11. Design Patterns as Role Models

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Literature (To Be Read)

- D. Riehle, T. Gross. Role Model Based Framework Design and Integration. Proc. 1998 Conf. On Object-oriented Programing Systems, Languages, and Applications (OOPSLA 98) ACM Press, 1998. http://citeseer.ist.psu.edu/riehle98role.html
- Dirk Riehle. Bureaucracy. In Robert Martin, Dirk Riehle, and Frank Buschmann, editors, Pattern Languages of Program Design 3, pages 163-185. Addison Wesley, 1998.
  - http://dirkriehle.com/computer-science/research/1996/europlop-1996-bureaucracy.pdf

Remark

- Many role models and figures have been taken from:

  Dirk Riehle: **A Role-Based Design Pattern Catalog of Atomic and Composite Patterns Structured by Pattern Purpose.** In: Ubilab Technical Report 97-1-1

- http://dirkriehle.com/computer-science/research/1997/ubilab-tr-1997-1-1.pdf

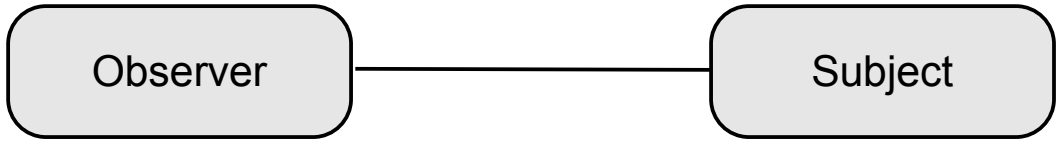
Goal

- Understand design patterns as role models
- Understand application of design patterns as merging role models into class models
- Understand composite design patterns
  - Understand how to mine composite design patterns
- Understand layered frameworks as role models
- Understand how to optimize layered frameworks and design patterns

