TECHNISCHE UNIVERSITÄT DRESDEN

Fakultät Informatik - Institut Software- und Multimediatechnik

41. Composition Filters - A Filter-Based Grey-Box Component Model

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1. Inheritance Anomaly
2. Design Pattern Decorator
3. Composition Filters
4. Implementations of the Filter Concept in Standard Languages
5. Evaluation

DRESDEN concept

Exzellenz aus Wissenschaft und Kultur

Literature (To Be Read)

- L. Bergmans, M. Aksit, K. Wakita, A. Yonezawa. An Object-Oriented Model for Extensible Concurrent Systems: The Composition-Filters Approach. Technical Report, University of Twente.
- http://trese.cs.utwente.nl
- Compose* is the current tool for Composition Filters. It is an extension of Java
  - http://composestar.sf.net/

Other Literature

- Mehmet Aksit and Lodewijk Bergmans. Obstacles in object-oriented software development. ACM Proceedings OOPSLA '92, SIGPLAN Notices, 27(10):341--358, October 1992.
- L. Bergmans. Composition filters. PhD thesis, Twente University, Enschede, Holland, 1994.
- Mehmet Aksit, Ken Wakita, Jan Bosch, Lodewijk Bergmans, and Akinori Yonezawa. Abstracting object interactions using composition filters. In O. Nierstrasz, R. Guerraoui, and M. Riveill, editors, Proceedings of the ECOOP'93 Workshop on Object-Based Distributed Programming, LNCS 79, pages 152--184. Springer, 1994.
- Mehmet Aksit and Lodewijk Bergmans. Composing crosscutting concerns using composition filters. Communications of the ACM, 44(10):51--57, October 2001.
- On the TRESE home page, there are many papers available for CF http://trese.cs.utwente.nl/

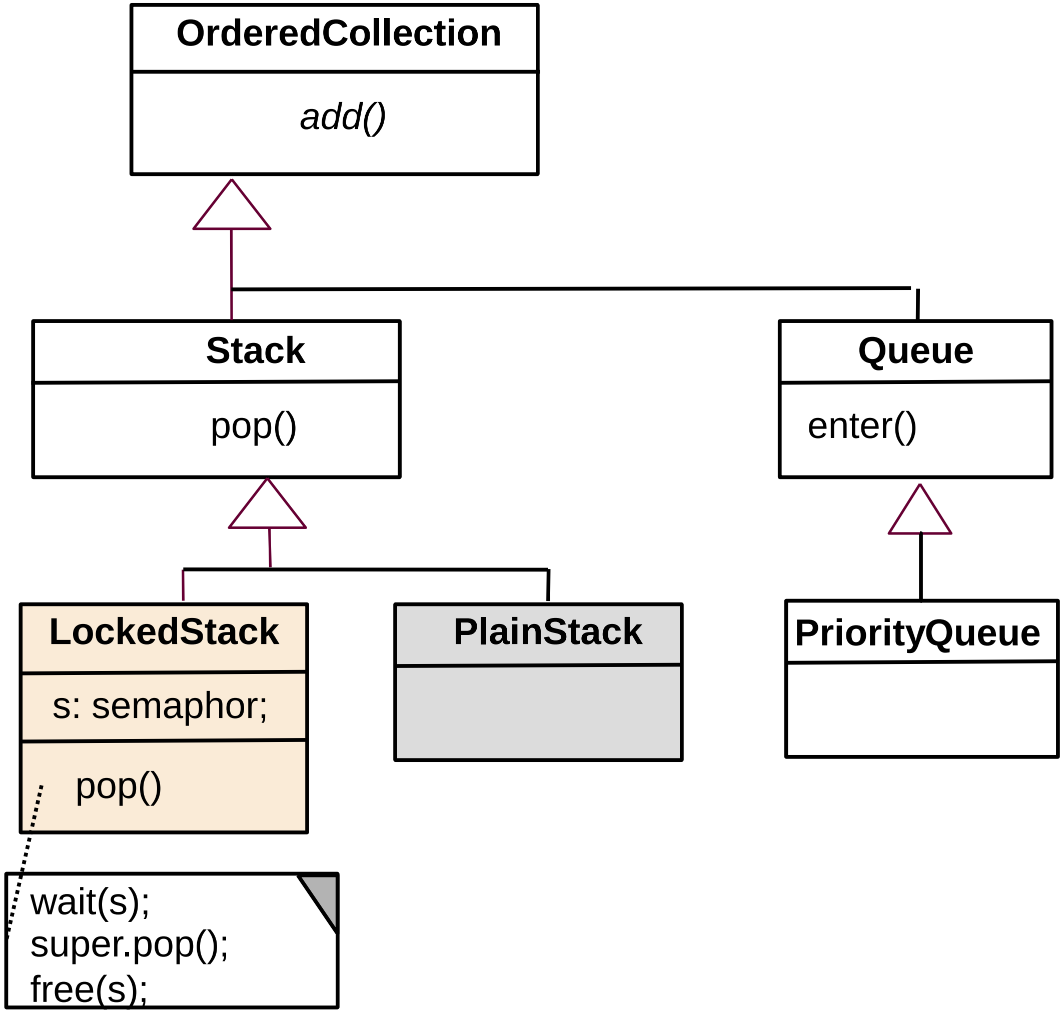
Goal

- Composition Filters (CF) are a solution to many composition problems
- The first approach to grey-box components
- Understand the similarty to decorator/adapter-based component models, and why grey-box provides an advantage

41.1 The Inheritance Anomaly

Inheritance Anomaly – Why Dimensional Software Composition Is Necessary

- In a parallel program, where should synchronization code be inserted?
  - Stack?
  - Queue?
  - OrderedCollection?
  - Collection?
  - Object?

