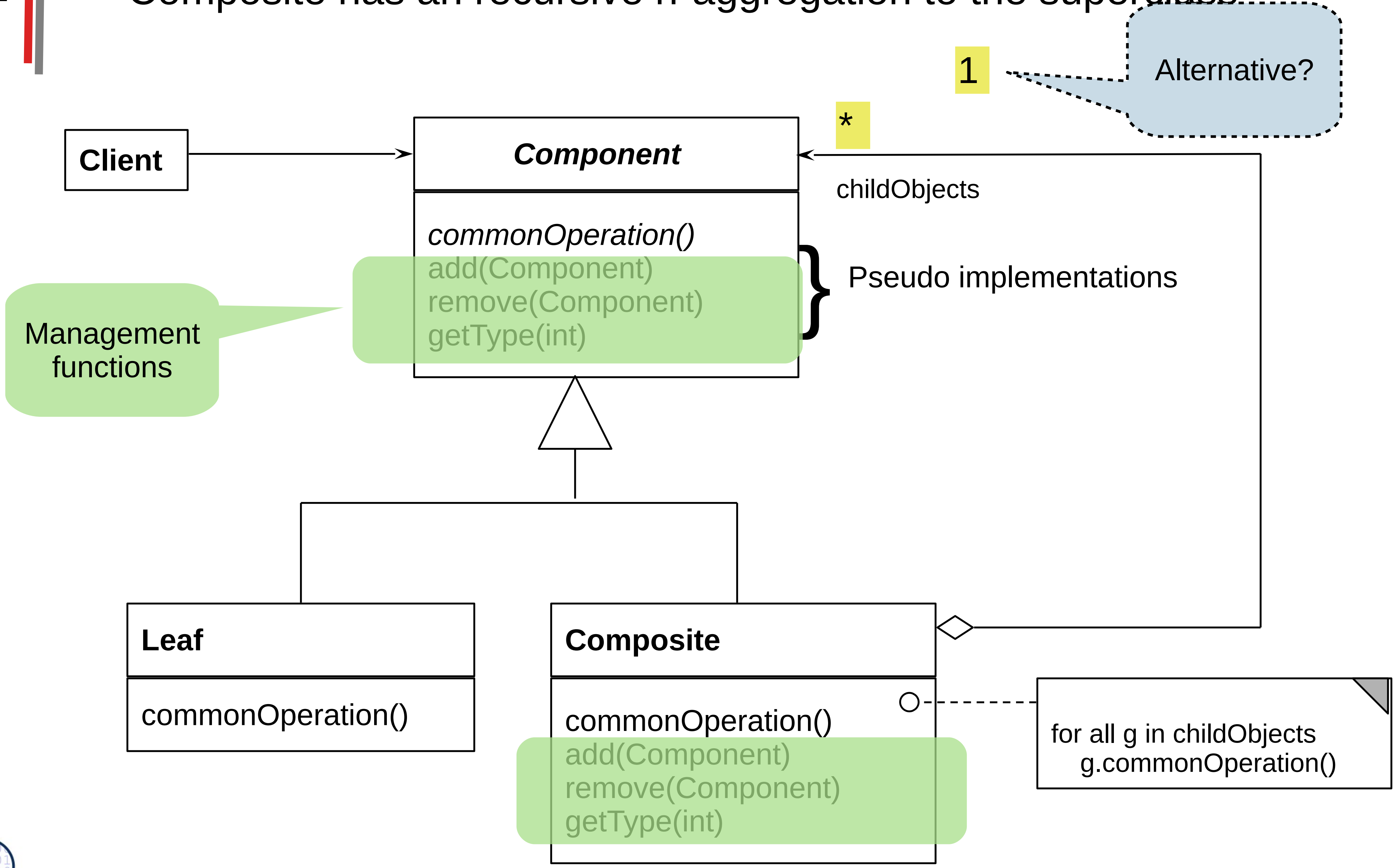
25.2) Patterns for Extensibility

Extensibility patterns describe how to build plug-ins (complements, extensions) to frameworks

Extensibility Pattern	# Run-time objects	Key feature
Composite	*	Whole/Part hierarchy
Decorator	*	List of skins
Callback	2	Dynamic call
Observer	1+*	Dynamic multi-call
Visitor	2	Extensible algorithms on a data structure
EventBus, Channel	*	Complex dynamic communication infrastructure (Appendix)

25.2.1 Structure Composite (Rpt.)

- Composite has an recursive n-aggregation to the superclass

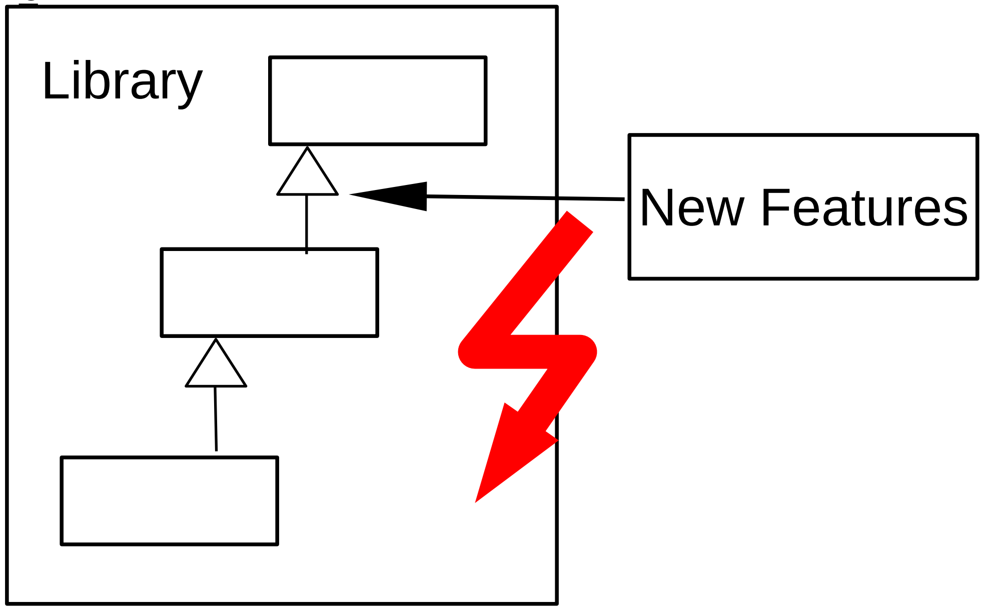


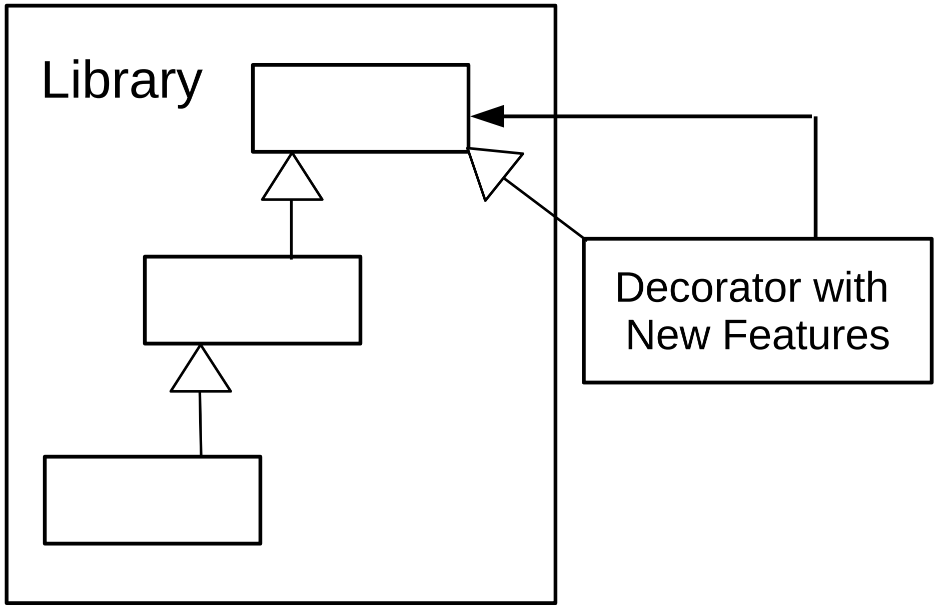
25.2.2. Decorator

- The “sibling” of Composite

Problem

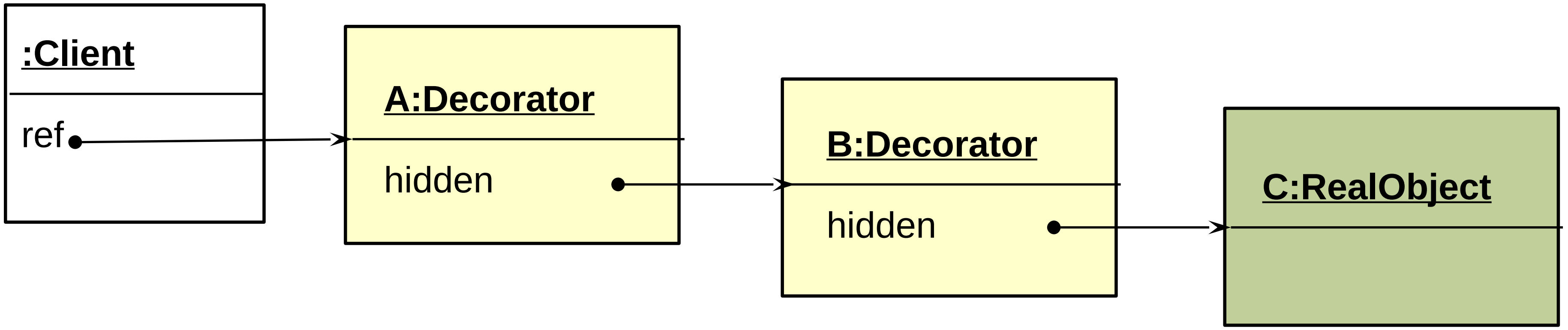
- How to extend an inheritance hierarchy of a library that was bought in binary form?
- How to avoid that an inheritance hierarchy becomes too deep?





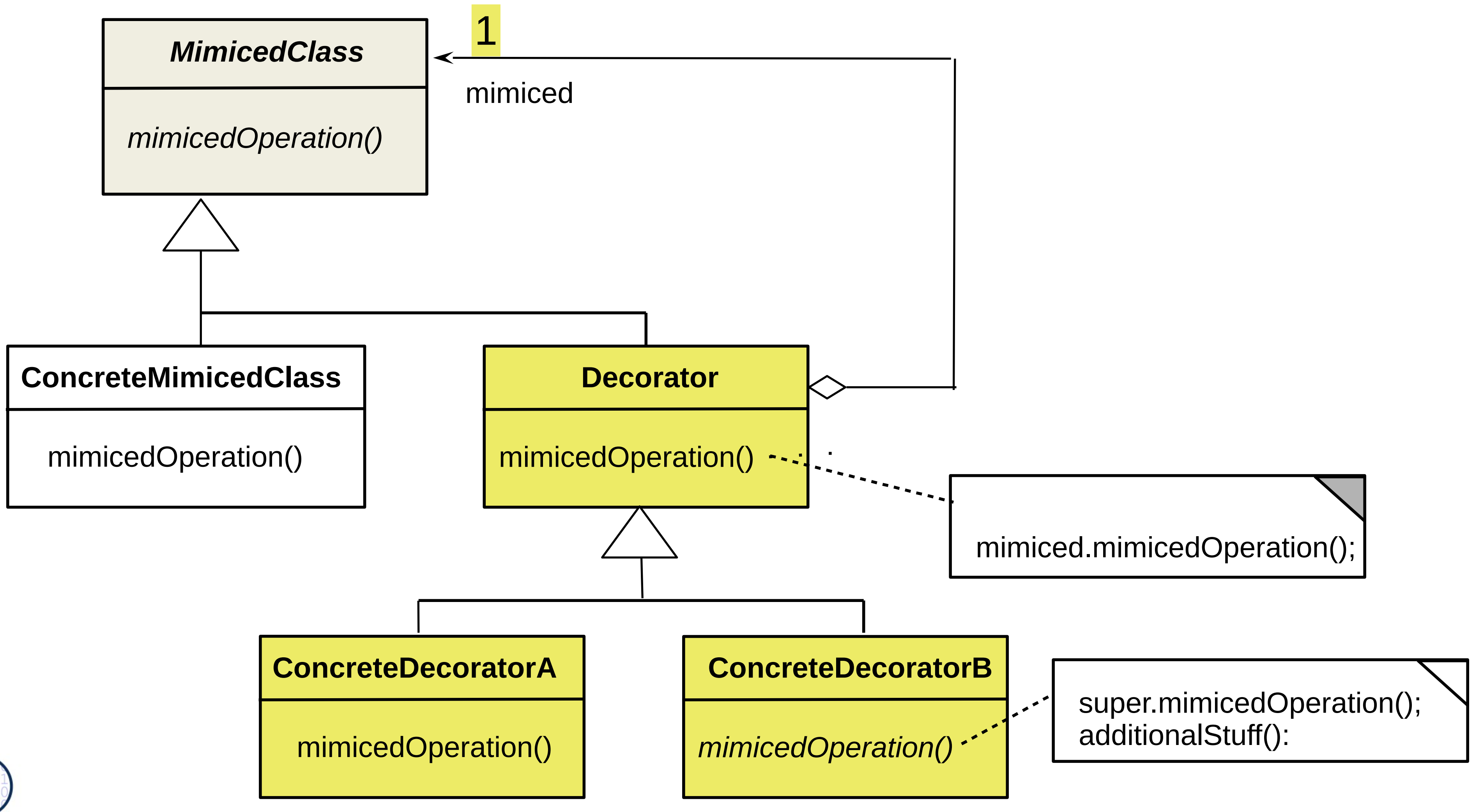
Decorator Pattern

- A Decorator object is a *skin* of another object
- The Decorator class *mimics* a class

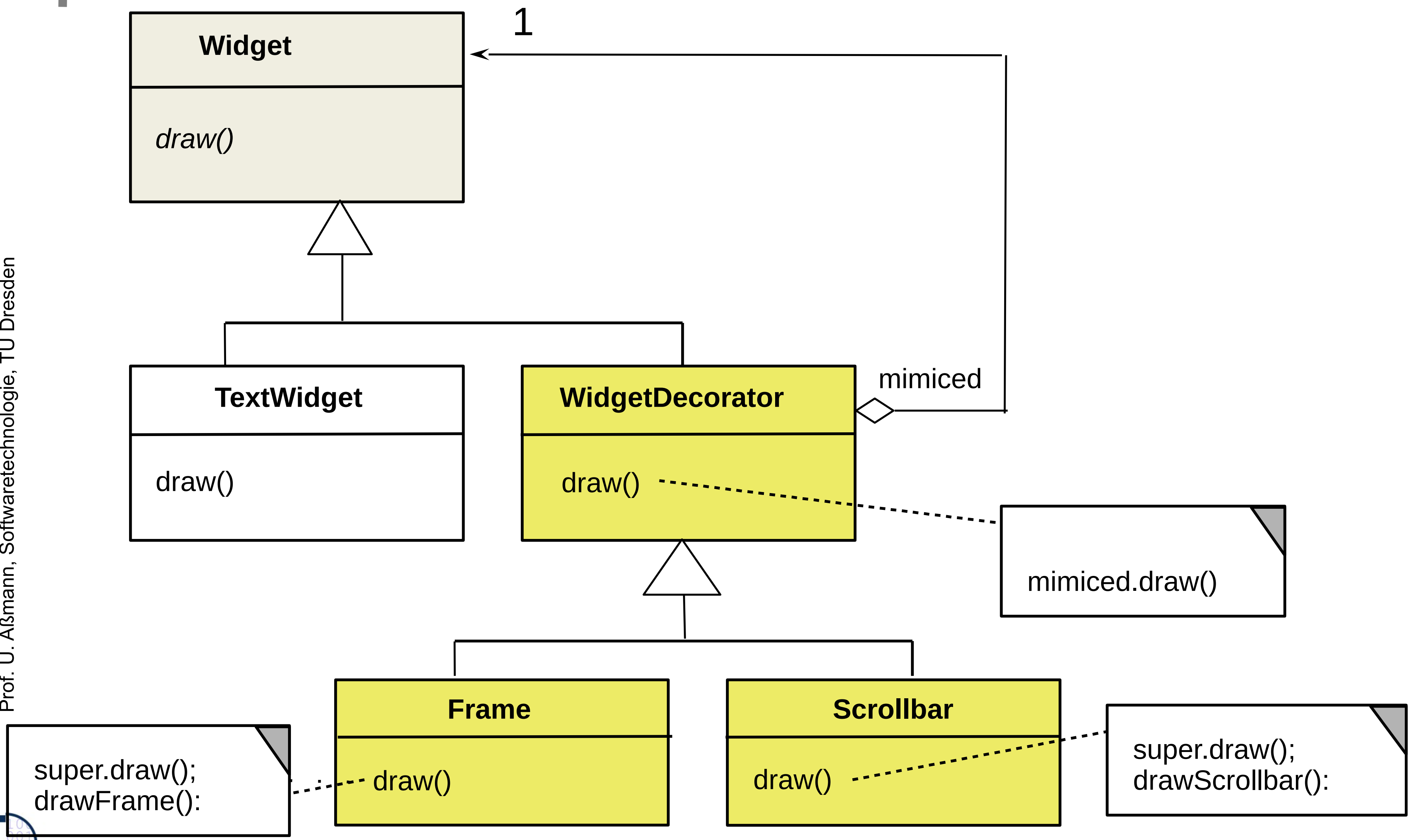


Decorator – Structure Diagram

- It is a restricted Composite with a 1-aggregation to the superclass
  - A subclass of a class that contains an object of the class as child
  - However, only one composite (i.e., a delegatee)
  - Combines inheritance with aggregation