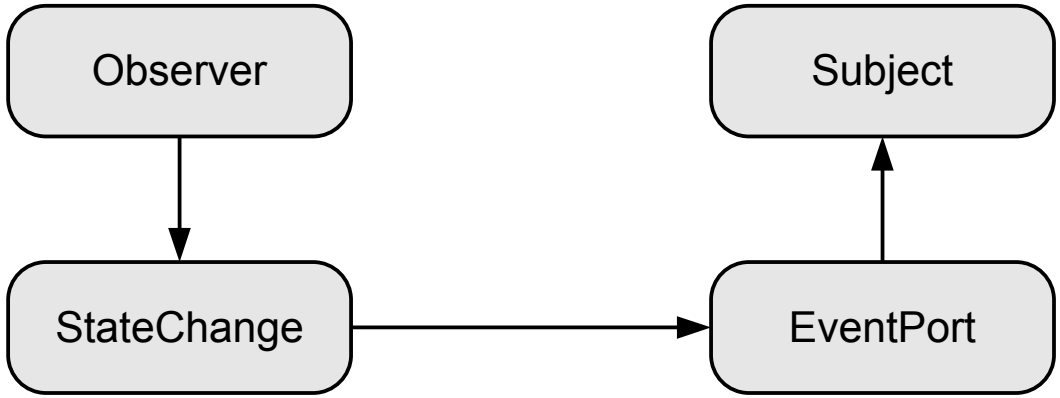
11.1 Design Patterns as Role Models

Design Patterns have Role Models

- Observer role model

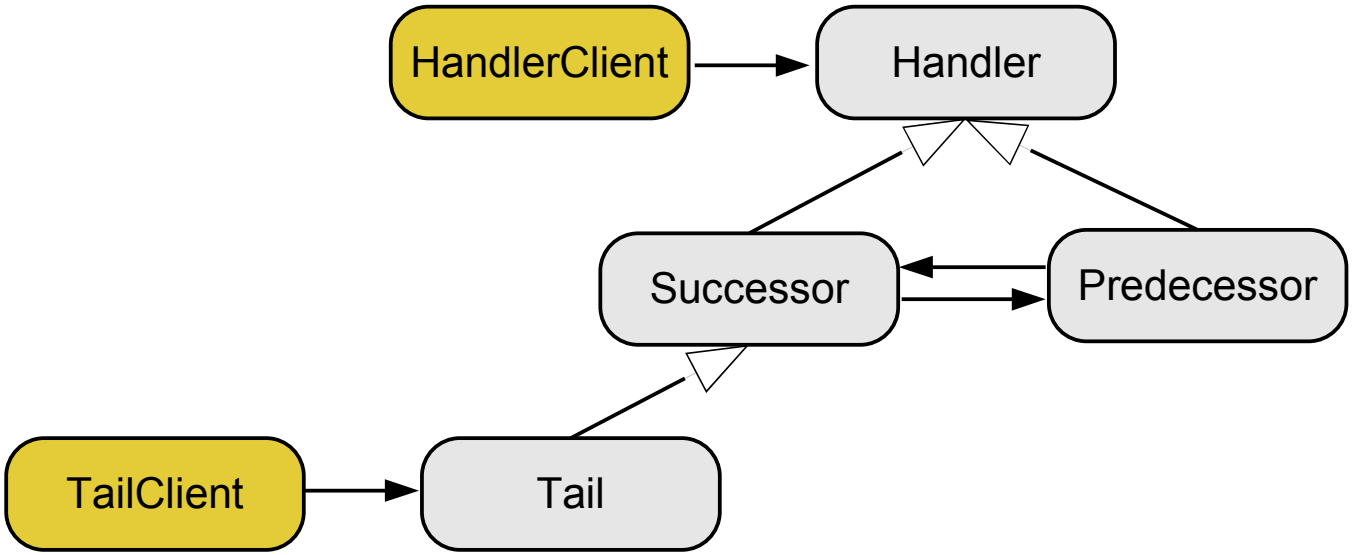


- Event Notification role model



Participants of Patterns form Role Models

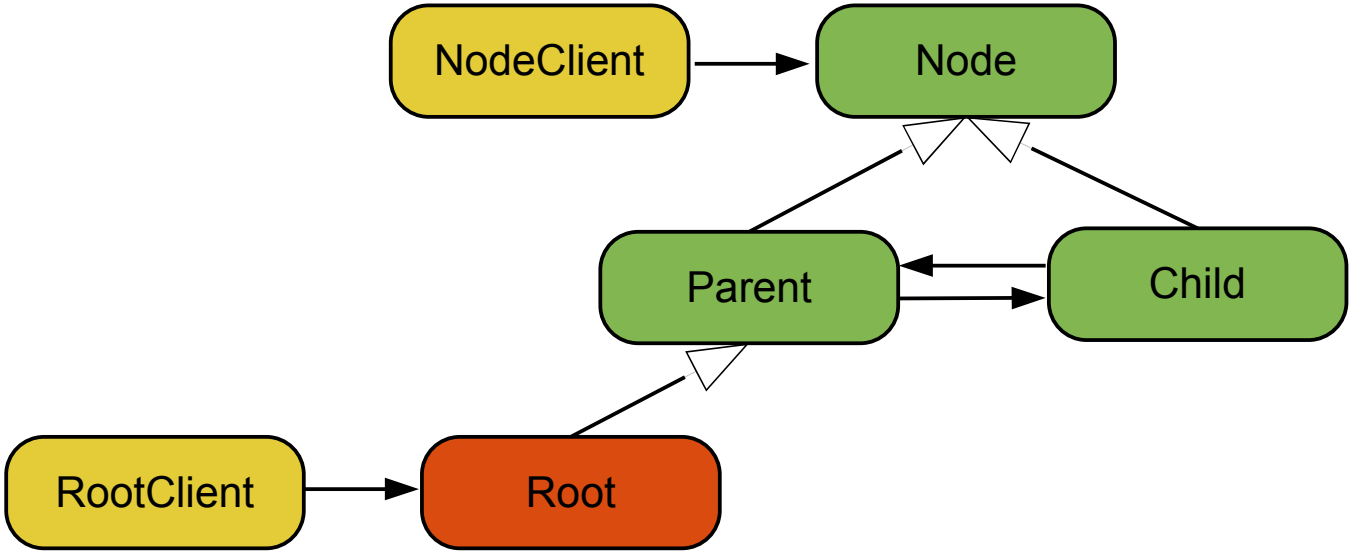
- The “participant” section of a GOF pattern is a *role model*