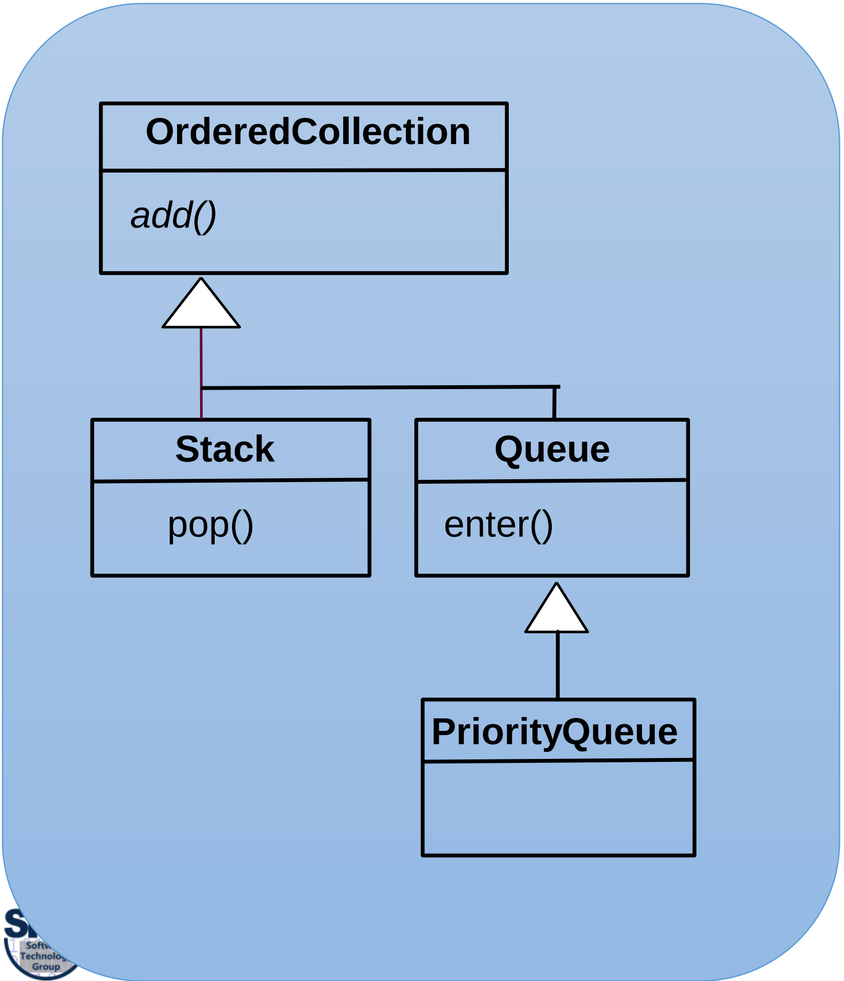


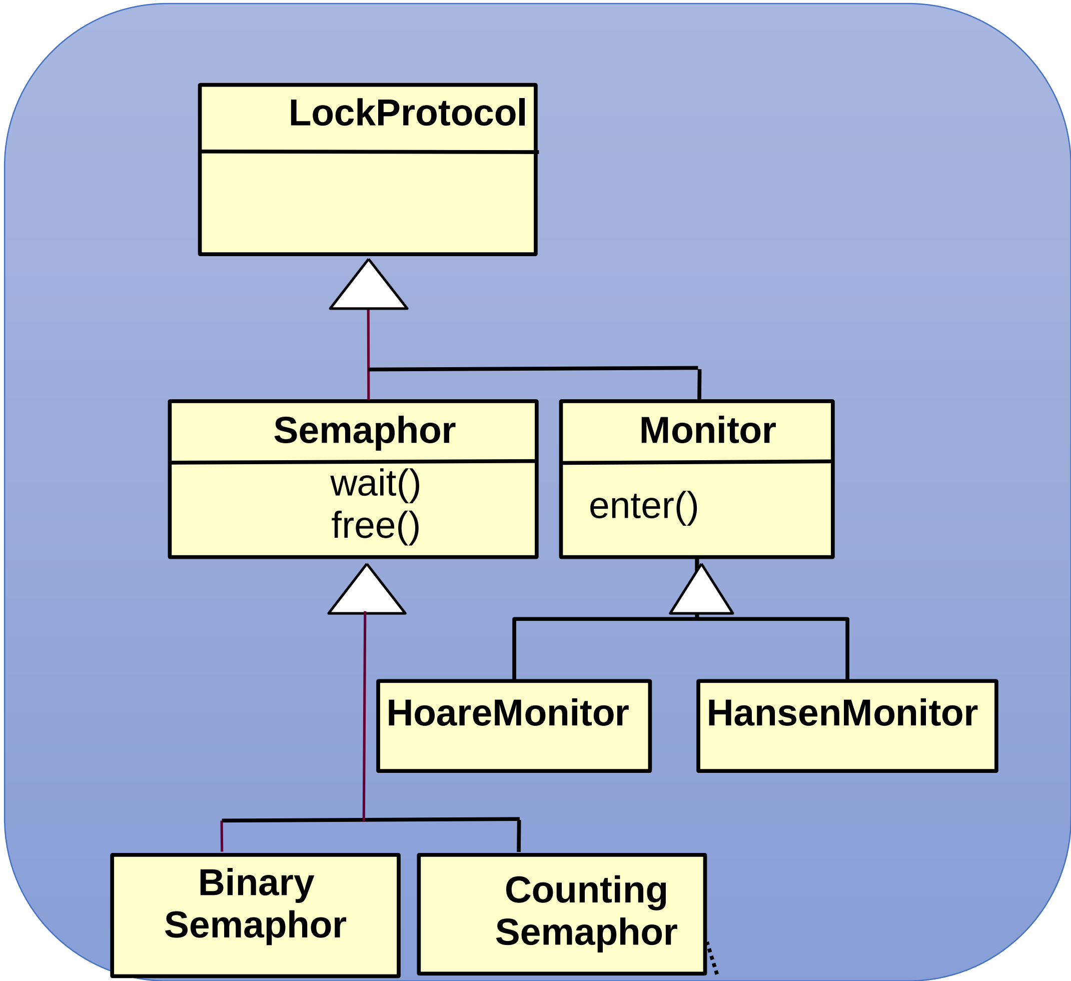
Inheritance Anomaly

- At the beginning of the 90s, parallel object-oriented languages failed, due to the inheritance anomaly problem
- **Inheritance anomaly**: In inheritance hierarchies, synchronization code is *tangled (interwoven)* with the algorithm,
  - and cannot be easily exchanged when the inheritance hierarchy should be extended
  - Ideally, one would like to specify algorithm and function independently

Algorithm and Synchronization are Almost Facets

- But they depend on each other
- How to mix them appropriately?