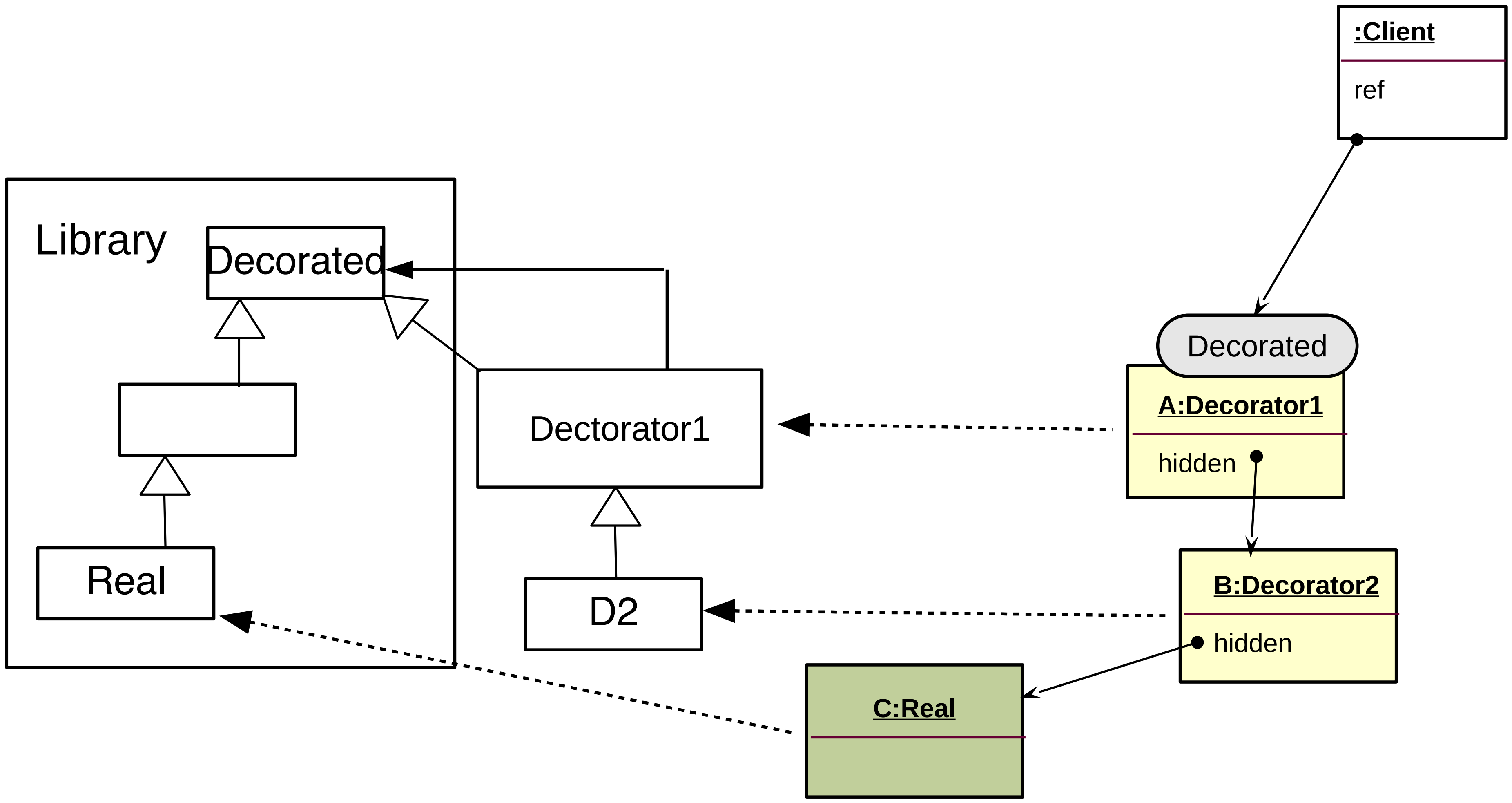


Ex.: Decorator for Widgets



Purpose Decorator

- For dynamically extensible objects (i.e., decoratable objects)
  - Addition to the decorator chain or removal possible
- For big objects

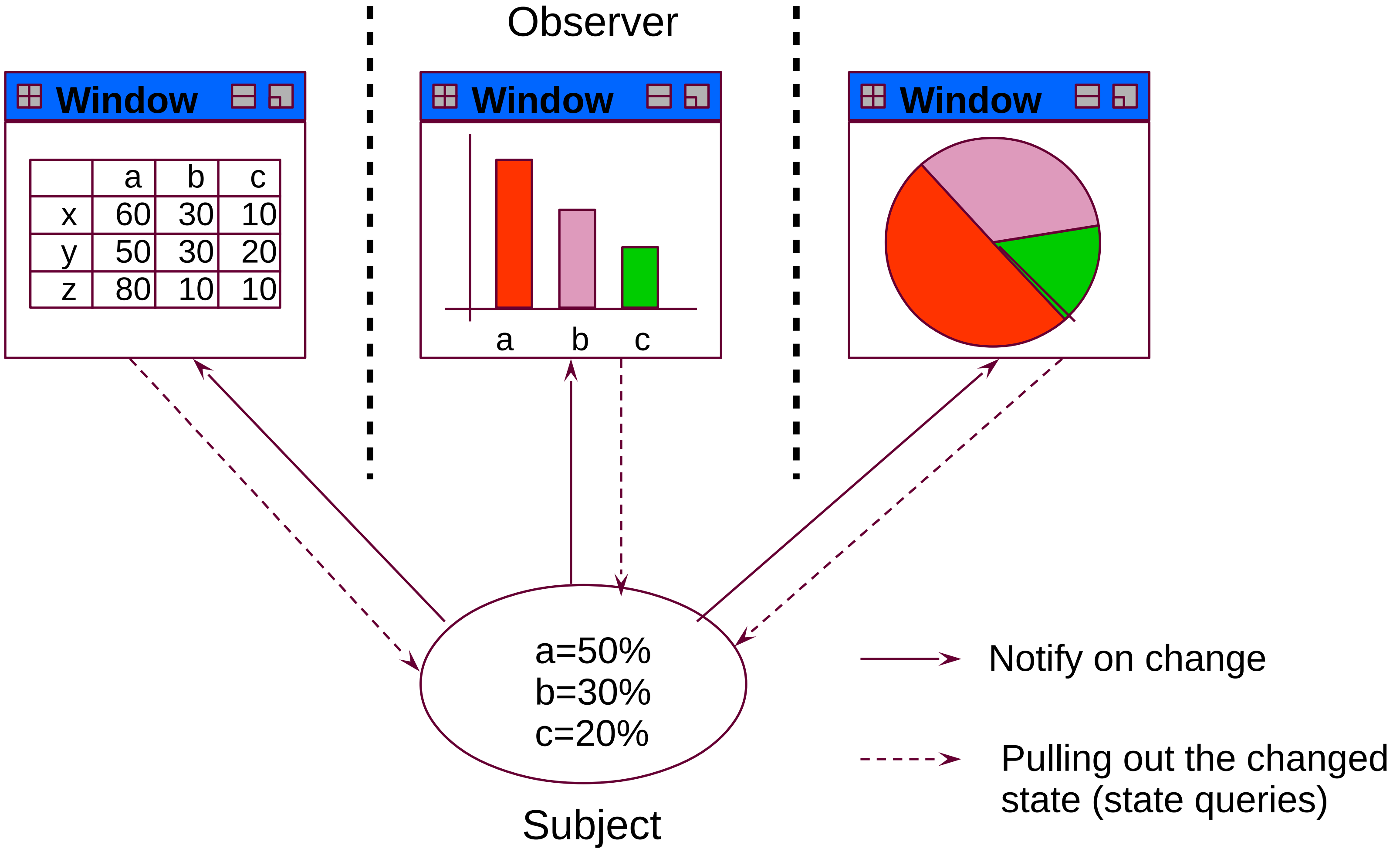


25.2.3 Different Kinds of Publish/Subscribe Patterns – (Event Bridge)

- Publish/Subscribe patterns are for dynamic, event-based communication in synchronous or asynchronous scenarios
- Subscribe functions build up dynamic communication nets
- Callback
- Observer
- EventBus

Publish/Subscribe Patterns

- Distinguish: Subscription of Observers to Subjects // Notification of event // Source of event (subject) // Data to be transfered // Relation of Subject and Observer
- Therefore, Observer exists in several variants (push, pull, CallBack, EventBus, ChannelBus)



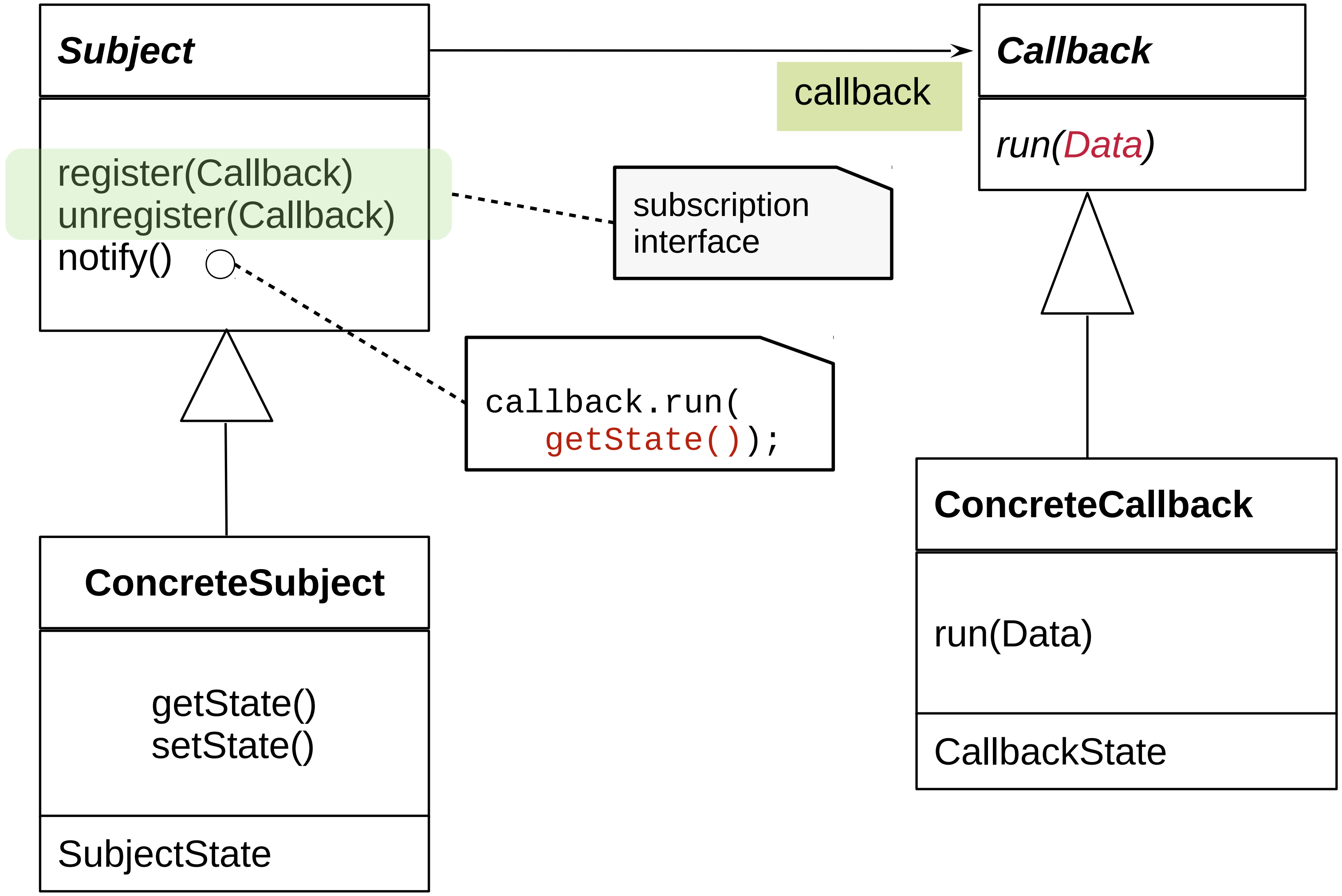
Overview

Push		Data is flowing with the call to “update”
	Callback	1 observer
	Observer	n observer
Pull		Data is pulled on demand
	Callback	1 observer
	Observer	n observer

- A **callback** is an observer pattern with **one** observer

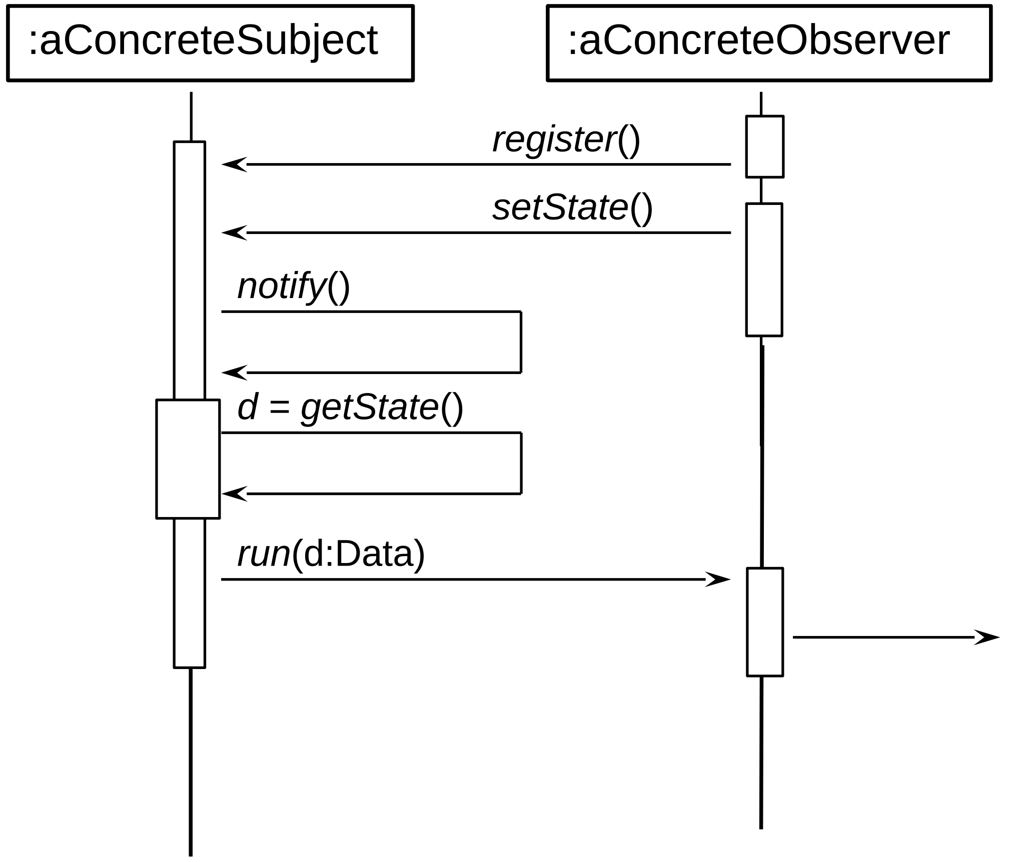
25.2.3.1 Publish/Subscribe with 1 Observer: Callback

- **Callbacks** have only one observer. It is not known statically, but registered dynamically, at run time
- A **(push-)Callback** pushes its data with the call to `run`



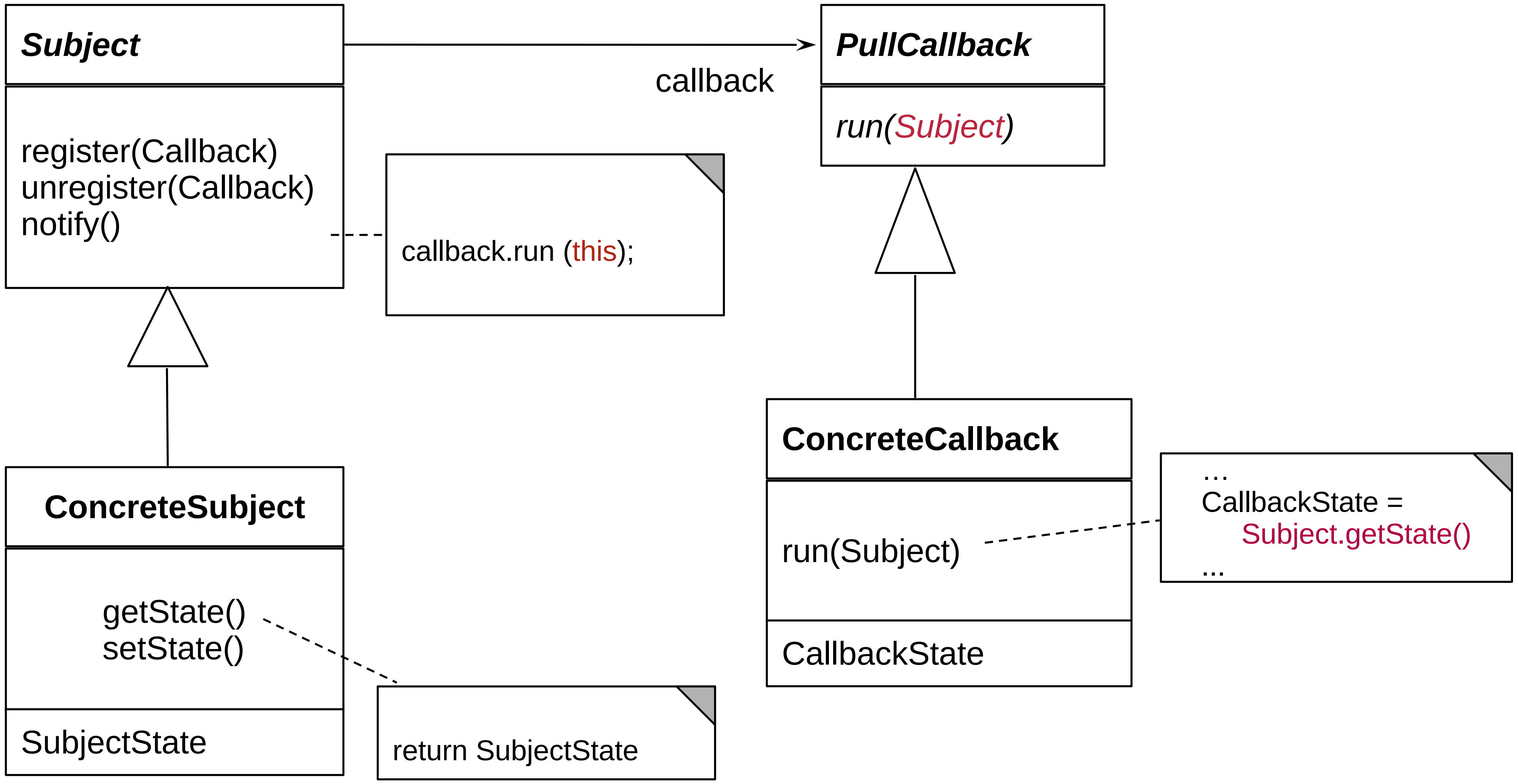
Sequence Diagram push-Callback

- run() directly transfers Data to Observer (push)