Role Model for Chain of Responsibility

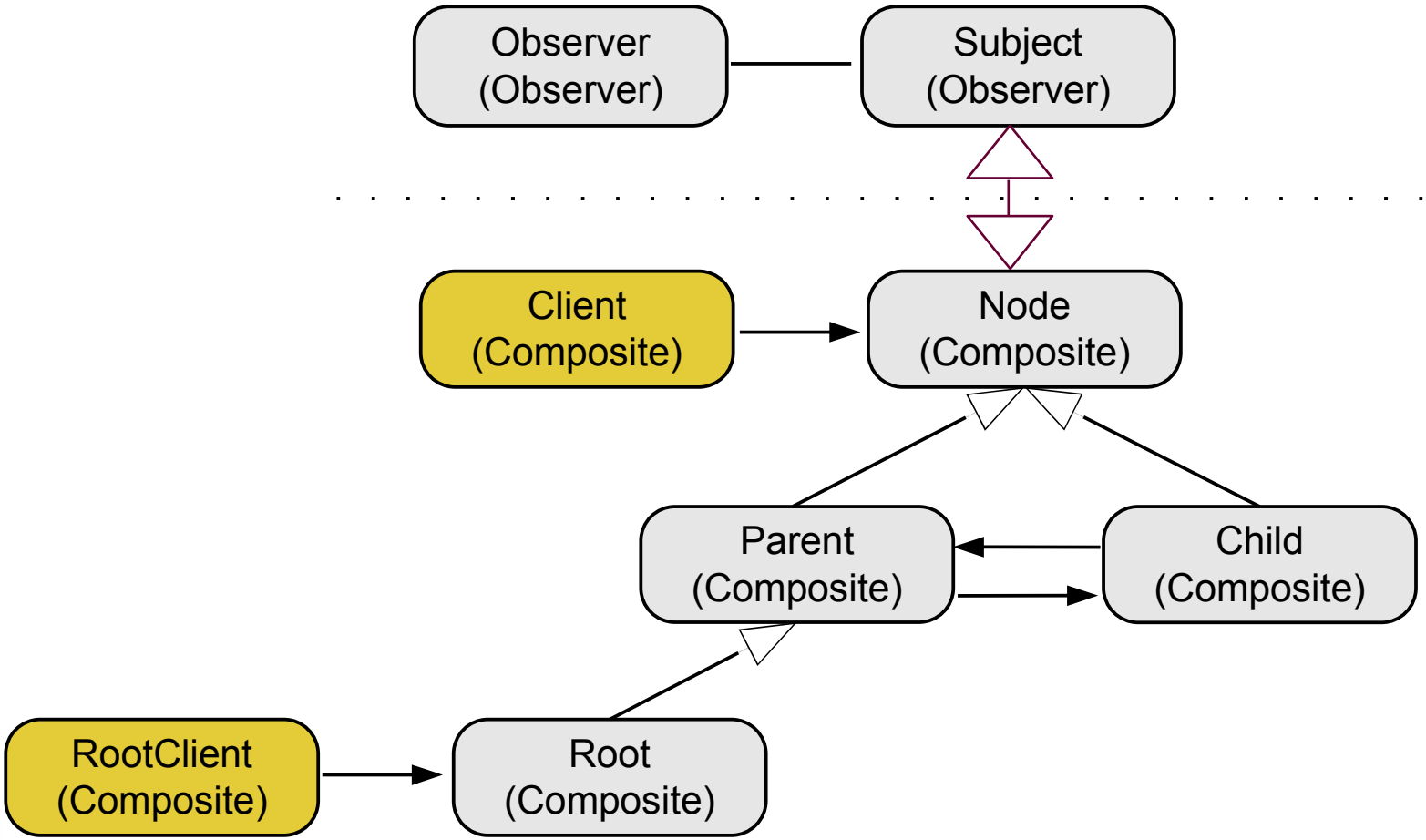
Role Model of Composite

- Root role is not in the GOF pattern description



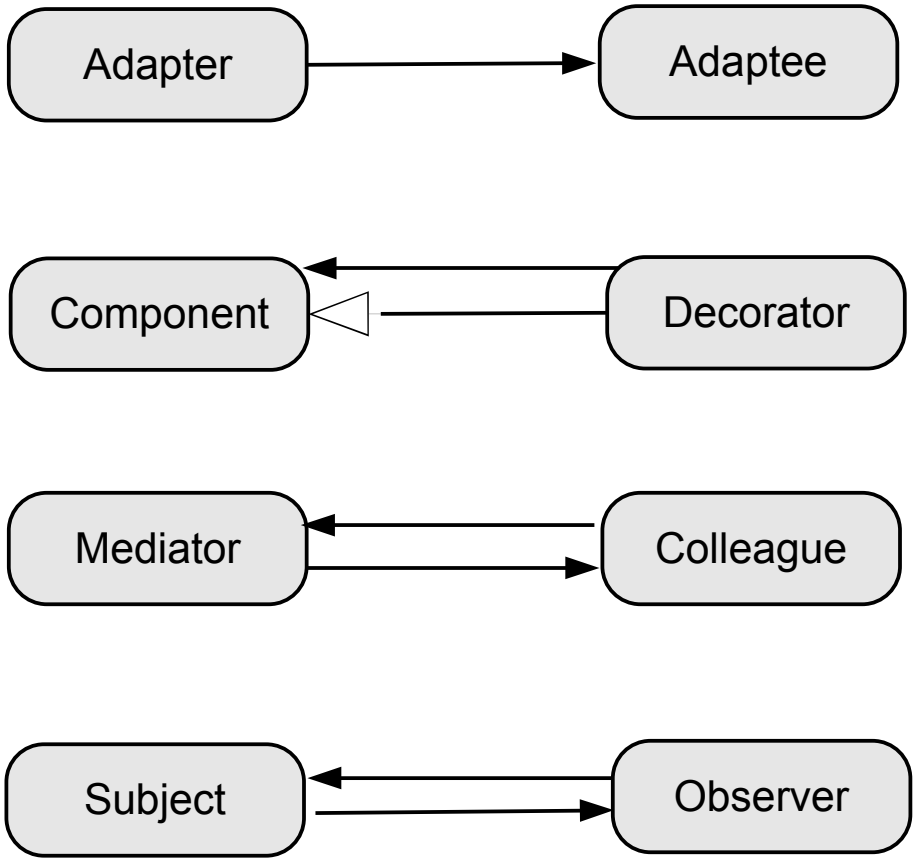
Composing Role Models

- Overlaying the Composite with the Observer role model by role equivalence



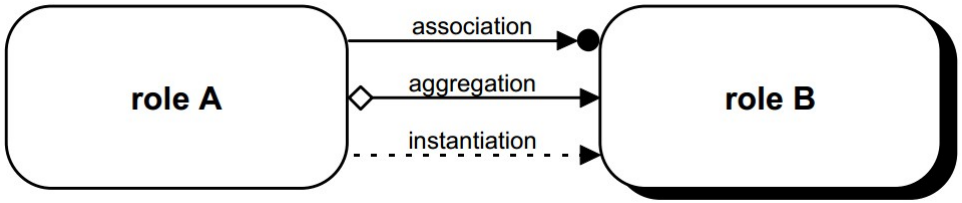
Core Role Diagrams of Several Patterns

- Many of them are quite similar



Adjustments to Riehle's Notation

- Riehle used special relationships between roles



a shadow indicates any number of roles with different role protocols (as opposed to a cardinality of n)

- We do not use these!
- Roles have no identity and, hence, cannot aggregate
- Riehle used role aggregation to express the need to introduce an aggregation between the classes the roles are mapped to.
- We differentiate two facets of role constraints:
  - Runtime constraints (role playership)
  - Mapping constraints (class-role mapping)