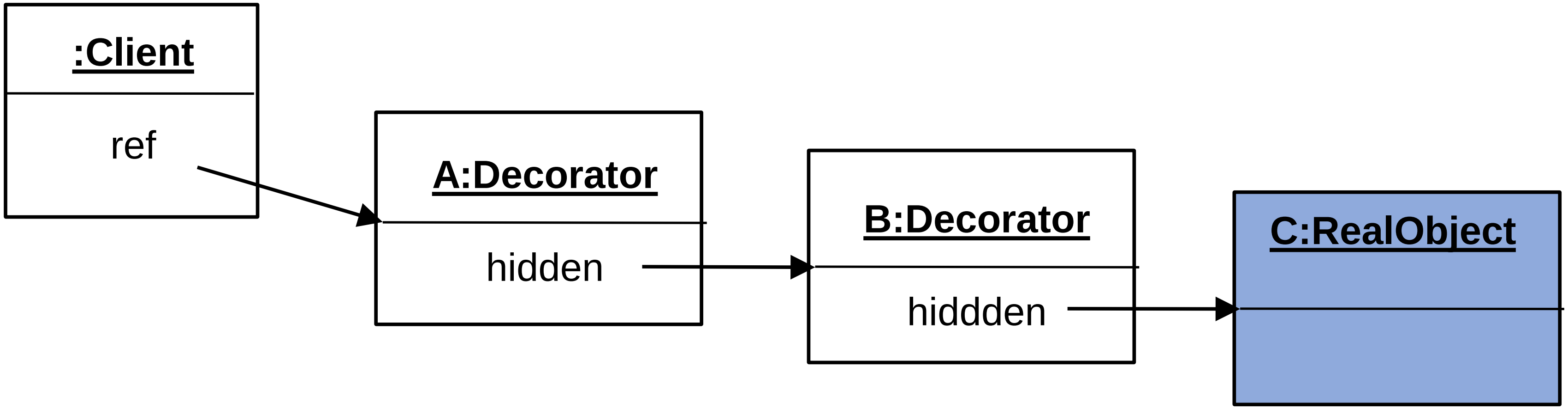




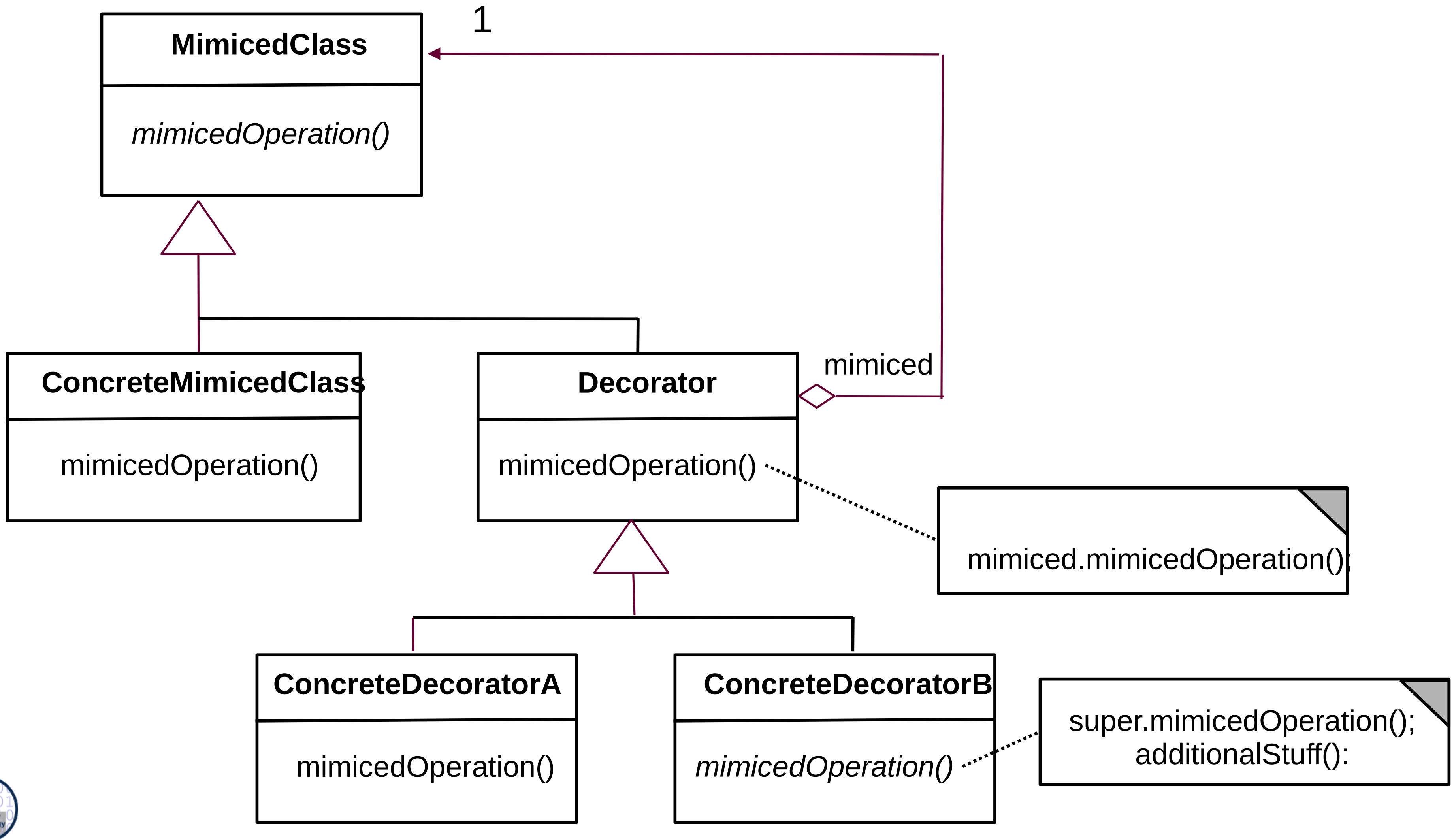
41.2 The Decorator Design Pattern (Rpt.)

Decorator Pattern

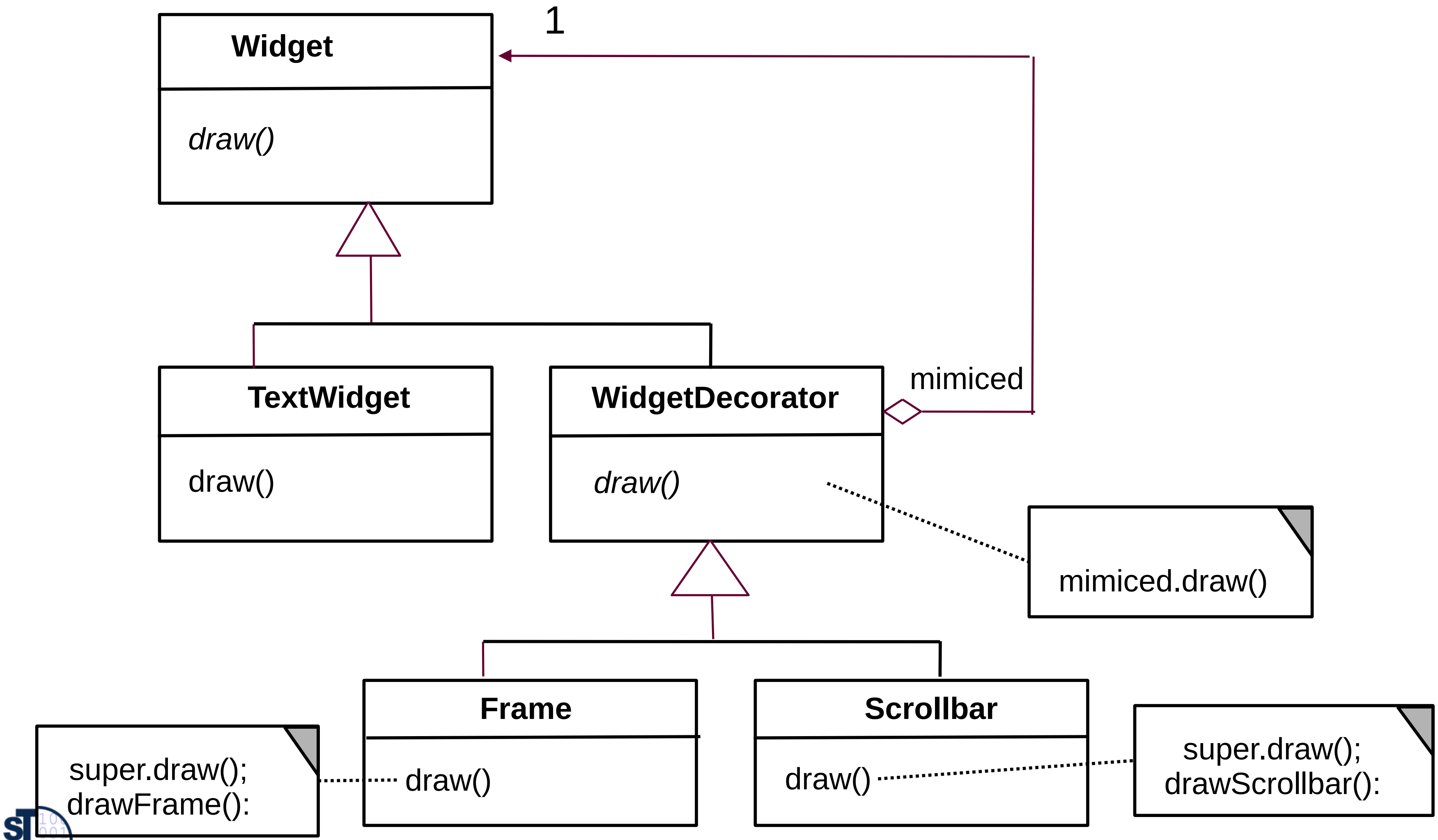
- A Decorator is a *skin* of another object
- It is a 1-ObjectRecursion (i.e., a restricted Composite):
  - A subclass of a class that contains an object of the class as child
  - However, only one composite (i.e., a delegatee)
- Combines inheritance with aggregation
  - Inheritance from an abstract Handler class
  - That defines a contract for the mimiced class and the mimicing class