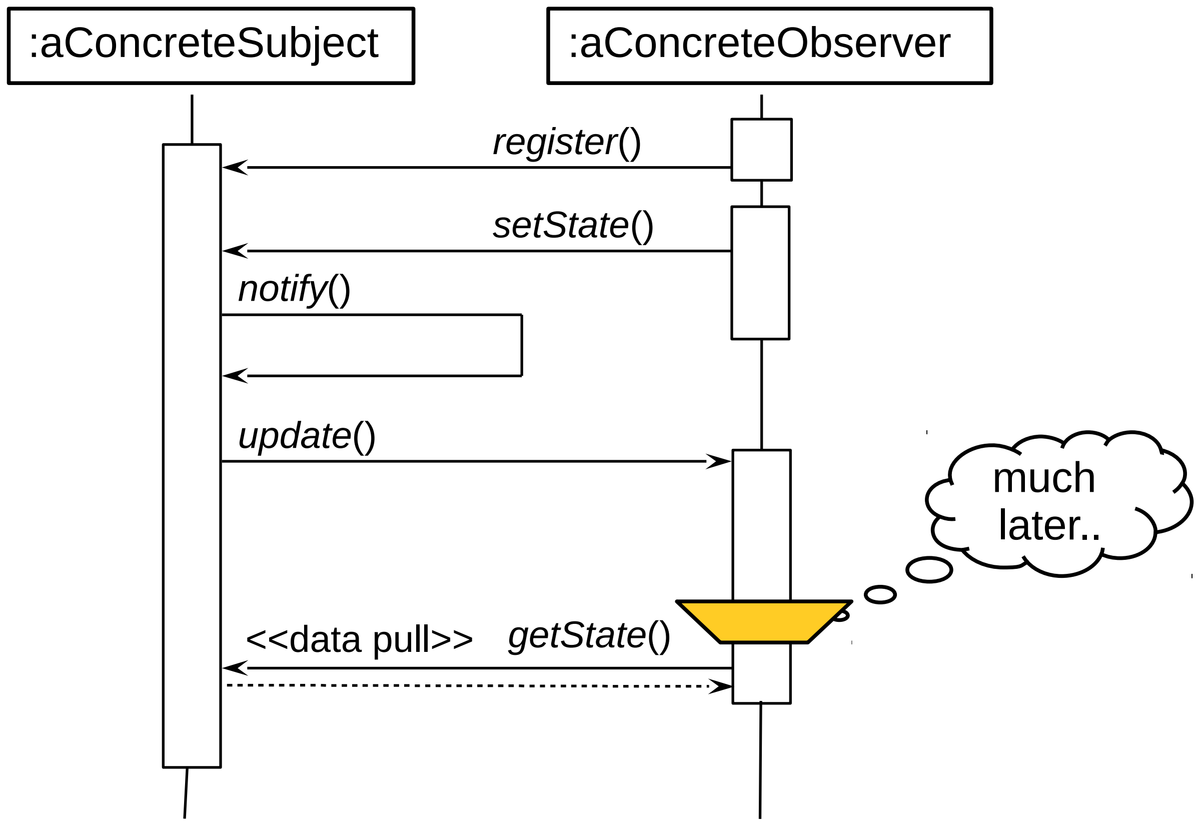
25.2.3.2 Structure pull-Callback

- A **pull-Callback** must push the Subject to later pull the data
- Responsibility for pull lies with the Callback



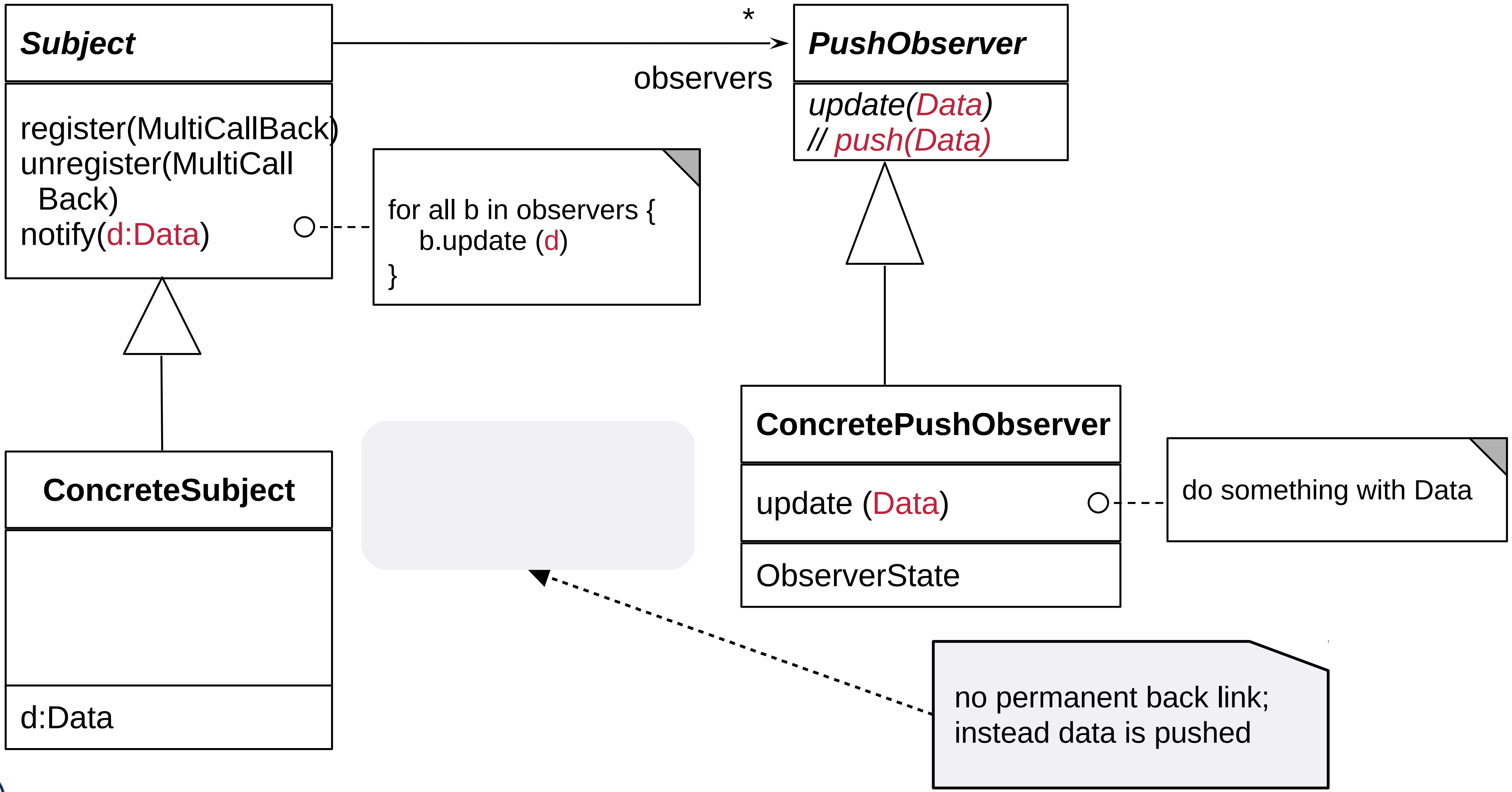
Sequence Diagram pull-Callback

- Update() does not transfer data, only an event (anonymous communication possible)
  - Observer pulls data out itself with getState()
  - Lazy processing (on-demand processing)



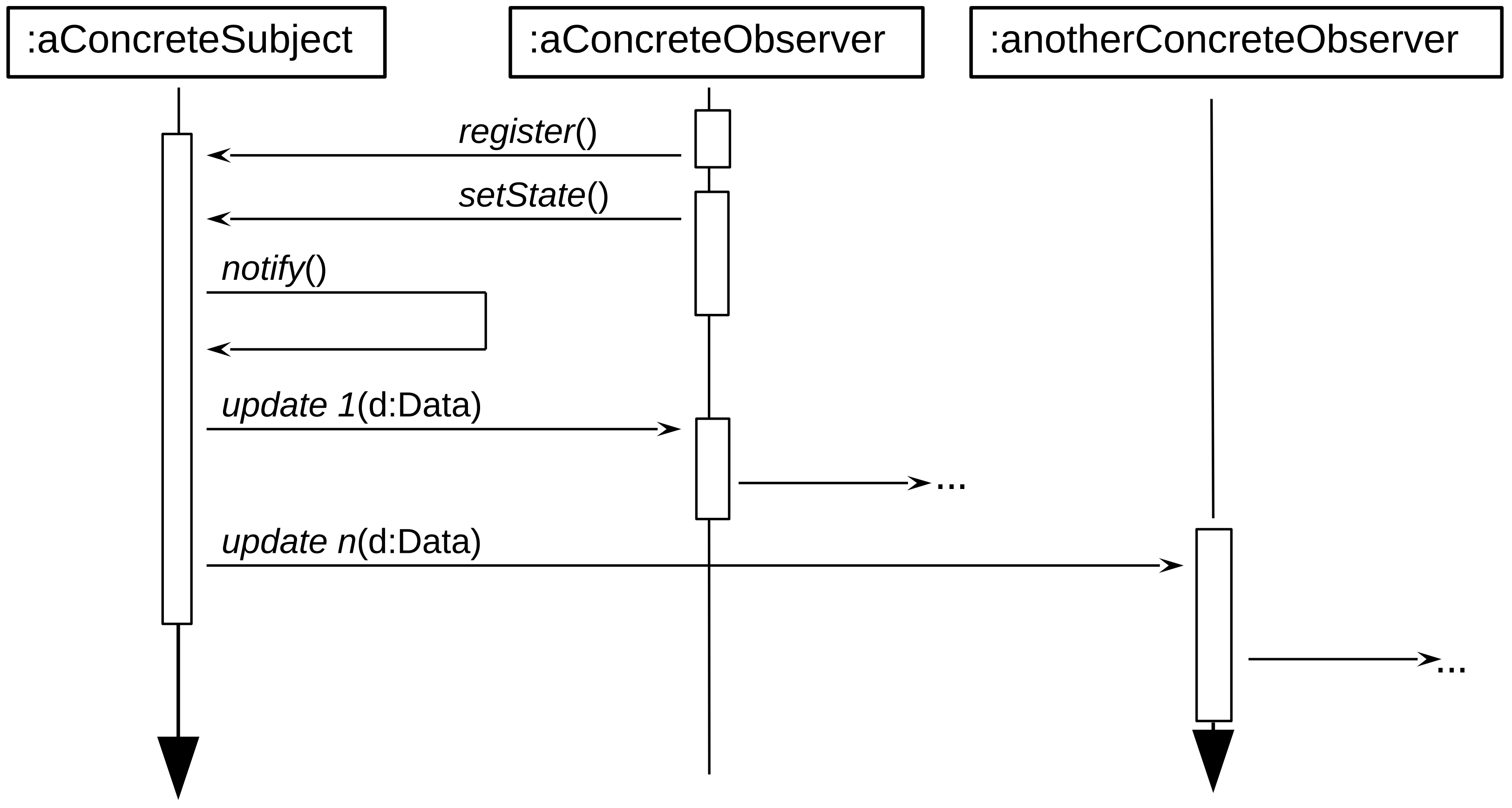
25.2.3.3 Structure push-Observer

- Subject pushes data with `update(Data)`
- Pushing resembles *Sink*, if data is pushed iteratively



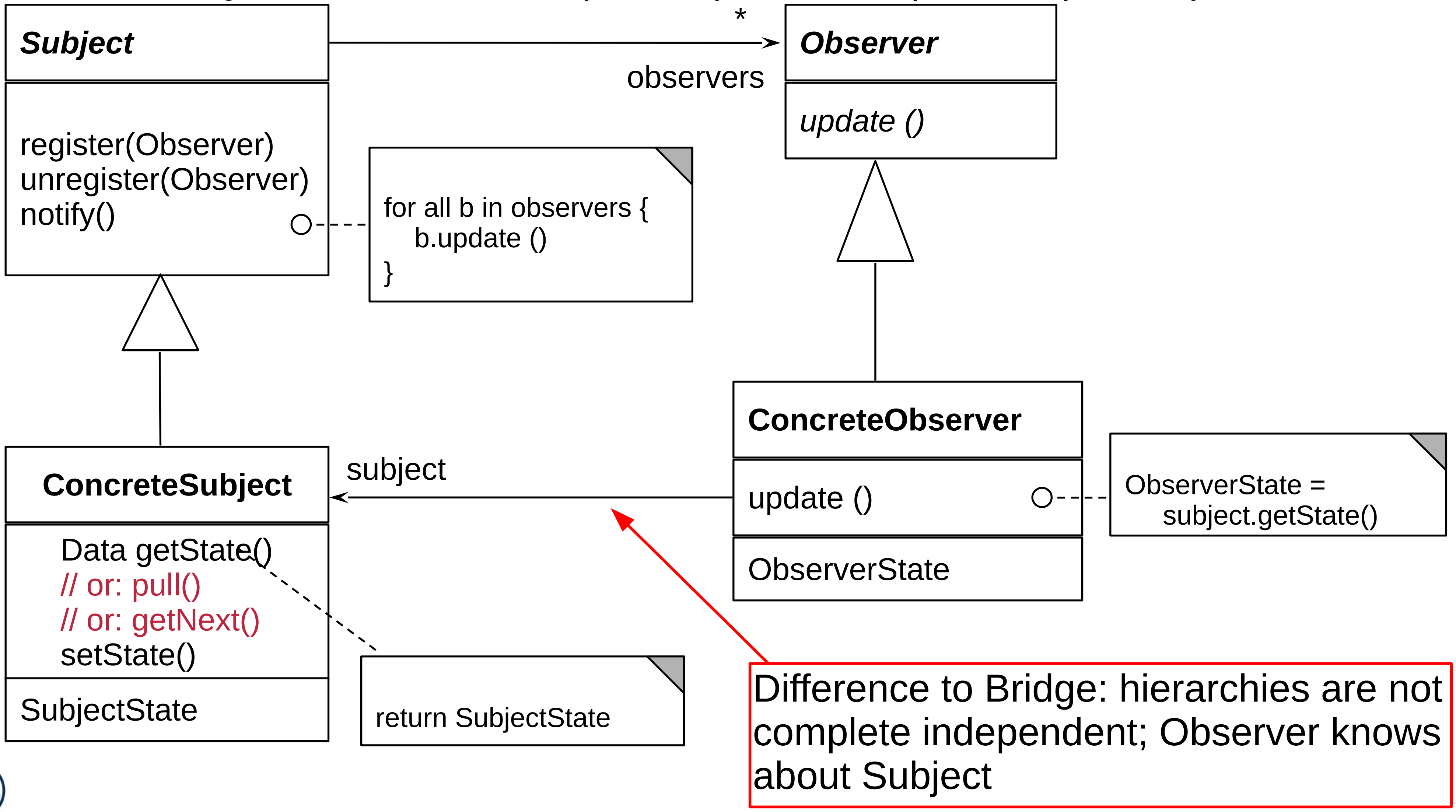
Sequence Diagram push-Observer

- Update() transfers Data to Observer (push)



25.2.3.4 Pull-Observer (Rpt.)

- The pull-Observer does not push anything, but pulls data later out with getState() or getNext() (same as in Iterator)
- Pulling resembles *Iterator (Stream)*, if data is pulled repeatedly