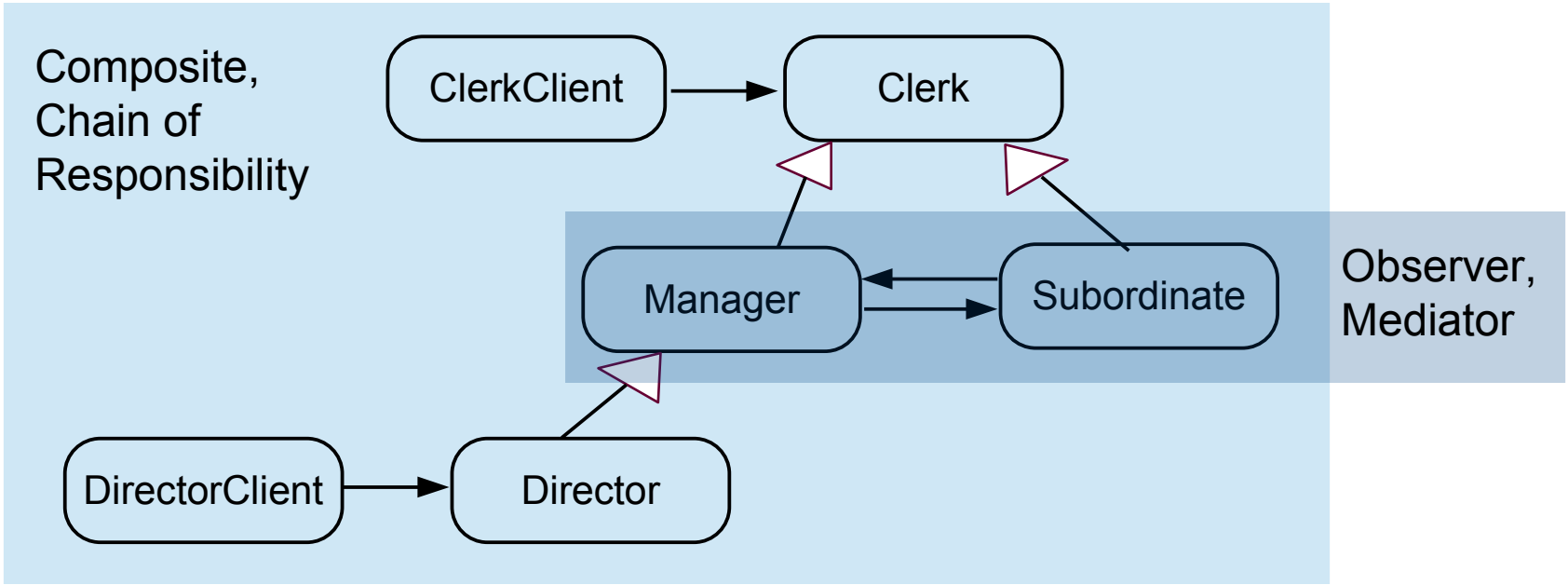
11.2 Composite Design Patterns with Role Model Composition

.. how to create bigger design patterns as composed role models..