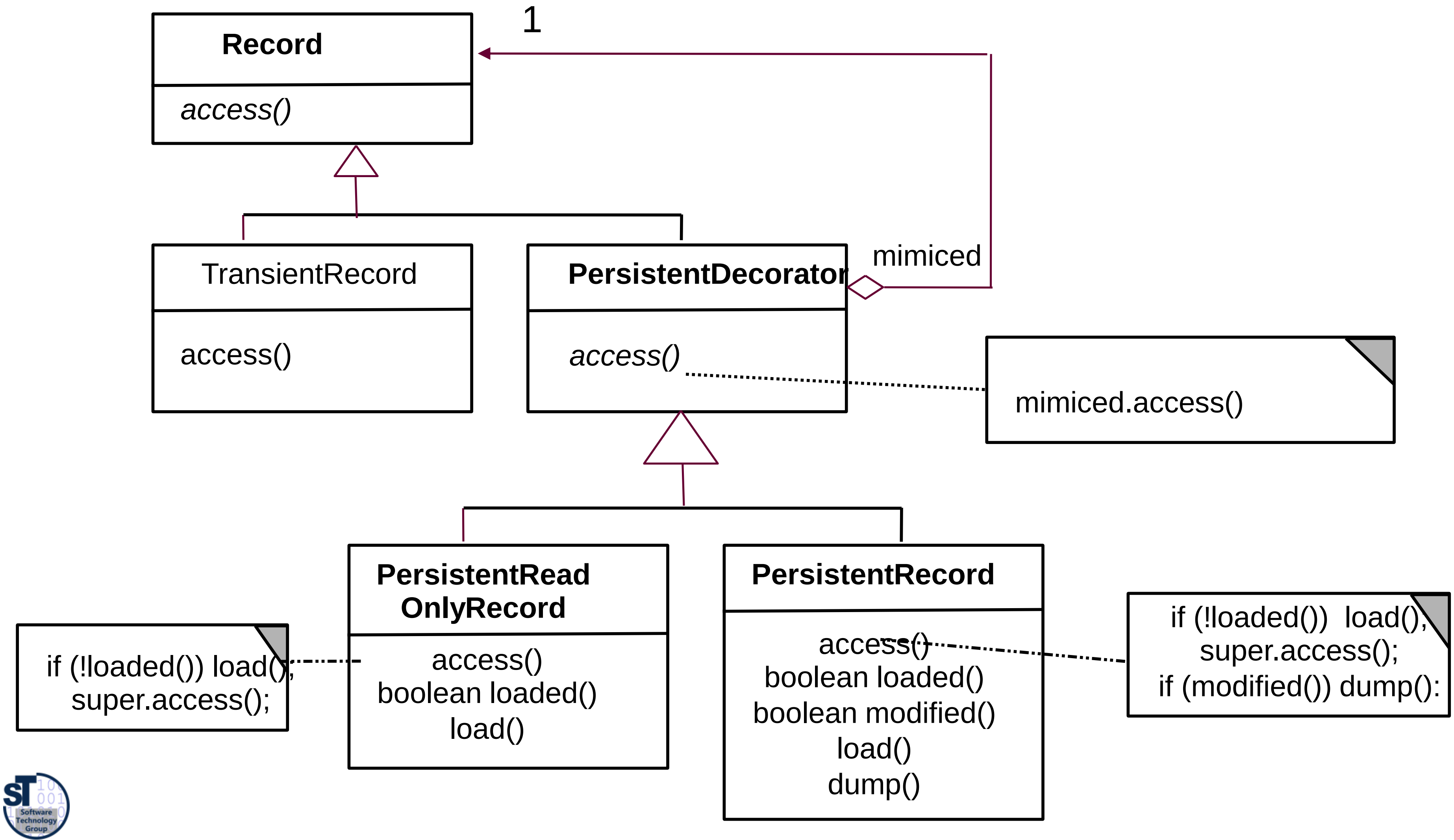
Decorator – Structure Diagram



Decorator for Widgets

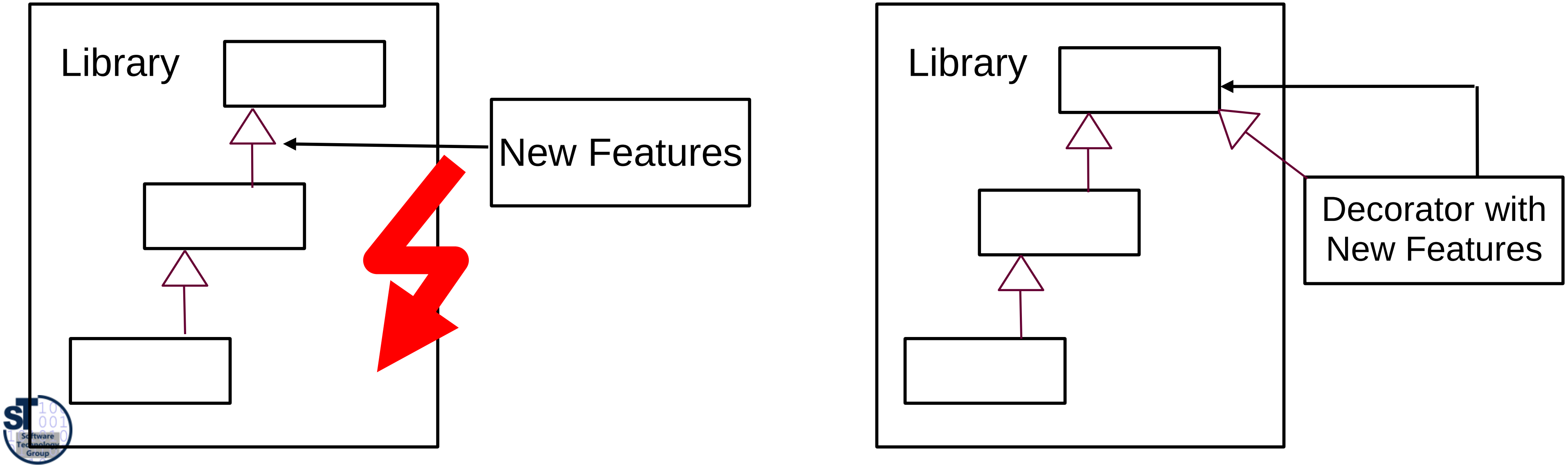


Decorator for Persistent Objects



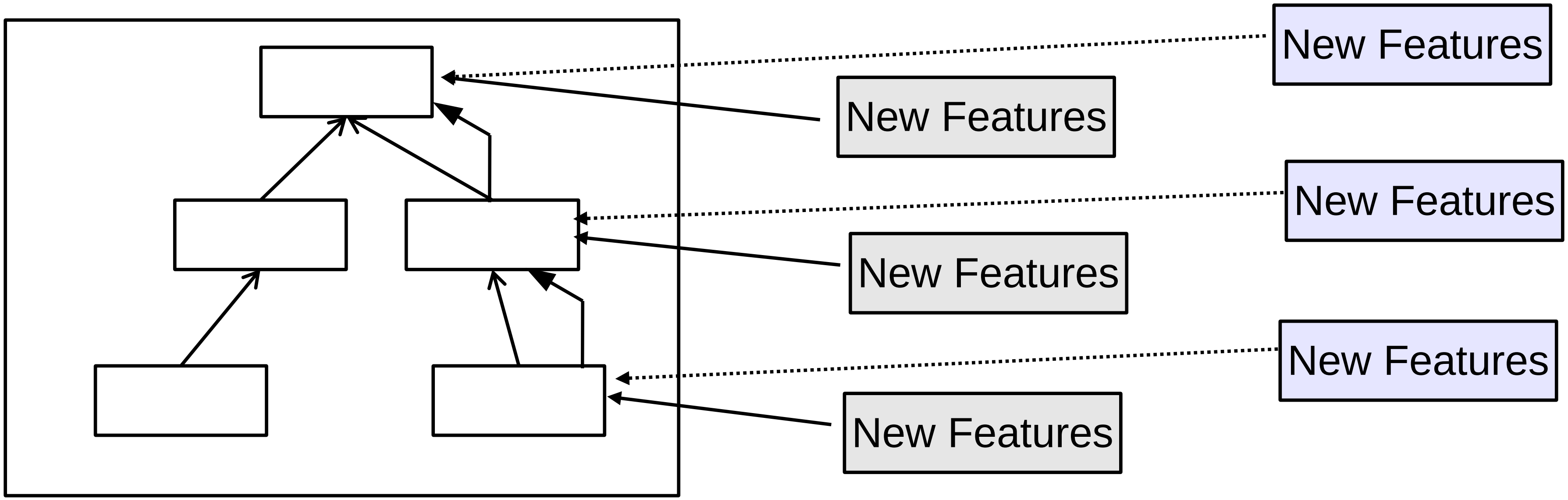
Purpose Decorator

- For extensible objects (i.e., decorating objects)
  - Extension of new features at runtime
  - Removal possible
- Instead of putting the extension into the inheritance hierarchy
  - If that would become too complex
  - If that is not possible since it is hidden in a library



Variants of Decorators