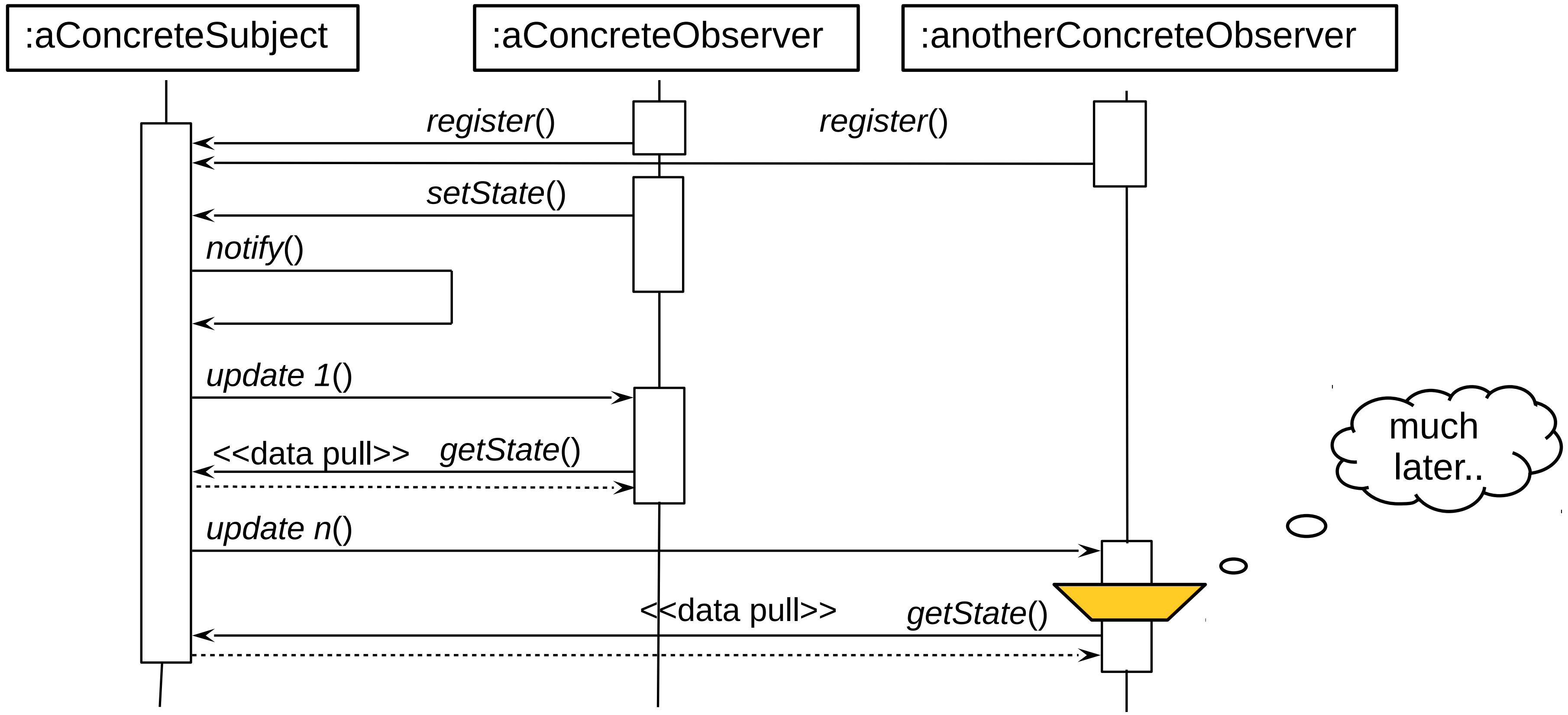
```
for all b in observers {
    b.update ()
}
```

```
ObserverState =
    subject.getState()
```

Difference to Bridge: hierarchies are not complete independent; Observer knows about Subject

Sequence Diagram pull-Observer

- Update() does not transfer data, only an event (anonymous communication possible)
  - Observer pulls data out itself with getState()
  - Lazy processing (on-demand processing)
- pull-Observer uses Iterator, if data is pulled iteratively



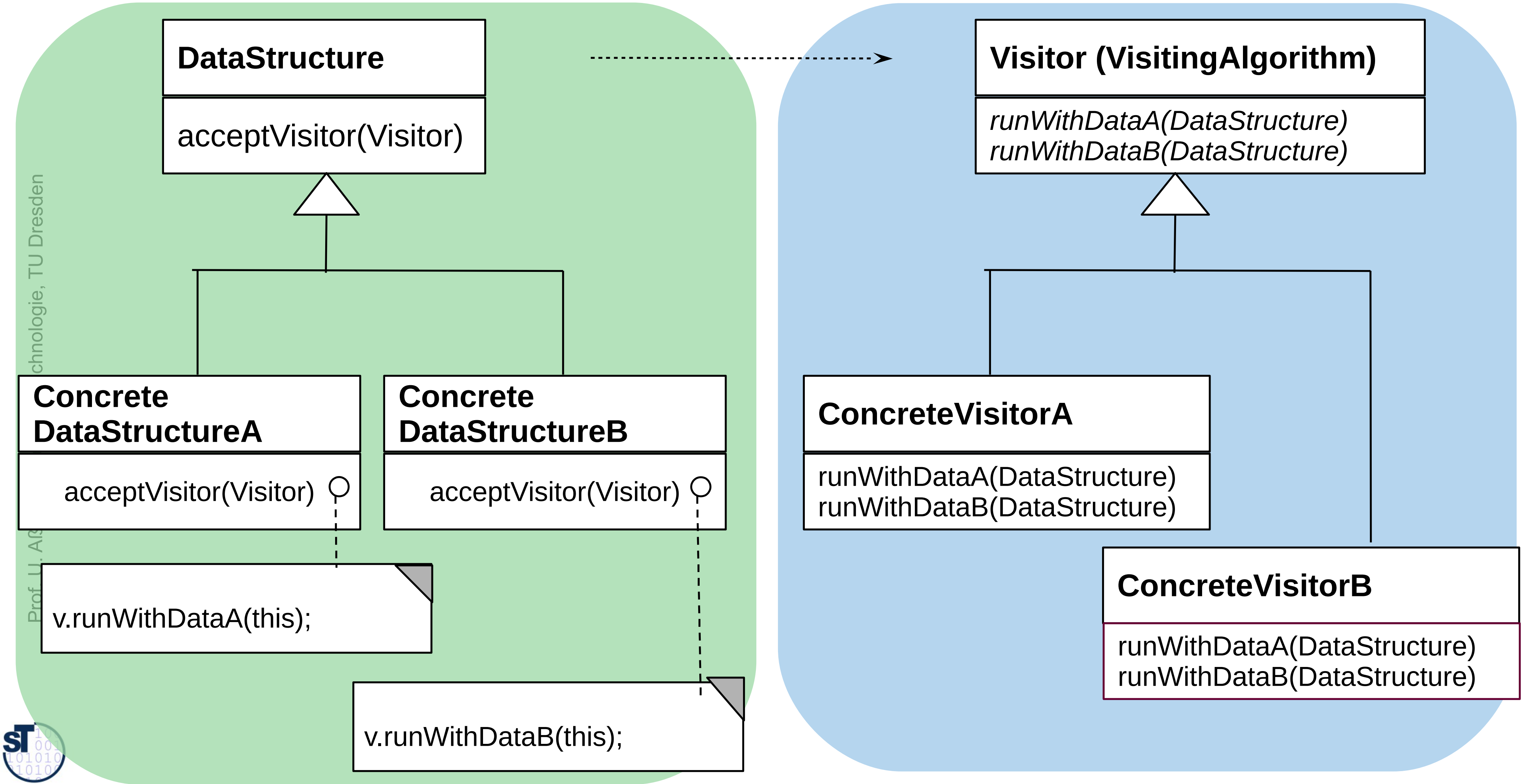
25.2.4. Visitor

Visitor provides an extensible family of algorithms on a data structure

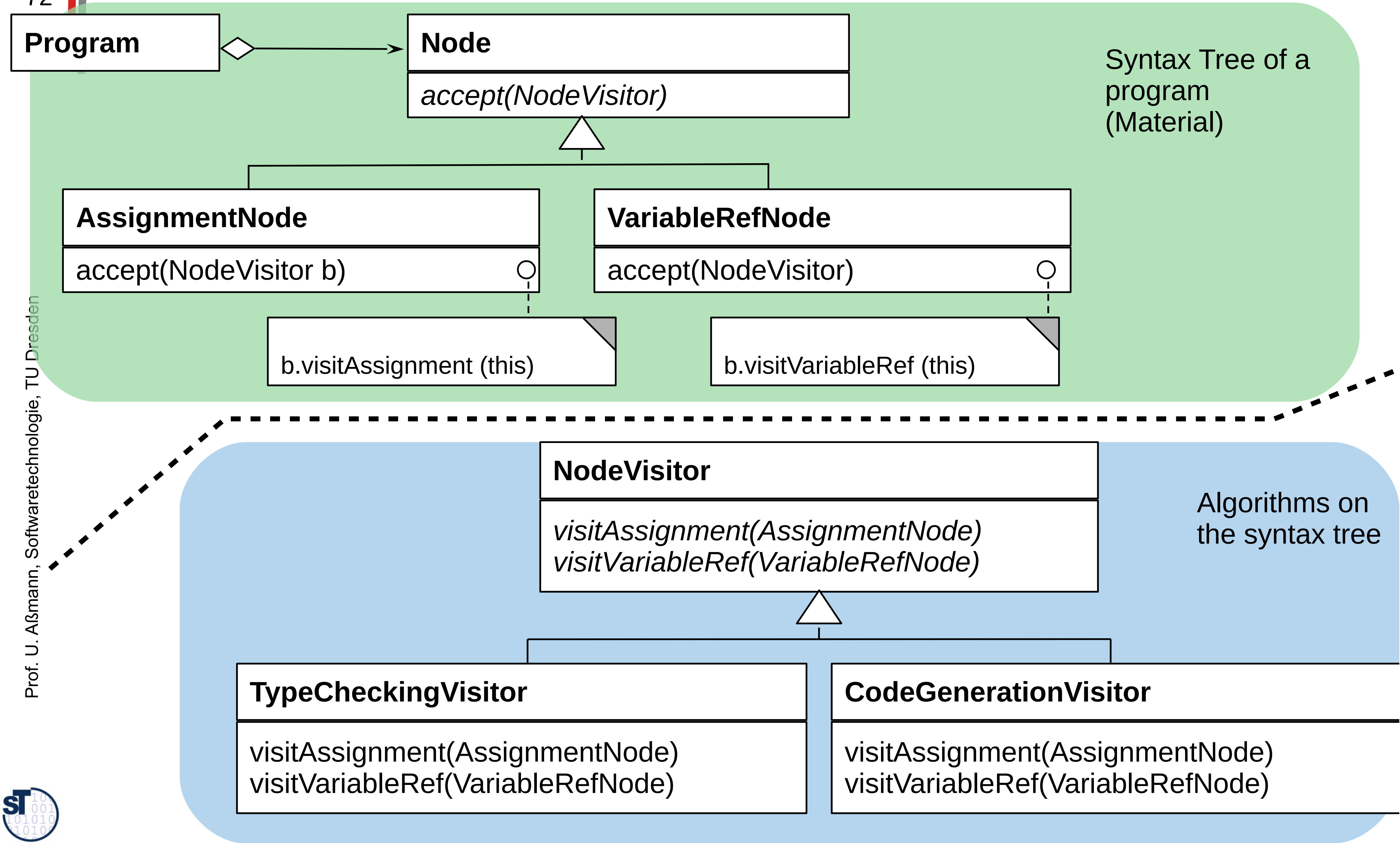
Powerful pattern for Materials

Visitor (VisitingAlgorithm)

- Implementation of *complex object* with a 2-dimensional structure
  - First dispatch on dimension 1 (data structure), then on dimension 2 (algorithm)
  - The Visitor has a lot of Callback methods
- Beauty: visiting algorithms can be added without touching the DataStructure

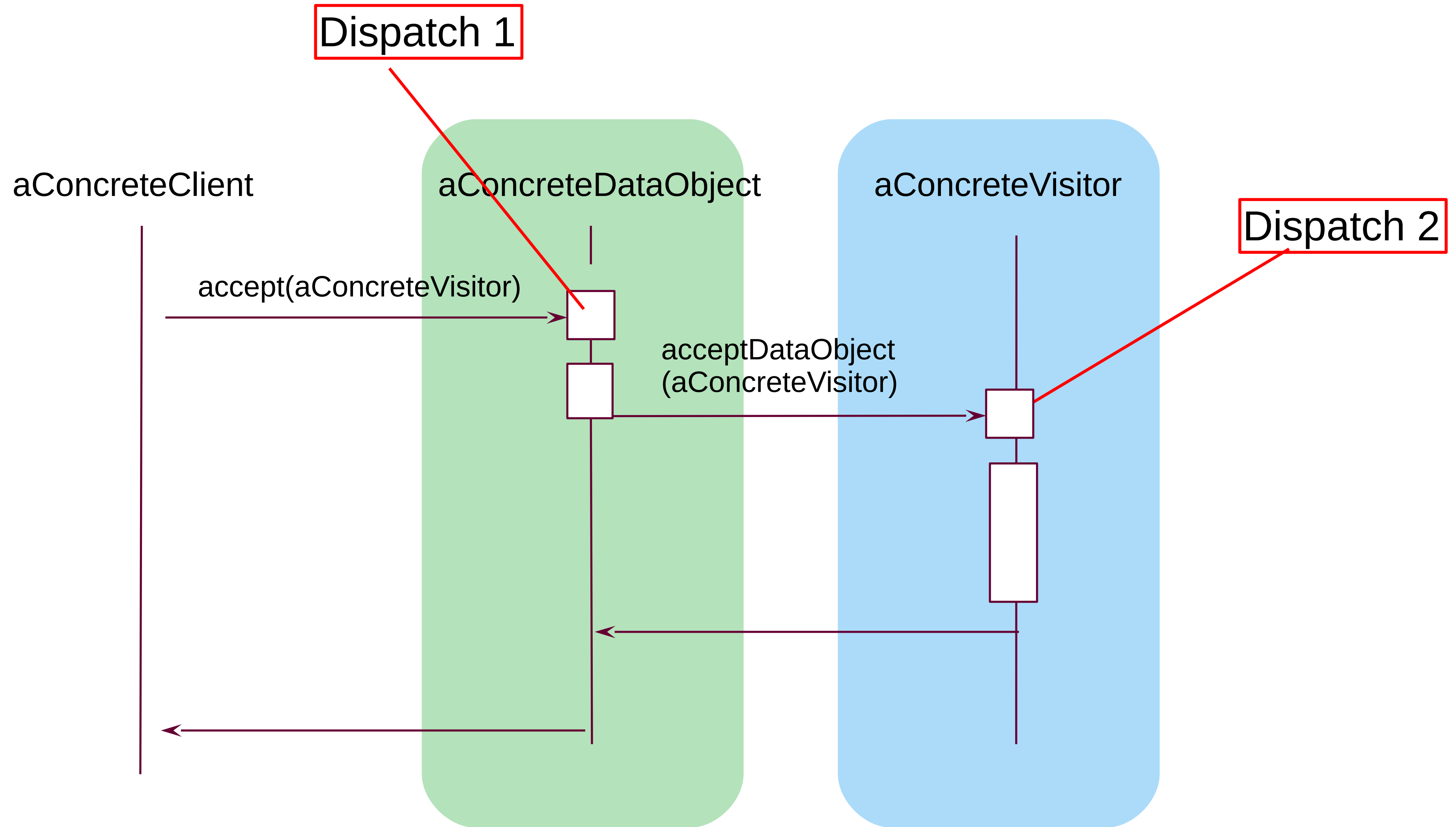


Working on Syntax Trees of Programs with Visitors


Program
Node
accept(NodeVisitor)
Syntax Tree of a program (Material)
AssignmentNode
accept(NodeVisitor b)
VariableRefNode
accept(NodeVisitor)
b.visitAssignment (this)
b.visitVariableRef (this)
NodeVisitor
visitAssignment(AssignmentNode)
visitVariableRef(VariableRefNode)
Algorithms on the syntax tree
TypeCheckingVisitor
visitAssignment(AssignmentNode)
visitVariableRef(VariableRefNode)
CodeGenerationVisitor
visitAssignment(AssignmentNode)
visitVariableRef(VariableRefNode)

Sequence Diagram Visitor

- First dispatch on data, then on visiting algorithm

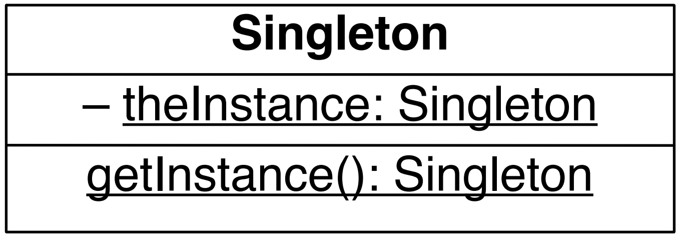


25.3) Patterns for Glue - Bridging Architectural Mismatch

Glue Pattern	# Run-time objects	Key feature
Singleton	1	Only one object per class
Adapter	2	Adapting interfaces and protocols that do not fit
Facade	1+*	Hiding a subsystem
Class Adapter	1	Integrating the adapter into the adapteel
Proxy (Appendix)	2	1-decorator

25.3.1 Singleton (dt.: Einzelinstanz)

- Problem: Store the global state of an application
  - Ensure that only *one* object exists of a class