11.2.1 Bureaucracy

Example: Bureaucracy

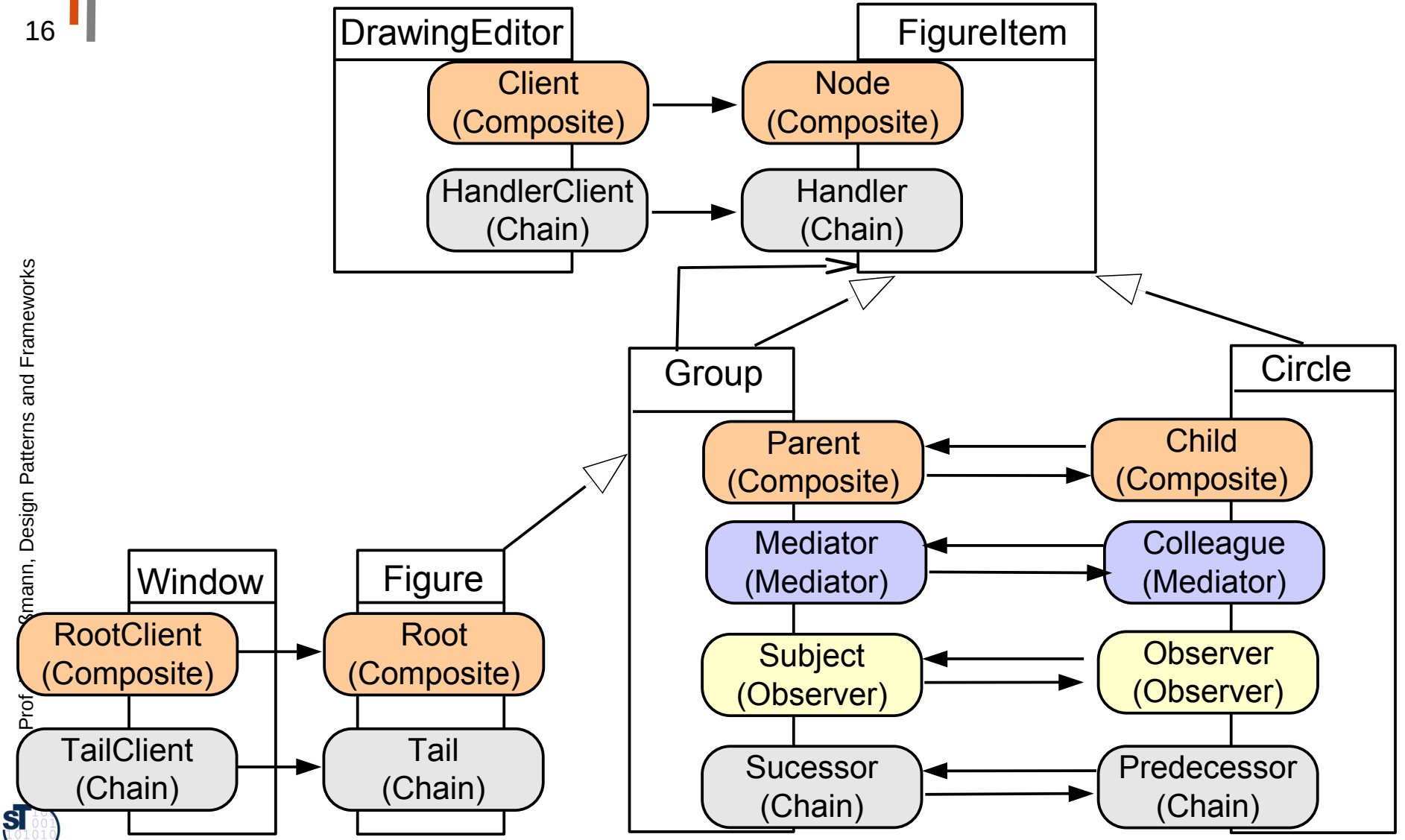
- A pattern to model organizations that have a tree-like structure (as opposed to matrix organizations)
  - Composed of the role models:
    Composite, Mediator, Chain of Responsibility and Observer



Example: Bureaucracy

- The *Composite* defines the organizational hierarchy of managers
- The *Mediator* is used to let colleagues talk to their siblings via a parent (mediator role)
- The *Chain* handles requests of clients
  - Every node may handle requests
  - If a node cannot handle a request, it is passed up in the hierarchy (on the path to the root)
- The *Observer* is used to listen to actions of a subordinate node
  - If a subordinate node (subject) changes something, its manager (observer) is notified