- If only one extension is planned, the abstract superclass Decorator can be saved; a concrete decorator is sufficient
- Decorator family: If several decorators decorate a hierarchy, they can follow a common style and can be exchanged together



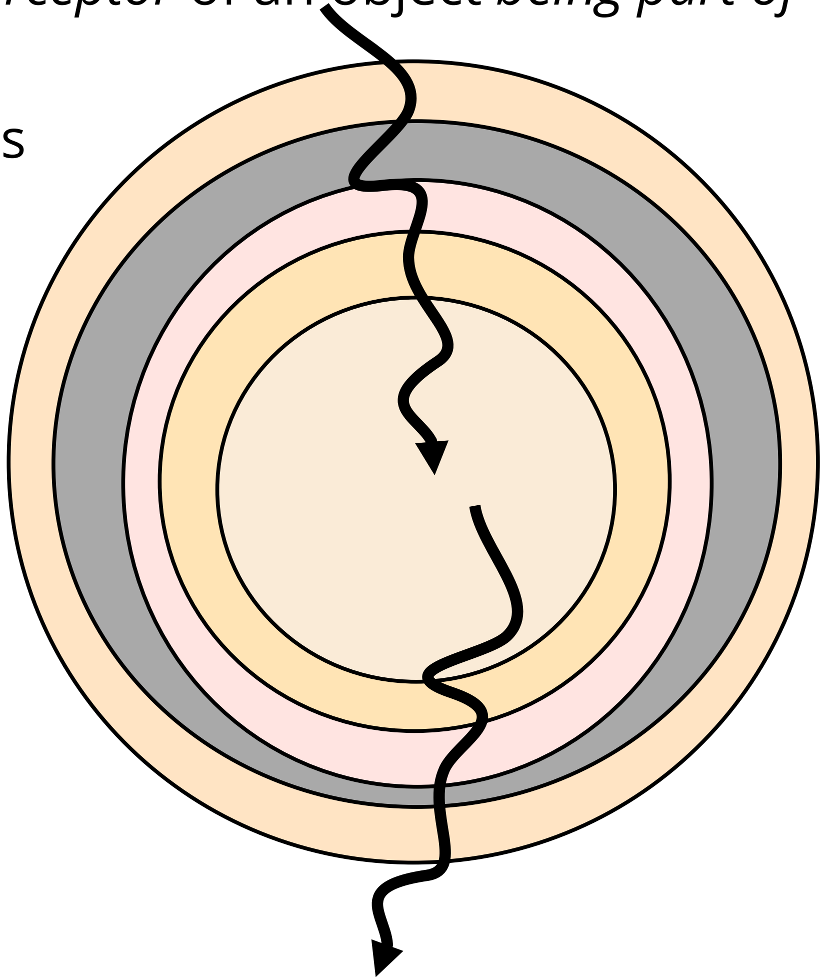
Decorator Relations

- Decorators can be chained to each other
- Dynamically, arbitrarily many new features can be added
- A decorator is a special ChainOfResponsibility with
  - The decorator(s) come first
  - Last, the mimiced object