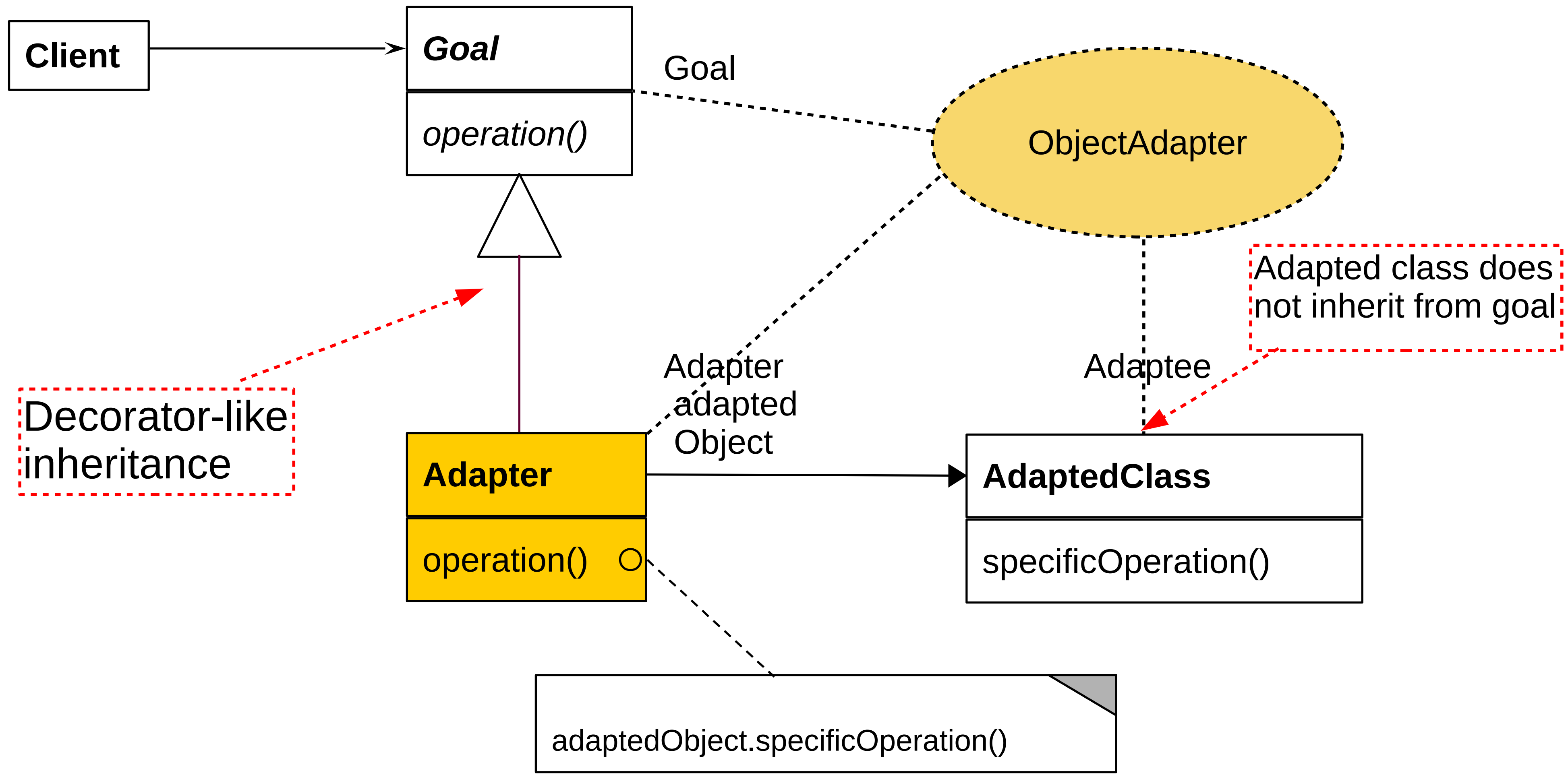
The usual constructor is invisible

```
class Singleton {

  private static Singleton theInstance;

  private Singleton () {}

  public static Singleton getInstance() {
    if (theInstance == null)
      theInstance = new Singleton();
    return theInstance;
  }
}
```

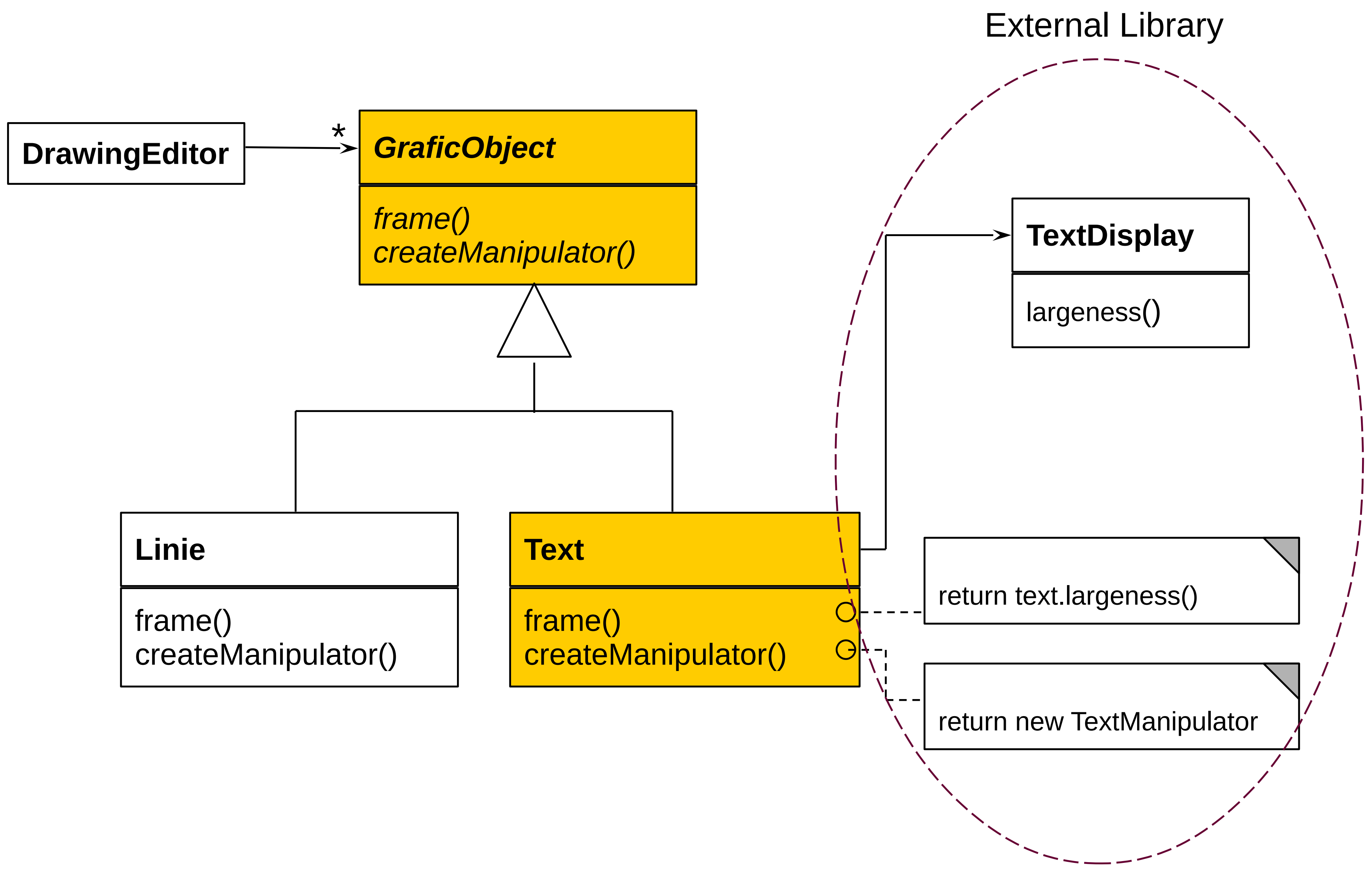
25.3.2 Adapter

Object Adapter

- An **object adapter** is a kind of a proxy mapping one interface, protocol, or data format to another

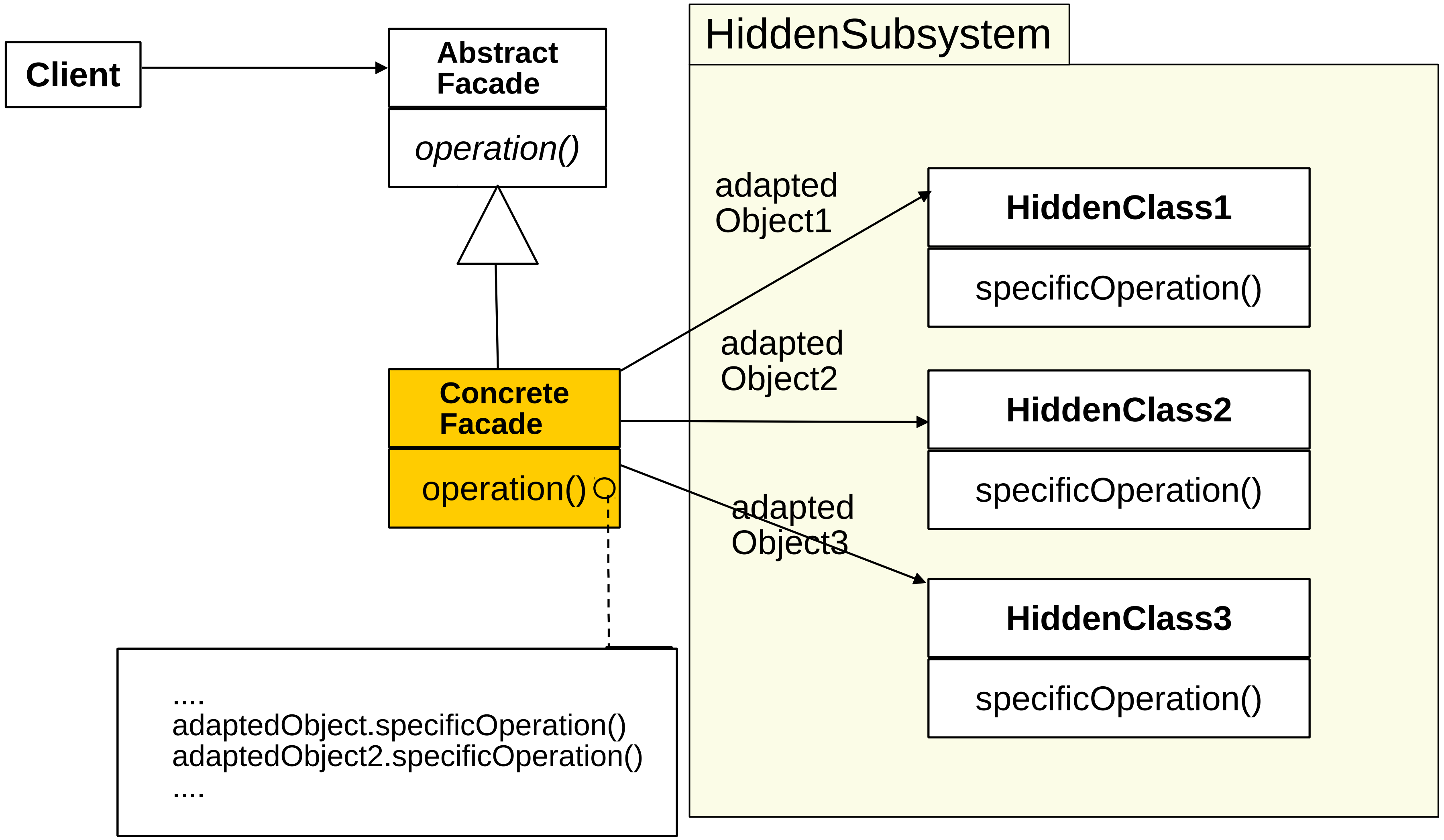


Example: Use of an External Class Library For Texts



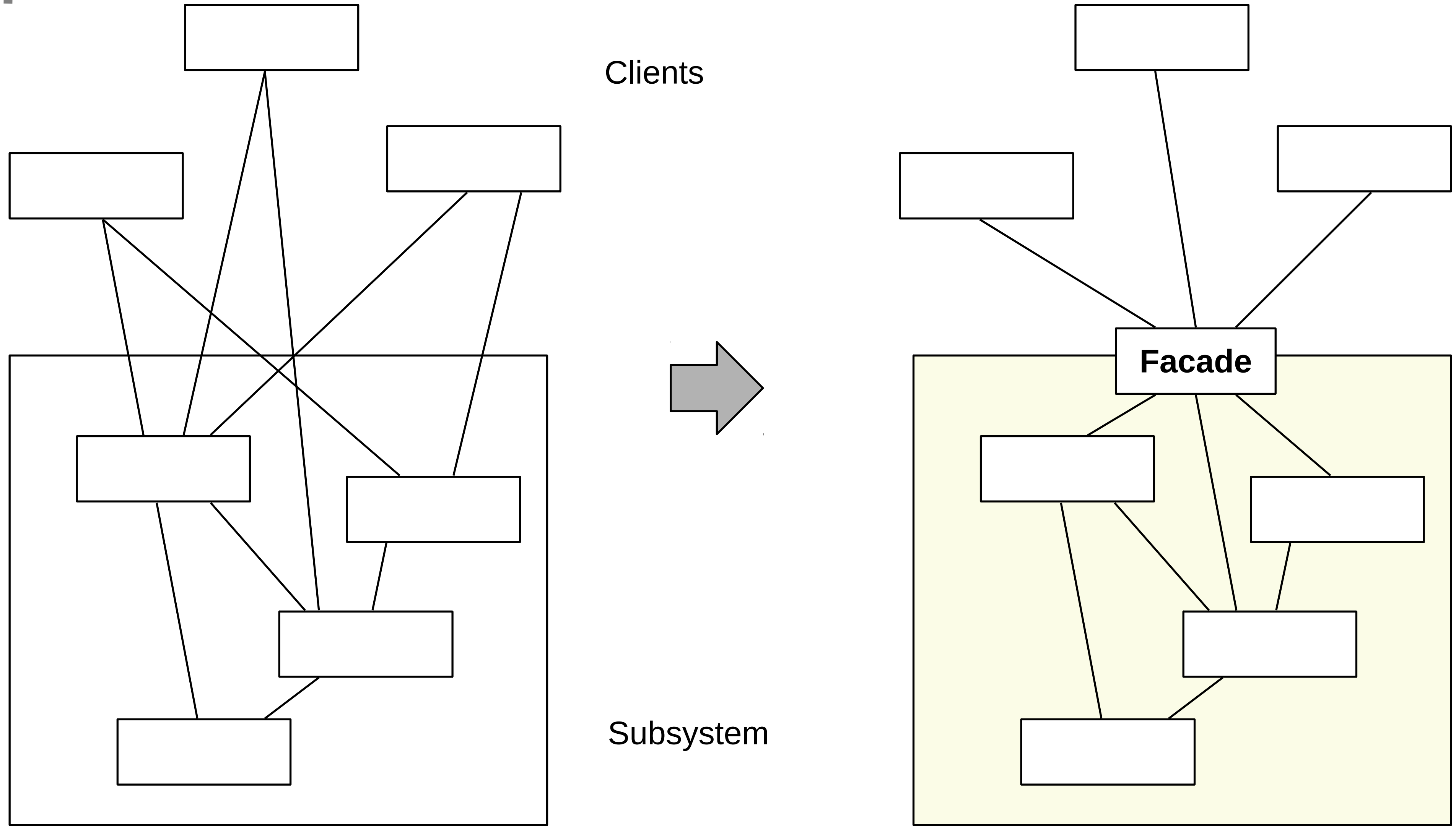
25.3.3 Facade Hides a Subsystem

- A **facade** is an object adapter hiding a complete set of objects (subsystem)
  - The facade has to map its own interface to the interfaces of the hidden objects



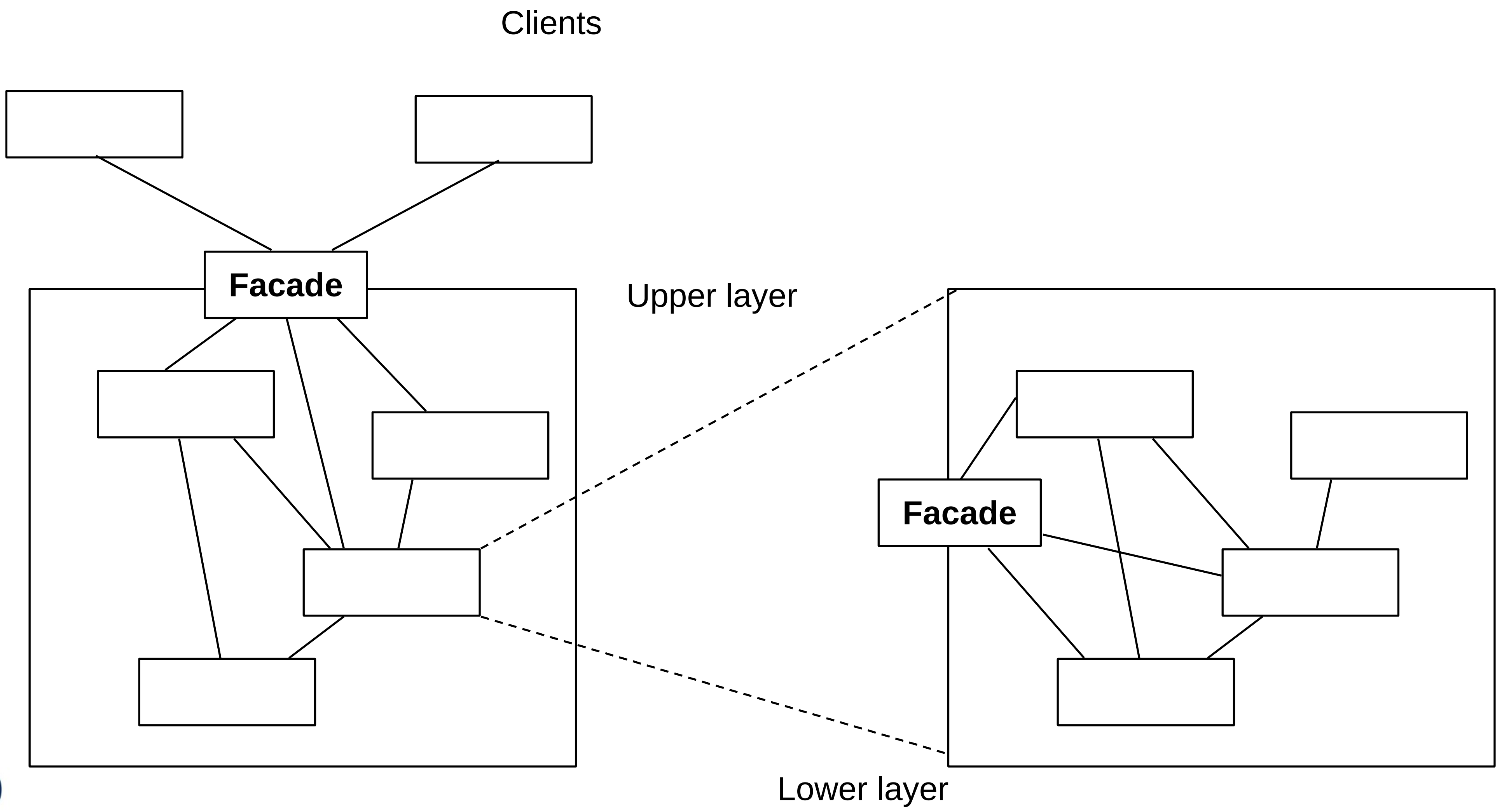
Refactoring Towards a Facade

- After a while, components are too much intermingled
- Facades serve for clear layered structure