Bureaucracy Applied to Figure Example



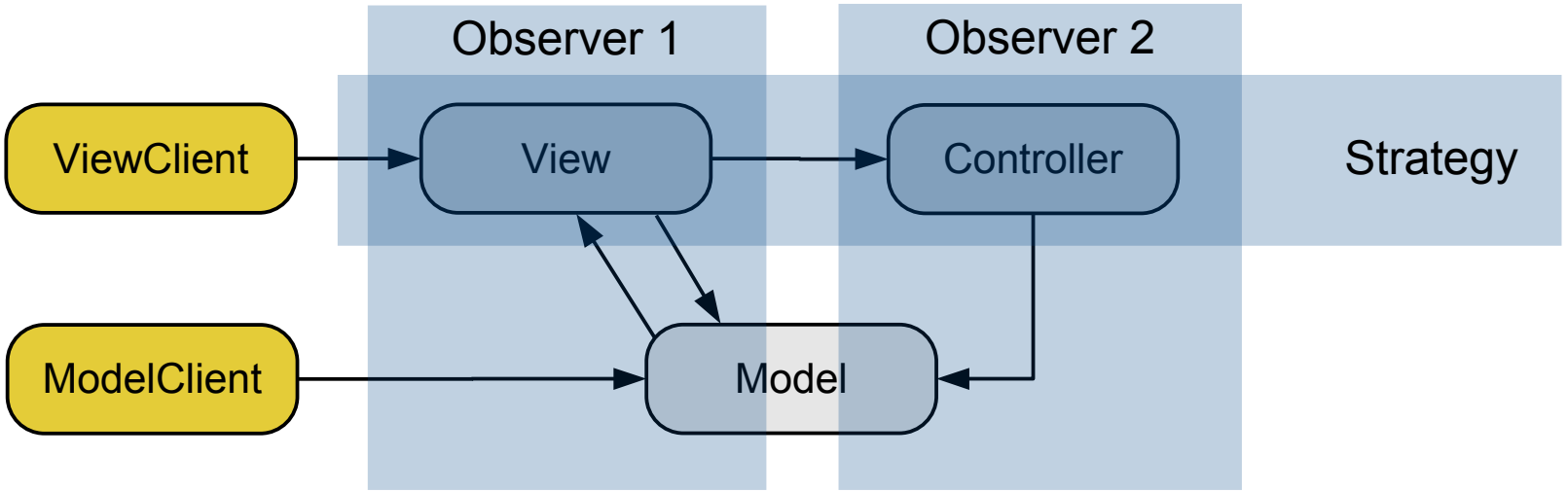
Application of Bureaucracy

- For all hierarchies
  - Figures in graphic and interactive applications
  - Widgets in GUIs
  - Documents in office systems
  - Piece lists in production management and CAD systems
  - Hierarchical tools in TAM (see later)
  - Modeling organizations in domain models: companies, governments, clubs