41.3 Composition Filters

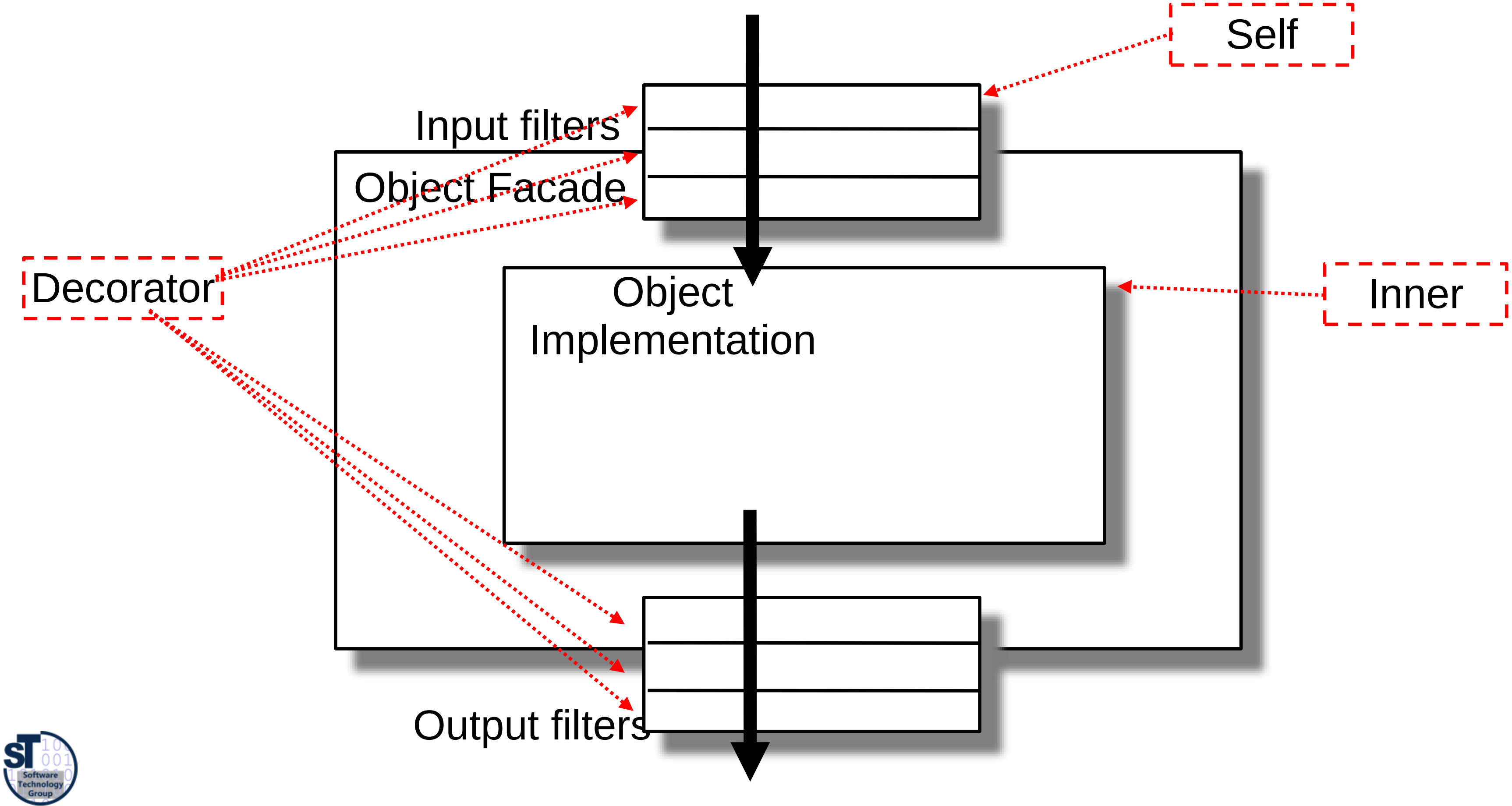
Filters are Layers

- Composition Filters (CF) wraps objects with *filters*
- A **filter** is an input or output *interceptor* of an object *being part of the object*
- Messages flow through the filters
  - are accepted or rejected
  - are modified by them
  - Wait on other objects
  - Notify other objects



Filters are Special Decorators

- Filters are decorators that do not suffer from object schizophrenia
- “inner” is the core of the object
- “self” comprises all filters and inner



Filter Types

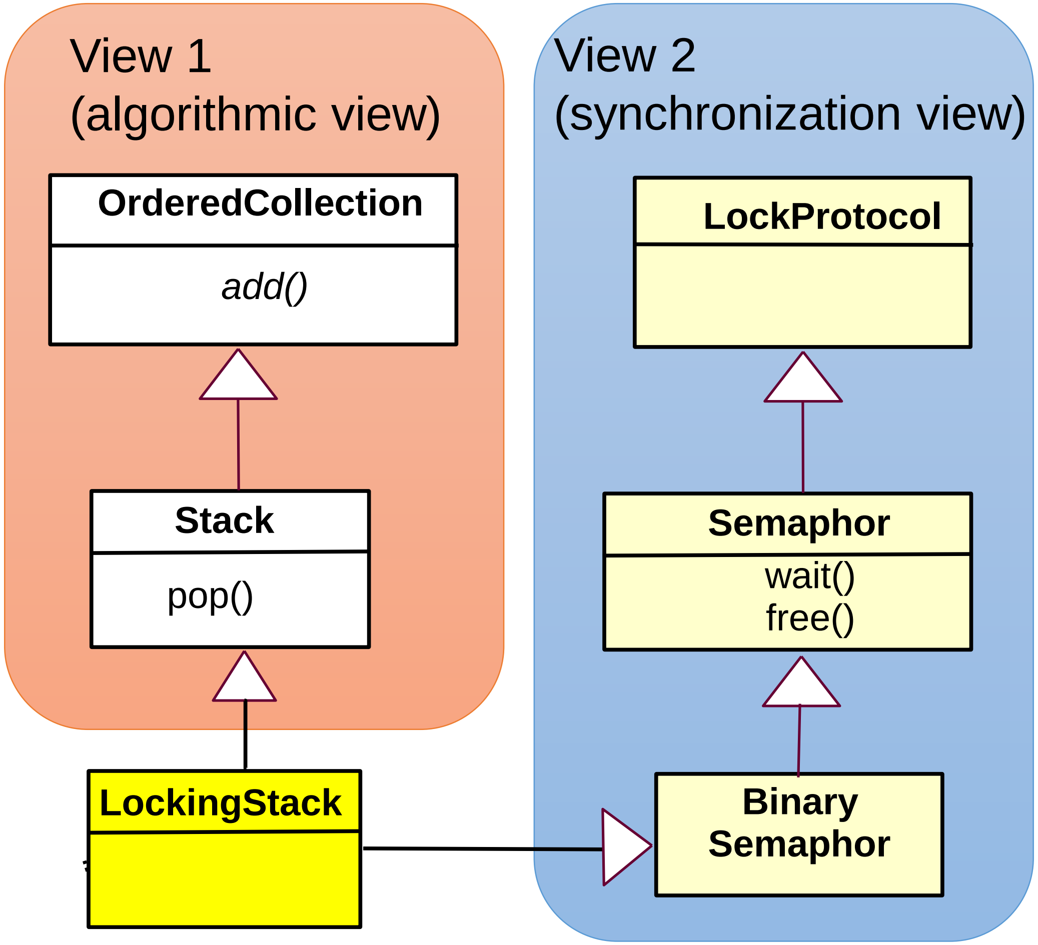
- Filters are Event-Condition-Action rules
- ***Error***. An error filter tests whether a method exists.
  - If not, it stops filtering and execution.
  - In statically typed languages, error filters can be replaced by the compiler
- ***Wait***. A wait filter accepts methods only if a condition is true, otherwise it waits until the condition becomes true.
  - The condition may refer to a semaphore that is shared by all objects of the class
  - In case the semaphore is not free, the wait filter blocks execution
- ***Dispatch***. A dispatch filter dispatches the message
  - to the internal implementation, the “inner”
  - to other external objects, to a superclass,
  - or to sequences of objects.
- ***Meta***. A meta filter converts the message to an instance of class Message and passes it on to the continuation method. Then, the method can evaluate the new message.
- ***RealTime***. Specify a real-time constraint.

Main Advantage of the Filter Concept

- Filters are *built into* an object, they are *grey-box decorators*
  - They avoid object-schizophrenia
- Filters are specified in the interface, not in the implementation
  - Implementations are free of synchronization code
  - Separation of concerns (SOC): synchronization and algorithm are separated
  - Filters and implementations can be varied independently
- Filters are specified statically, but can be activated or deactivated dynamically
- Filters are statically composed with multiple inheritance
  - One dimension from algorithm,
  - one from synchronization strategy
  - Filters can be overwritten during inheritance

Composing a Locking Stack by Composing Filters

- Filter composition can be specified by selecting filters from superclasses
- Compose* can superimpose filters also dynamically