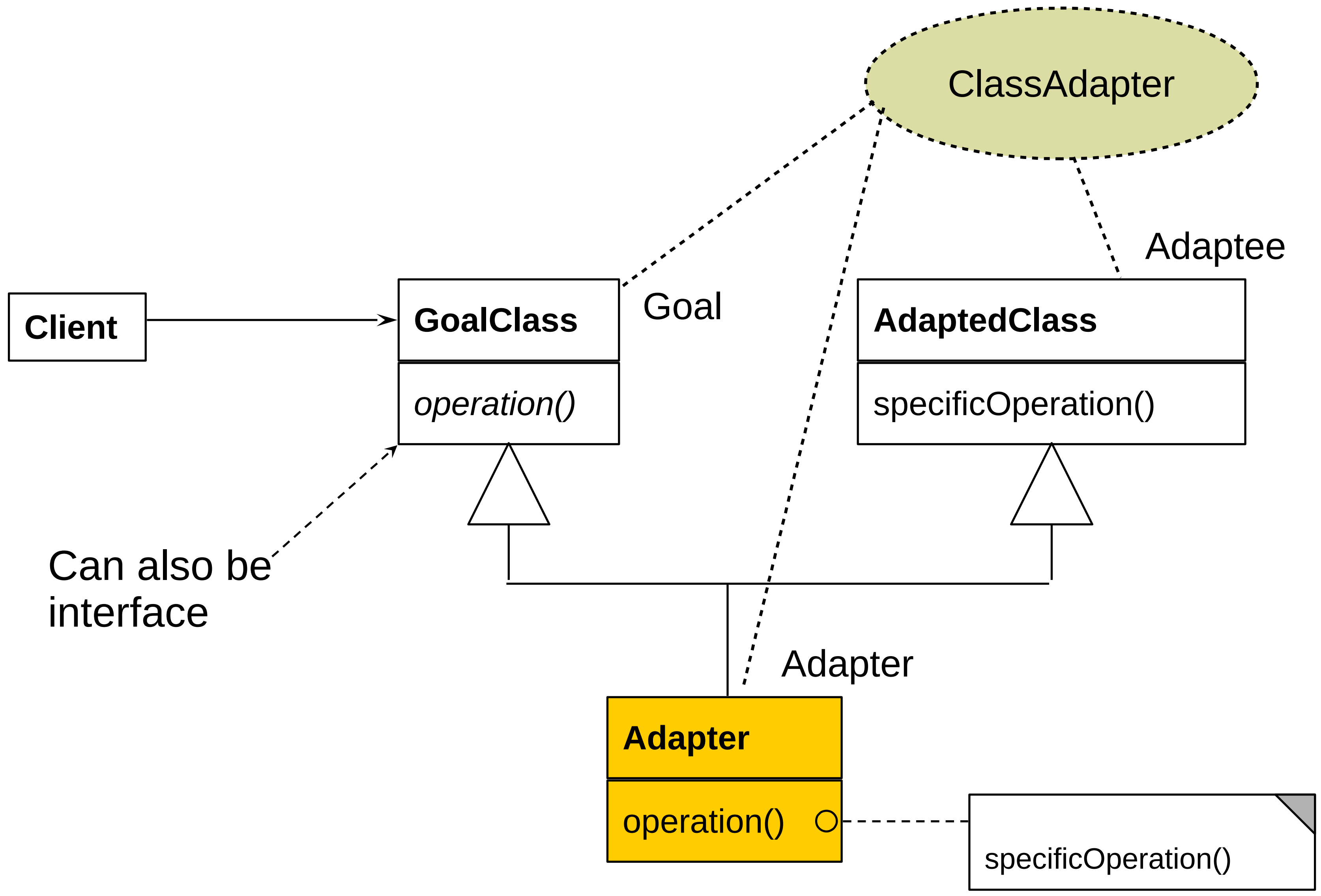
Facade and Layers

- If classes of the subsystem are again facades, **layers** result
  - Layers need nested facades



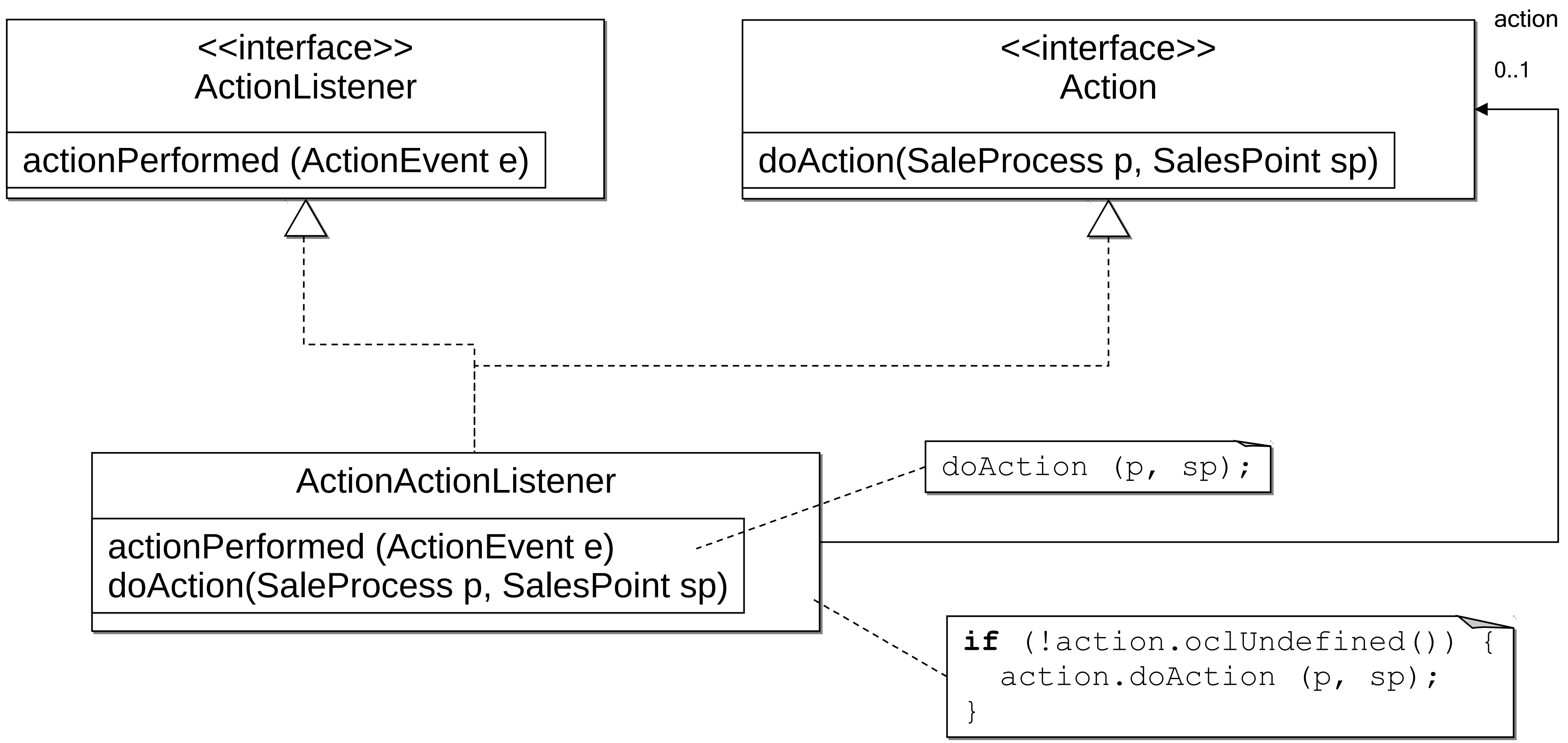
25.3.4 Class Adapter

- Instead of delegation, class adapters use multiple inheritance



Adapter for Observer in SalesPoint Framework

- In the SalesPoint framework (project course), a ClassAdapter is used to embed an Action class in an Listener of Observer Pattern



<<interface>>
ActionListener
actionPerformed (ActionEvent e)
<<interface>>
Action
doAction(SaleProcess p, SalesPoint sp)
action
0..1
ActionActionListener
actionPerformed (ActionEvent e)
doAction(SaleProcess p, SalesPoint sp)

```
doAction (p, sp);
```

```
if (!action.oclUndefined()) {
  action.doAction (p, sp);
}
```

25.4 Other Patterns

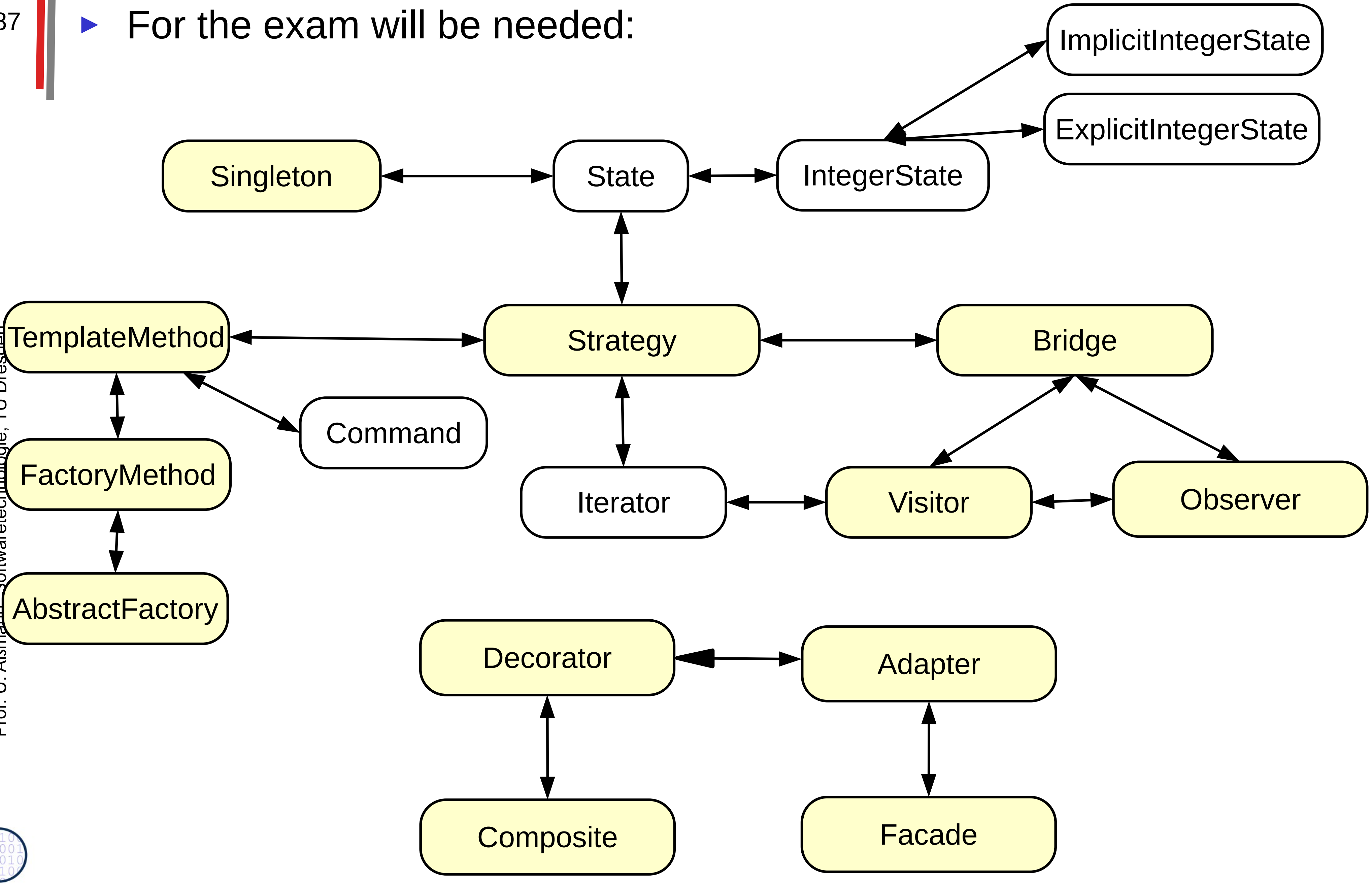
What is discussed elsewhere...

- Iterator, Sink, and Channel
- Composite
- TemplateMethod
- Command

- Chapter “Analysis”:
  - State (Zustand), IntegerState, Explicit/ImplicitIntegerState
- Chapter “Architecture”:
  - Facade (Fassade)
  - Layers (Schichten)
  - 4-tier architecture (4-Schichtenarchitektur, BCED)
  - 4-tier abstract machines (4-Schichtenarchitektur mit abstrakten Maschinen)

Relations between Design Patterns

- For the exam will be needed:



Other Important GOF Patterns

Variability Patterns

- Visitor: Separate a data structure inheritance hierarchy from an algorithm hierarchy, to be able to vary both of them independently
- AbstractFactory: Allocation of objects in consistent families, for frameworks which maintain lots of objects
- Builder: Allocation of objects in families, adhering to a construction protocol
- Command: Represent an action as an object so that it can be undone, stored, redone

Extensibility Patterns

- Proxy: Representant of an object
- ChainOfResponsibility: A chain of workers that process a message

Others

- Memento: Maintain a state of an application as an object
- Flyweight: Factor out common attributes into heavy weight objects and flyweight objects

25.5 Design Patterns in a Larger Library

Design Pattern in the AWT

- AWT/Swing is part of the Java class library
  - Uniform window library for many platforms (portable)
- Employed patterns
  - Observer (for widget super class java.awt.Window)
  - Compositum (widgets are hierarchic)
  - Strategy: The generic composita must be coupled with different layout algorithms
  - Singleton: Global state of the library
  - Bridge: Widgets such as Button abstract from look and provide behavior
    - Drawing is done by a GUI-dependent drawing engine (pattern bridge)
  - Abstract Factory: Allocation of widgets in a platform independent way

What Have We Learned?

- Design Patterns grasp good, well-known solutions for standard problems
- Variability patterns allow for variation of applications
  - They rely on the template/hook principle
- Extensibility patterns for extension
  - They rely on recursion
  - An aggregation to the superclass
  - This allows for constructing runtime nets: lists, sets, and graphs
  - And hence, for dynamic extension
- Architectural Glue patterns map non-fitting classes and objects to each other

Why is the Frauenkirche Beautiful?

- ..because she contains a lot of patterns from the baroque pattern language...

The End

- Design patterns and frameworks, WS, contains more material.
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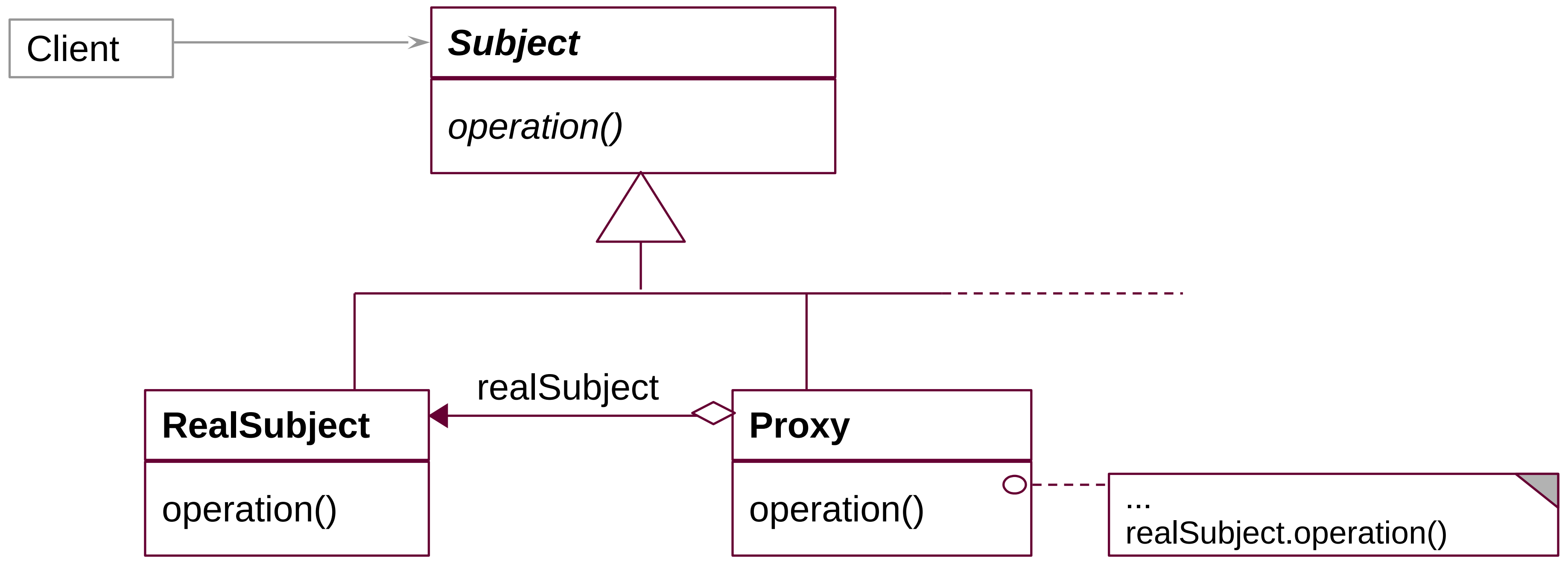
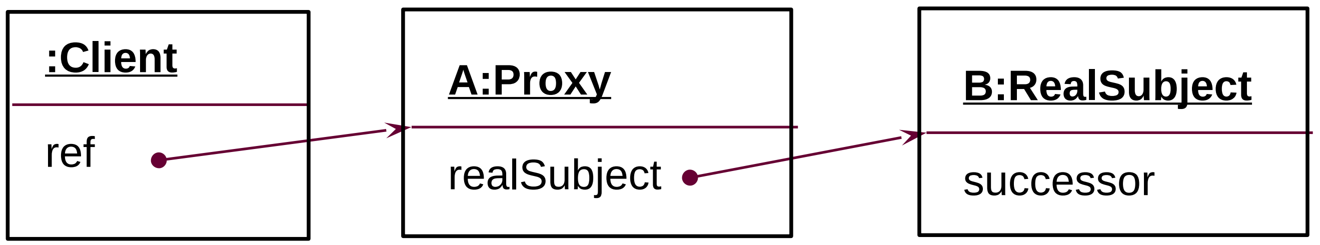
25.A.1 Proxy

Proxy

- Hide the access to a real subject by a representant



Object Structure:



Proxy

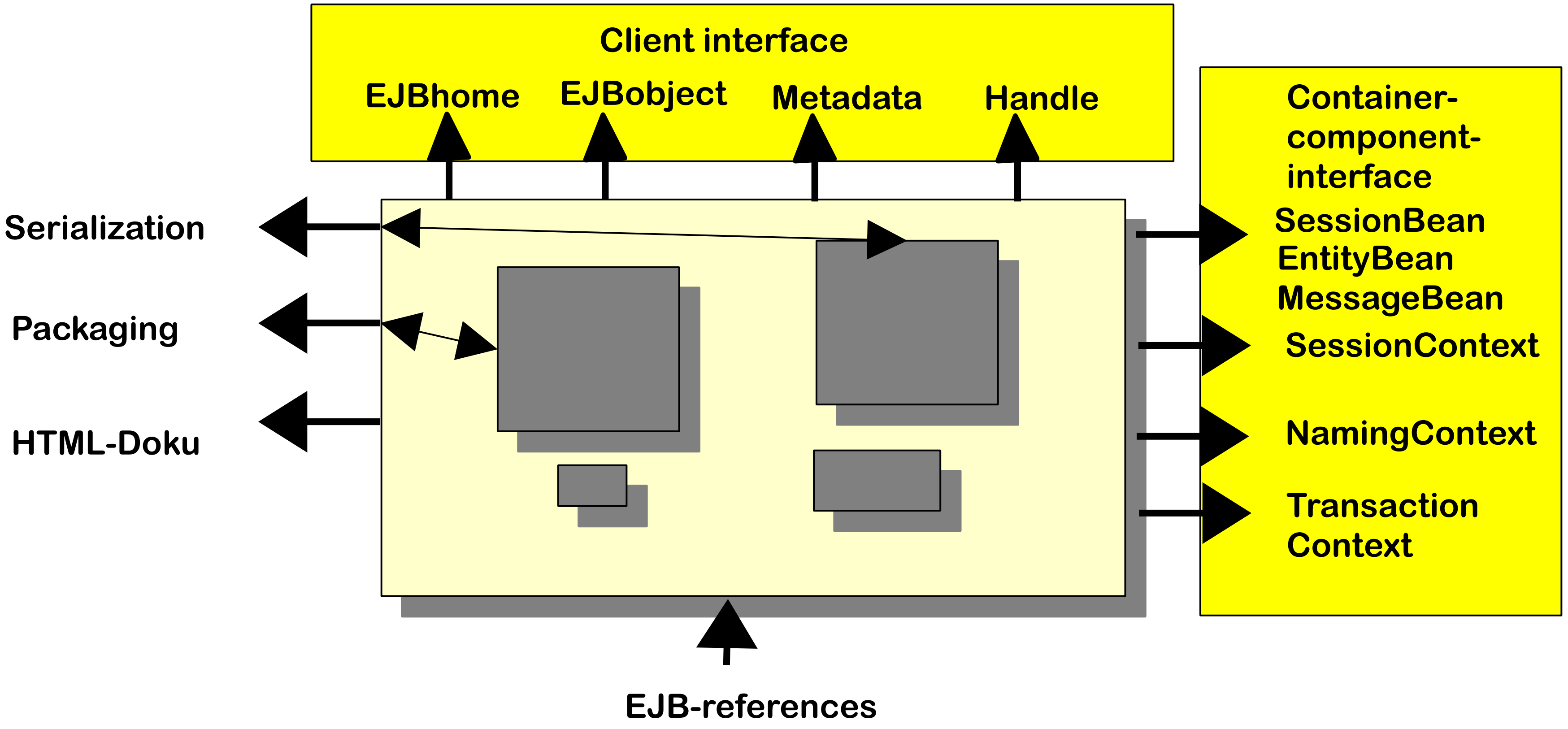
- The proxy object is a representant of an object
  - The Proxy is similar to Decorator, but it is not derived from ObjectRecursion
  - It has a direct pointer to the sister class, *not* to the superclass
  - It may collect all references to the represented object (shadows it). Then, it is a facade object to the represented object
- Consequence: chained proxies are not possible, a proxy is one-and-only
- It could be said that Decorator lies between Proxy and Chain.

Proxy Variants

- **Filter proxy** (smart reference):
  - executes additional actions, when the object is accessed
- **Protocol proxy**:
  - Counts references (reference-counting garbage collection
  - Or implements a synchronization protocol (e.g., reader/writer protocols)
- **Indirection proxy** (facade proxy):
  - Assembles all references to an object to make it replaceable
- **Virtual proxy**: creates expensive objects on demand
- **Remote proxy**: representant of a remote object
- **Caching proxy**: caches values which had been loaded from the subject
  - Caching of remote objects for on-demand loading
- **Protection proxy**
  - Firewall proxy

Adapters for COTS

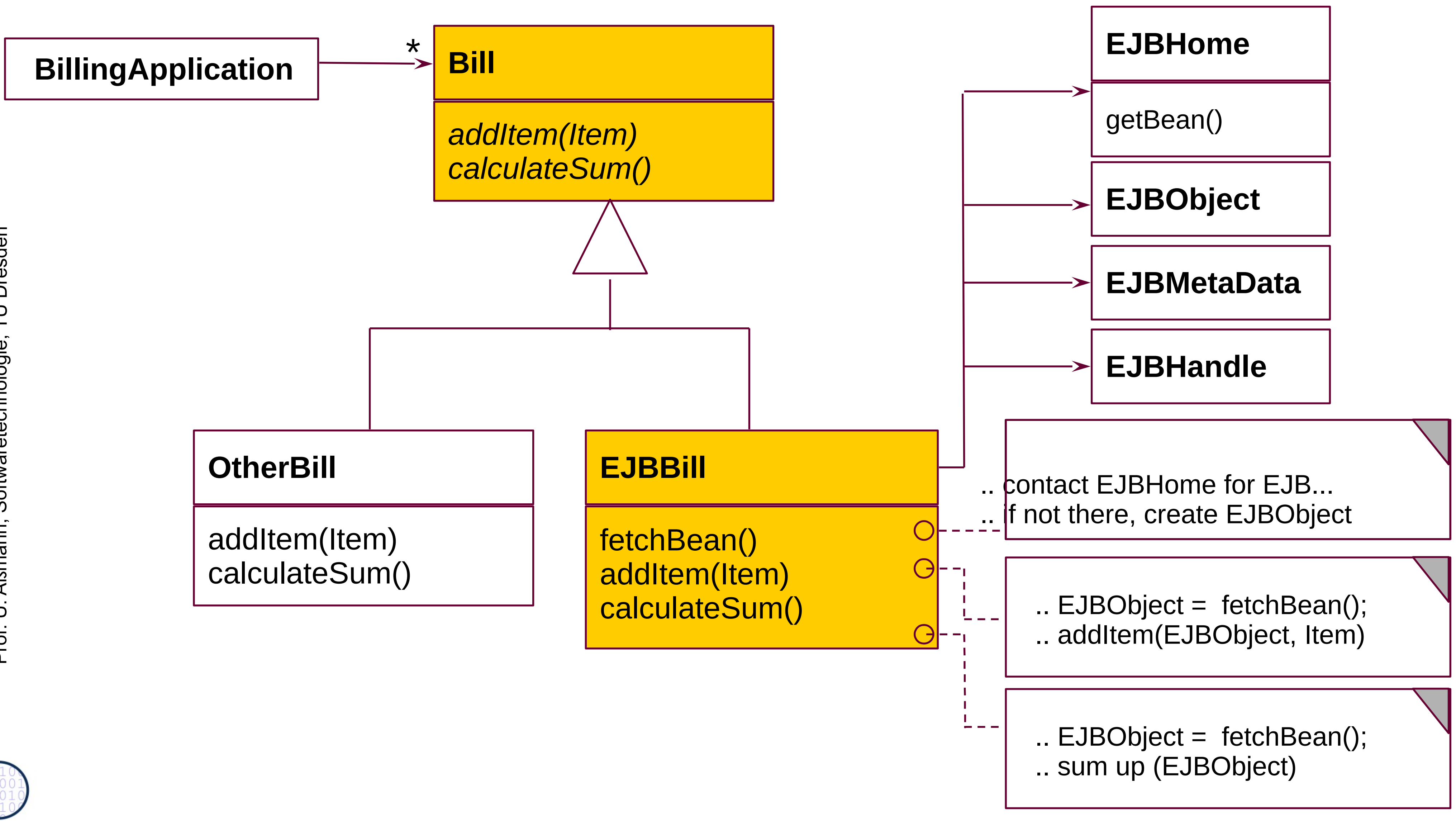
- Adapters are often used to adapt components-off-the-shelf (COTS) to applications
- For instance, an EJB-adapter allows for reuse of an Enterprise Java Bean in an application



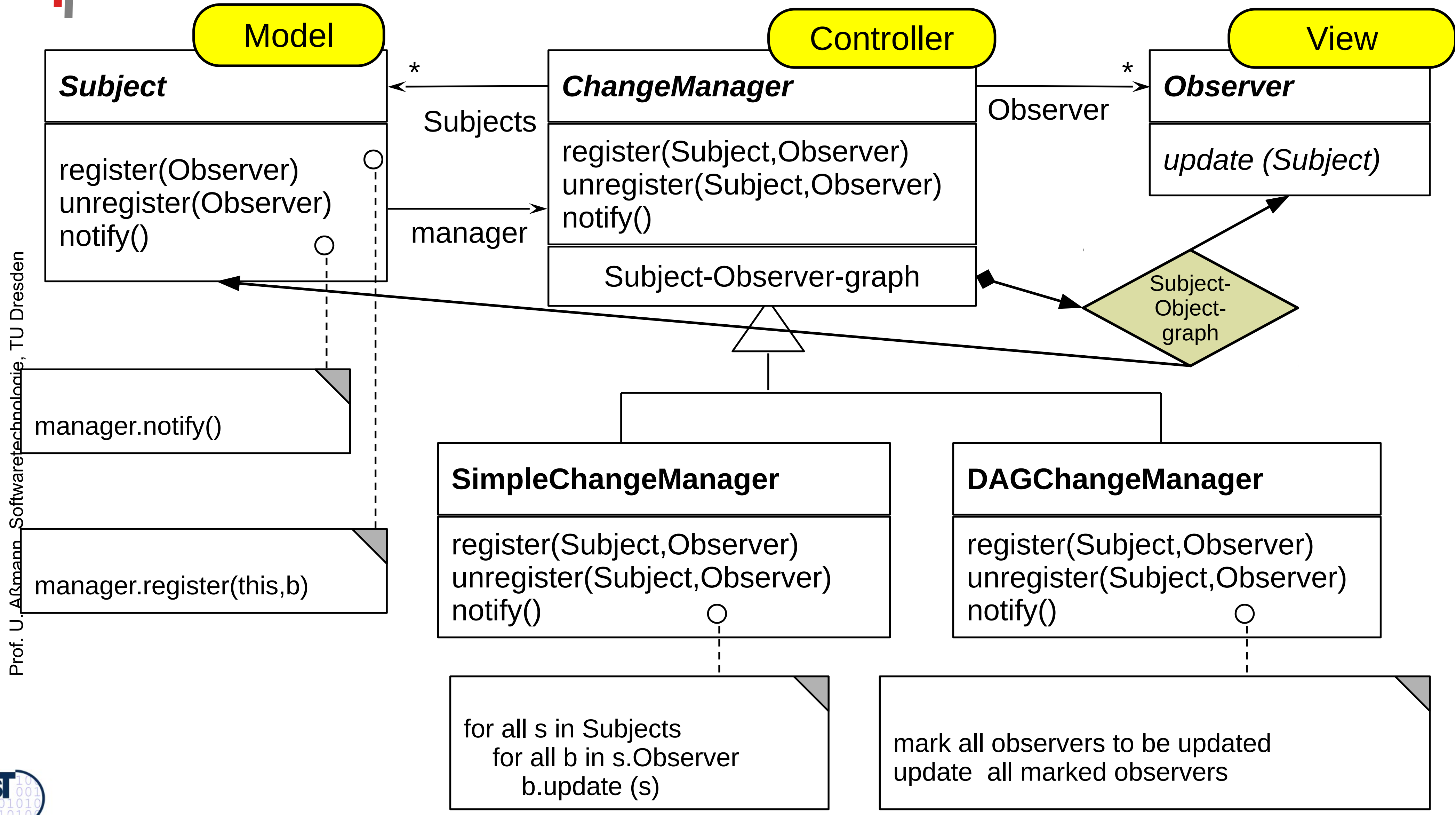
EJB Adapter

Client interface

EJBhome EJBobject Metadata Handle

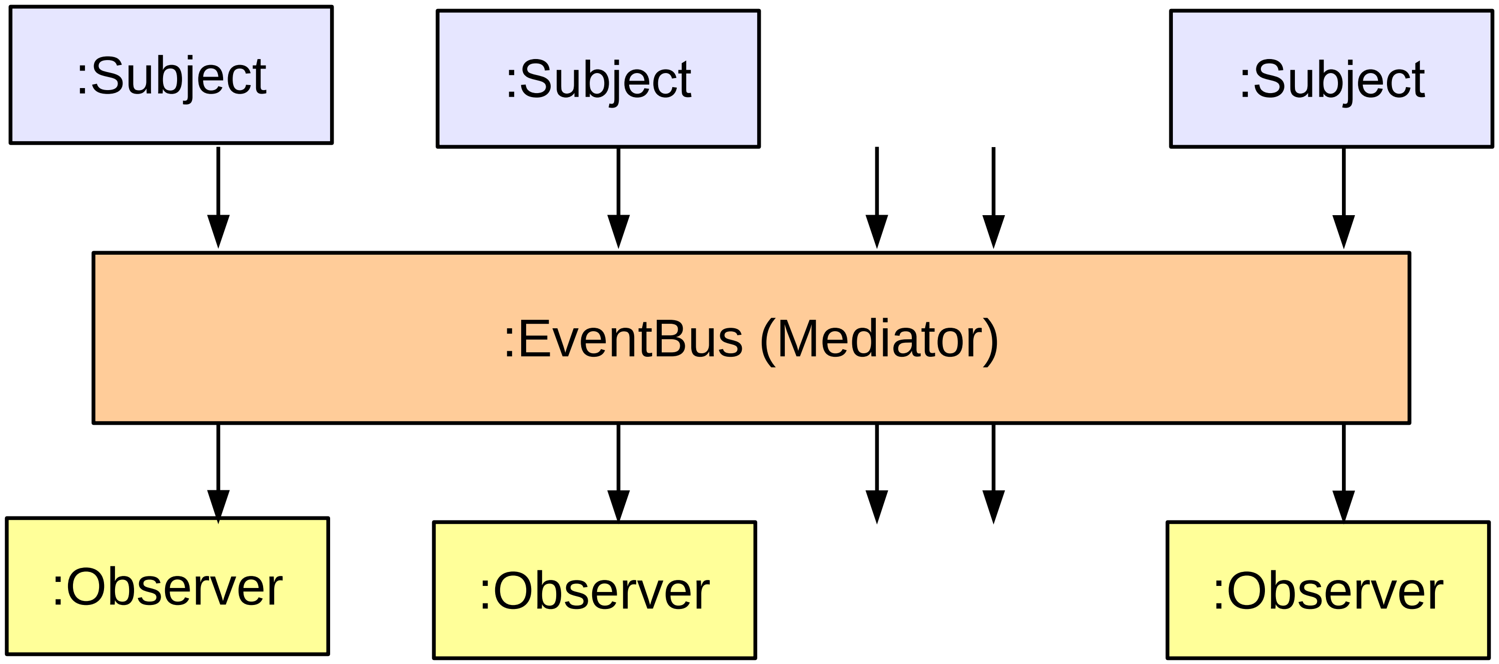


25.A.2 Observer with ChangeManager (EventBus)