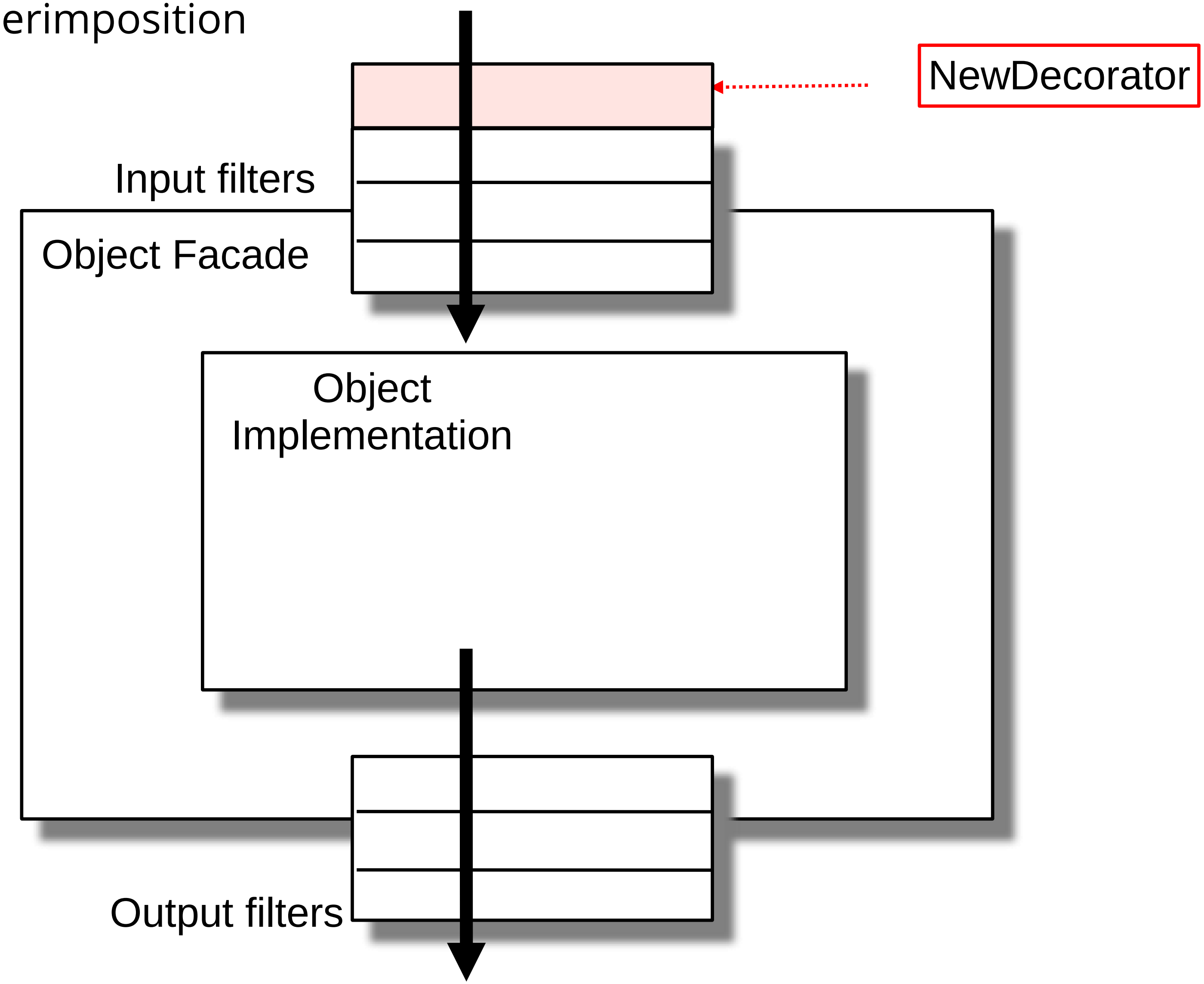
41.4 Implementations of the Filter Concept in Standard Languages

Implementation with Decorator

- The superclass of the Decorator pattern implements the object interface
  - The decorating classes are the filters
  - Problem: Decorators do not provide access to the “inner” object or the “self” object
- Filters also can be regarded as ChainOfResponsibility
  - However, there is a final element of the Chain, the object implementation

Filters Can be Composed From Outside

- Filter superimposition



Superimposing a Decorator in Hand-Written Code

- Walk through the list of decorators
- Insert a new decorator where appropriate

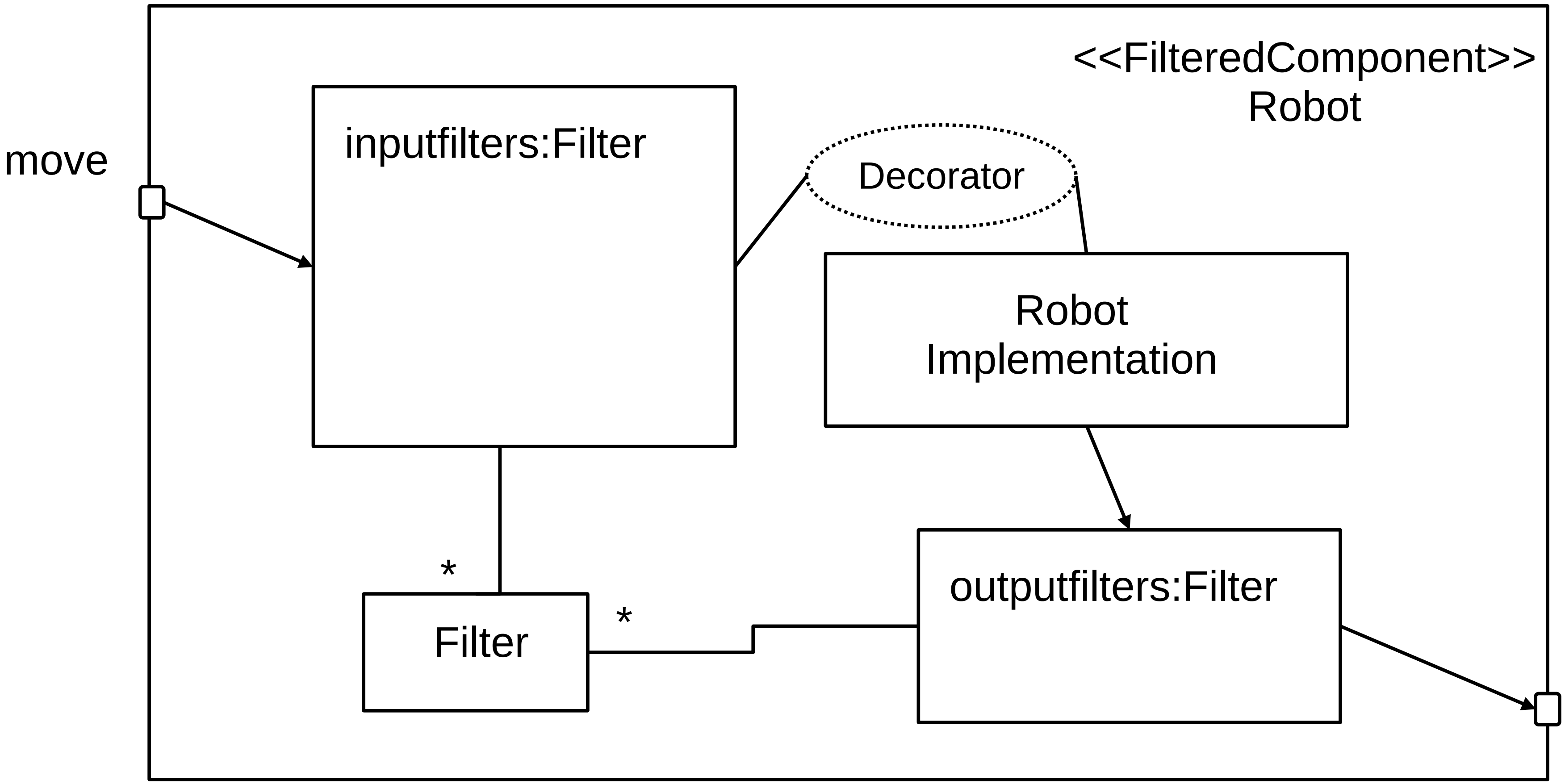
- Example: superimposing synchronization:
  - Do for all objects involved:
    - Get the first decorator
    - Append a locking decorator, accessing a common semaphore
- Removing synchronization
  - Do for all objects involved:
    - Get the synchronizing decorator
    - Dequeue it