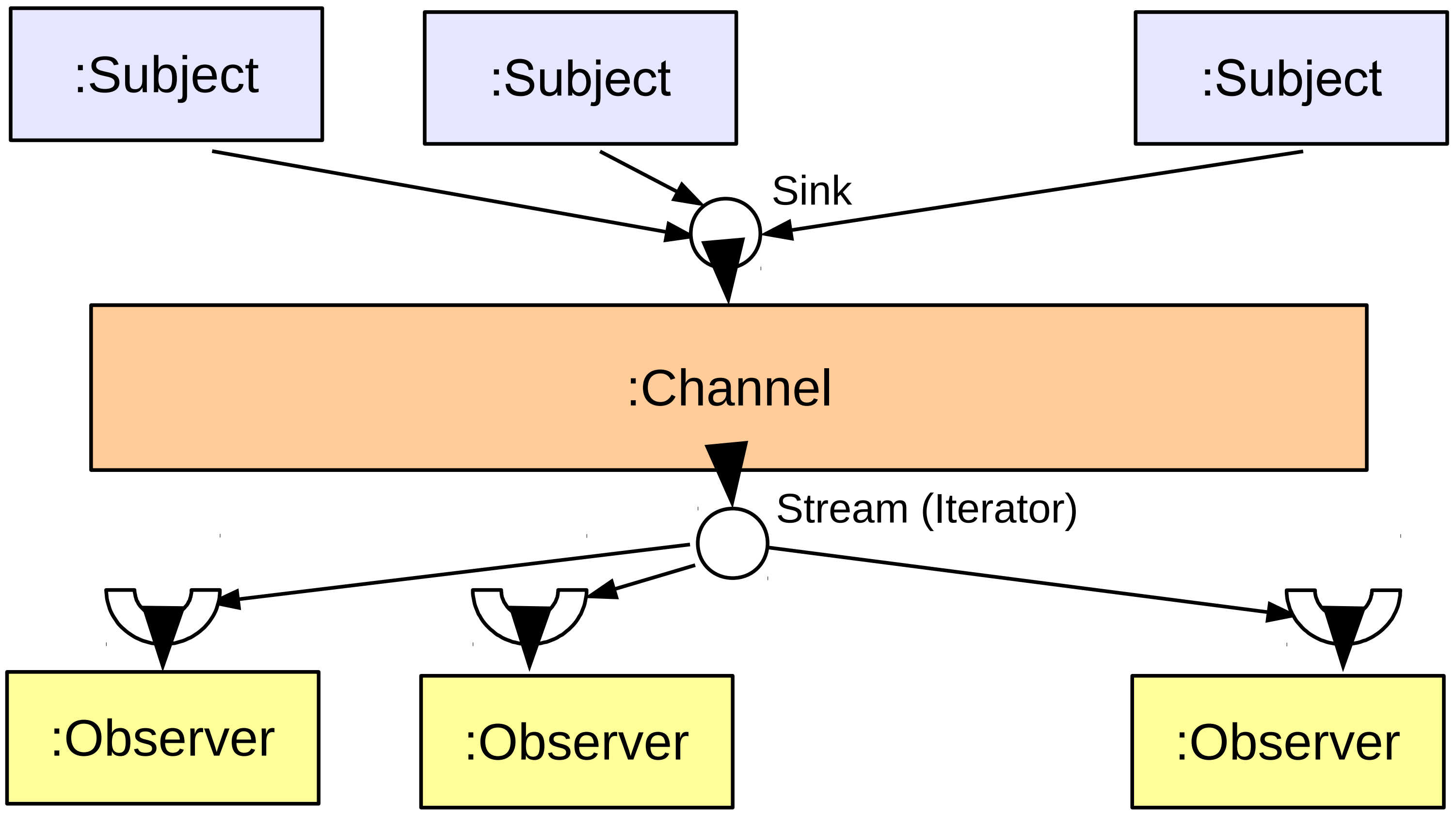
Observer with ChangeManager is also Called Event-Bus

- Basis of many interactive application frameworks (Xwindows, Java AWT, Java InfoBus, ...)
- Loose coupling in communication
  - Observers decide what happens
- Dynamic extension of communication
  - Anonymous communication
  - Multi-cast and broadcast communication



25.2.3.7 A Variant of EventBus is the Channel

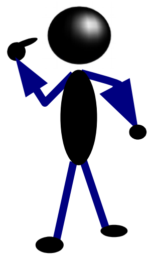
- push-Subjects and pull-Observers can be connected by Channel, to emphasize the continuous pushing and pulling
- Then Subjects write the Sink of the Channel and Observers pull the Stream of the Channel
  - Channel is a buffer



Appendix

What Does a Design Pattern Contain?

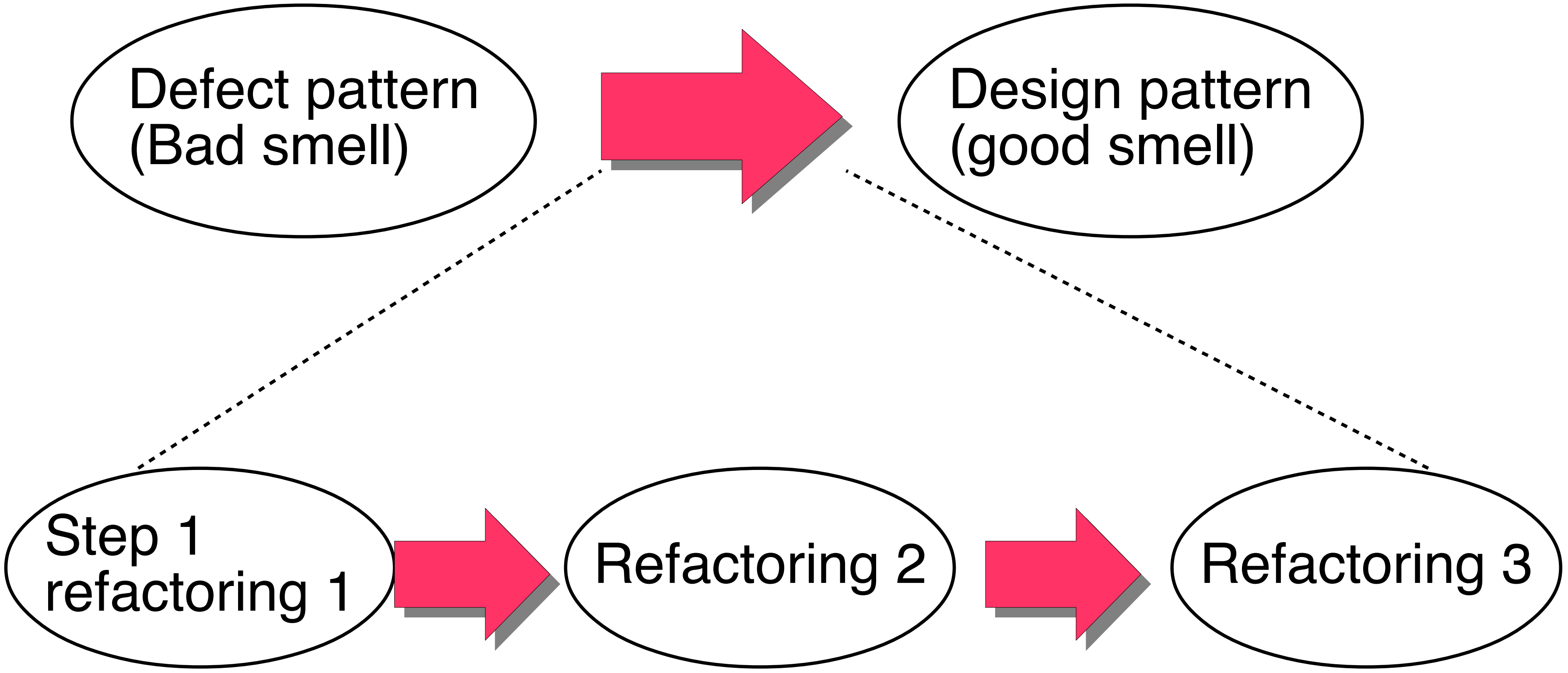
- A part with a “bad smell”
  - A structure with a bad smell
  - A query that proved a bad smell
  - A graph parse that recognized a bad smell
- A part with a “good smell” (standard solution)
  - A structure with a good smell
  - A query that proves a good smell
  - A graph parse that proves a good smell
- A part with “forces”
  - The context, rationale, and pragmatics
  - The needs and constraints



$$\text{“bad smell”} \xrightarrow{\text{forces}} \text{“good smell”}$$

Refactorings Transform Antipatterns (Defect Patterns, Bad Smells) Into Design Patterns

- Software can contain bad structure
- A DP can be a goal of a *refactoring,* transforming a bad smell into a good smell

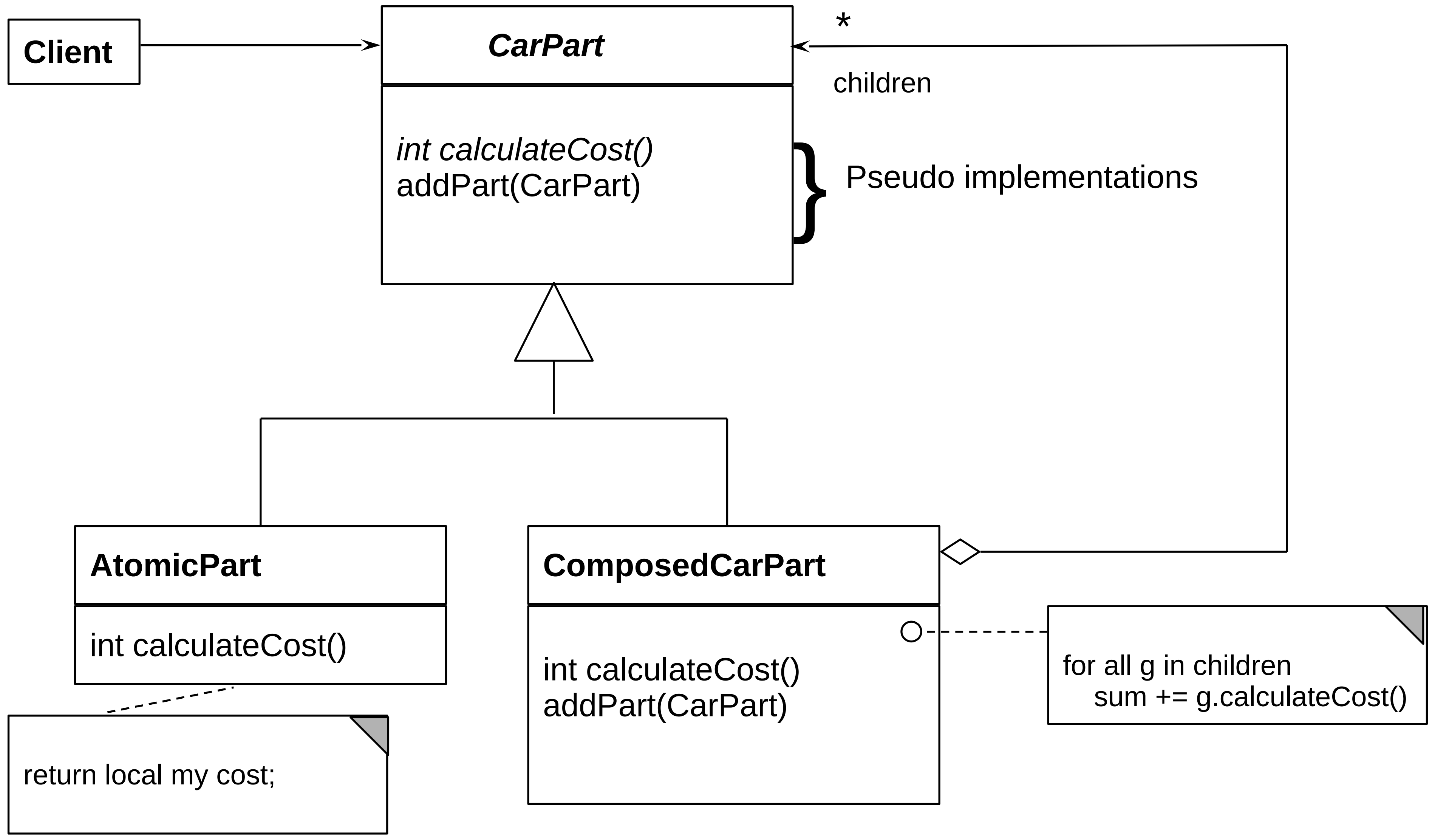


Structure for Design Pattern Description (GOF Form)

- Name (incl. Synonyms) (also known as)
- Motivation (purpose)
  - also “bad smells” to be avoided
- Employment
- Solution (the “good smell”)
  - Structure (Classes, abstract classes, relations): UML class or object diagram
  - Participants: textual details of classes
  - Interactions: interaction diagrams (MSC, statecharts, collaboration diagrams)
  - Consequences: advantages and disadvantages (pragmatics)
  - Implementation: variants of the design pattern
  - Code examples
- Known Uses
- Related Patterns

A.2 Example for Composite: PieceLists in Cars

- Big technical objects can have thousands of parts



Piece Lists of Complex Technical Objects

```
abstract class CarPart {
    int myCost;
    abstract int calculateCost();
}
class ComposedCarPart extends CarPart {
    int myCost = 5;
    CarPart [] children;  // here is the n-recursion
    int calculateCost() {
       for (i = 0; i <= children.length; i++) {
         curCost += children[i].calculateCost();
      }
      return curCost + myCost;
    }
    void addPart(CarPart c) {
         children[children.length] = c;
    }
```

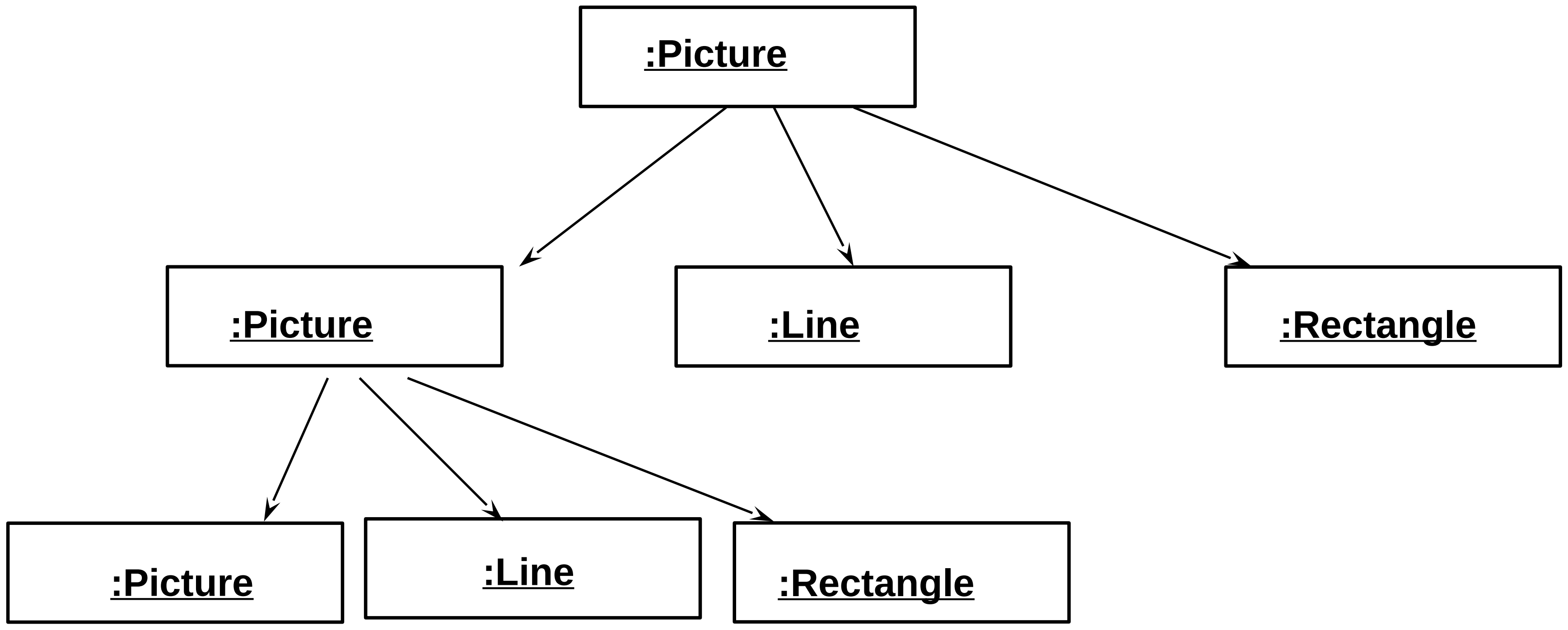
```
class AtomicCarPart extends CarPart {
     int calculateCost() { return  myCost; }
    void addPart(CarPart c) {
         /// impossible, dont do anything
    }
}
class Screw extends AtomicCarPart {
     int myCost = 10;
}
class SteeringWheel extends AtomicCarPart {
    int myCost = 200;
}
```

```
// application
int cost = carPart.calculateCost();
```

Iterator algorithms (map)
Folding algorithm (folding a tree with a scalar function)

Composite for Part/Whole Hierarchies (Structured Piece Lists)

- Part/Whole hierarchies, e.g., nested graphic objects (widgets)
- Dynamic Extensibility of Composite
  - Due to the n-recursion, new children can always be added dynamically into a composite node
  - Whenever you have to program an extensible part of a framework, consider Composite



common operations: draw(), move(), delete(), scale()