Filters in MOP-Based Languages

- In languages with a MOP, a filter can be implemented as a specific object that is called during the functions
    - enterObject
    - accessAttribute
    - callMethod

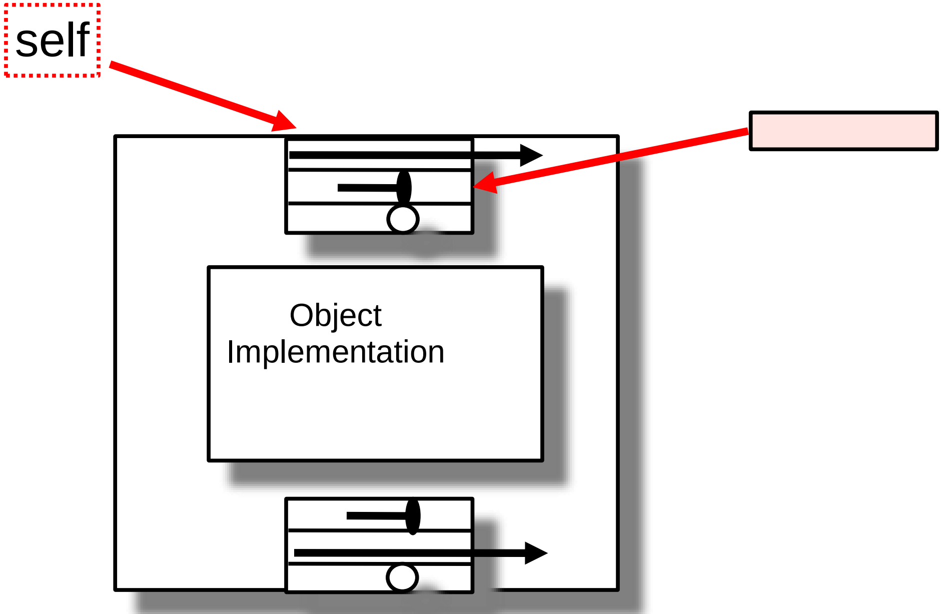
Filters In UML

- Realize as inner components



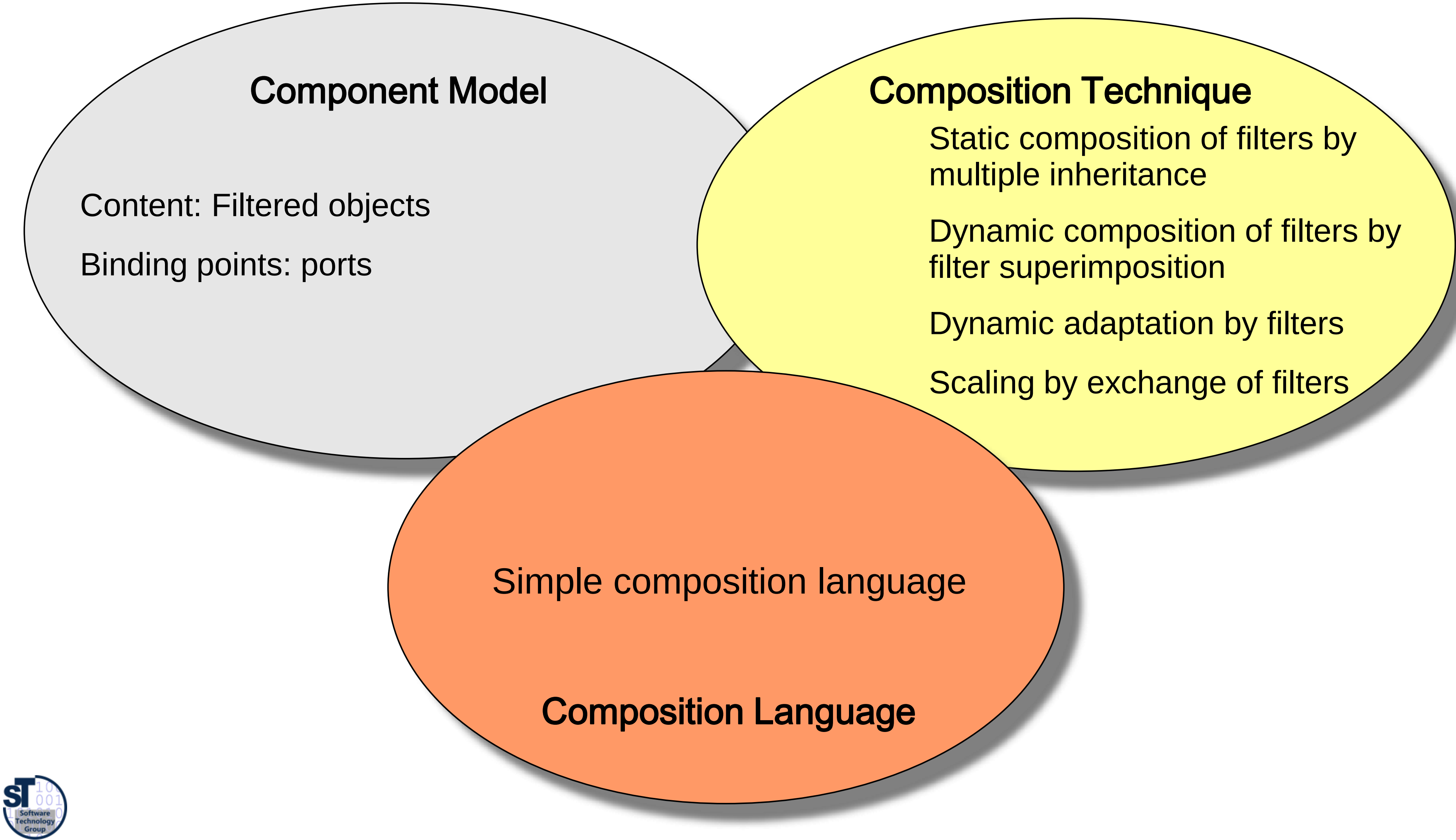
Insight: Greybox Composition Relies on Extensibility

- Composition Filters is a *greybox* composition technology
  - Because it inlines Decorators into objects
- Superimposition of filters can be used for greybox composition
  - Adding filters changes objects extensively, but the “self” identity does not change
  - Connectors can be made grey-box with the Filter-Connector pattern



41.5 Evaluation

CF as Composition System



Component Model

Content: Filtered objects

Binding points: ports

Composition Technique

Static composition of filters by multiple inheritance

Dynamic composition of filters by filter superimposition

Dynamic adaptation by filters

Scaling by exchange of filters

Simple composition language

Composition Language

What Have We Learned?

- CF extends the standard object model to a new component model *FilteredComponent*
  - The objects have filters and can be adapted easily
- Any component model that provides interceptors or decorators can be used as filtered component
- Filtered components support
  - Adaptation
  - Greybox composition

The End