11.2.2 Model-View-Controller (MVC)

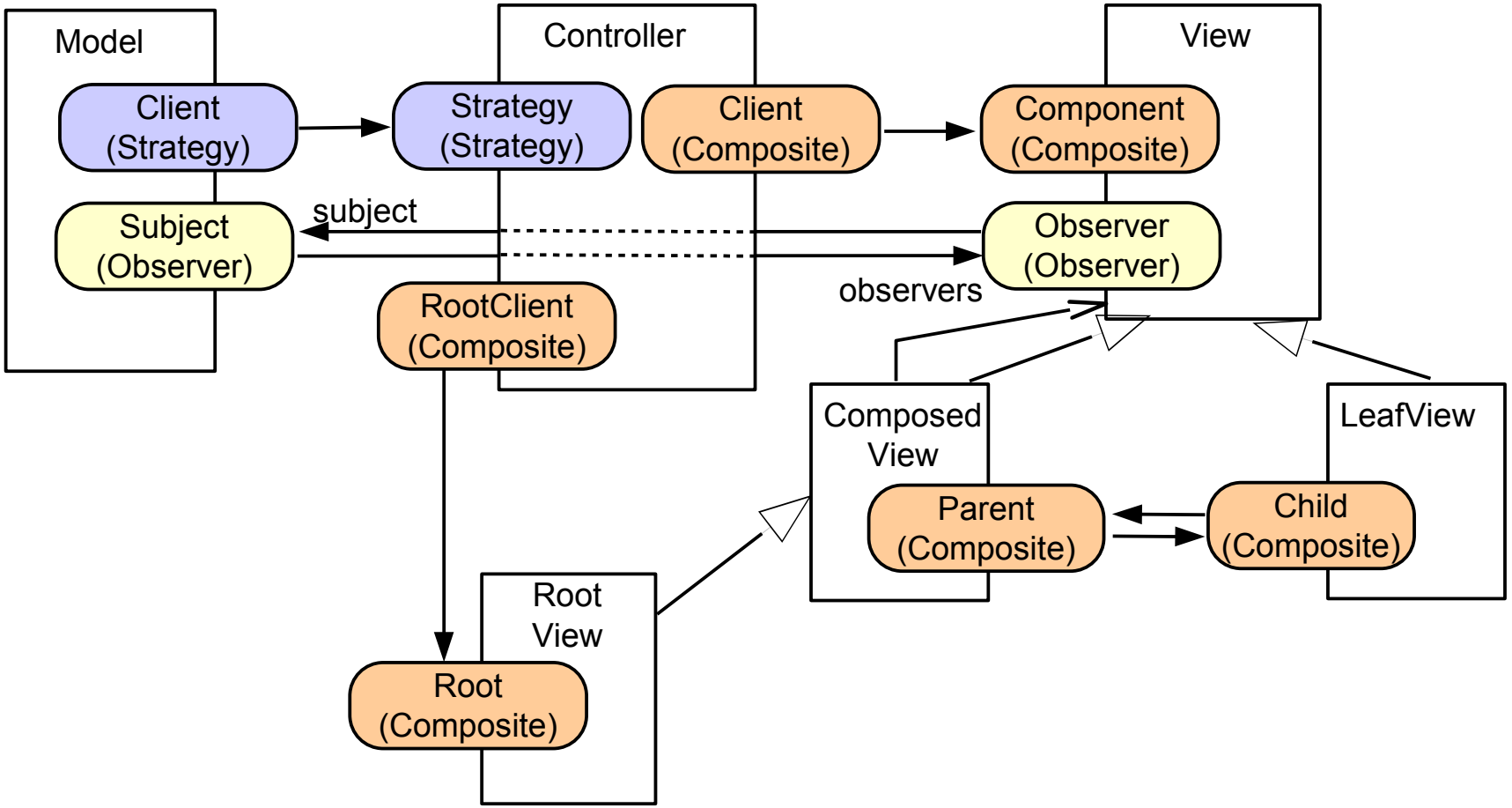
Role Model of MVC

- MVC originates from Trygve Reenskaug and Adele Goldberg
- MVC role model can be composed from the role models of Observer and Strategy
  - Views and Controllers observe the model
  - Controllers can be varied (Strategy)
  - Extension with Composite Pattern for views possible



Role-Class Model of MVC

- MVC originates from Trygve Reenskaug and Adele Goldberg
- MVC role model can be composed from the role models of Observer, Strategy, Composite



This Closes a Big Loop

- Remember, Reenskaug developed MVC 1978 with Goldberg, while working on Smalltalk-78 port for Norway
- Starting from his MVC pattern, Reenskaug has worked on role-based design
- 1998, Riehle/Gross transferred role-based models to design patterns
- Today, MVC can be explained as composed role model of other design patterns

Riehle-Gross Law On Composite Design Patterns

The role model of a composite design patterns is composed of the role models of their component design patterns

- Consequences
  - Complex patterns can be easily split into simpler ones (decomposition)
  - Variants of patterns can more easily be related to each other (variability of patterns)
    - e.g., ClassAdapter and ObjectAdapter
  - Template&Hook conceptual pattern can be explained as role model (see next chapter)

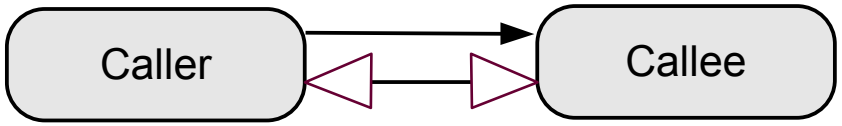
11.2.3 Composition of Simple Variability Patterns

Warning

- The following is an attempt to build up the basic GOF patterns from simple role models based on the findings by Riehle and colleagues
- The compositions of patterns depend on the concrete form of their role models
- It explains why Strategy is different from Bridge and TemplateClass, etc.

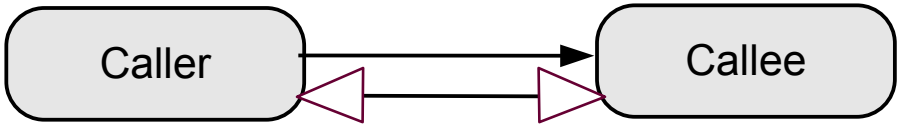
Derived Method

- In a class,
  - A *kernel method* implements the feature directly on the attributes of the class, calling no other method
  - A *derived method* is implemented by calling only kernel methods
- Caller and callee role have to be bound to the same class (as the purpose is to have class-internal method calls)

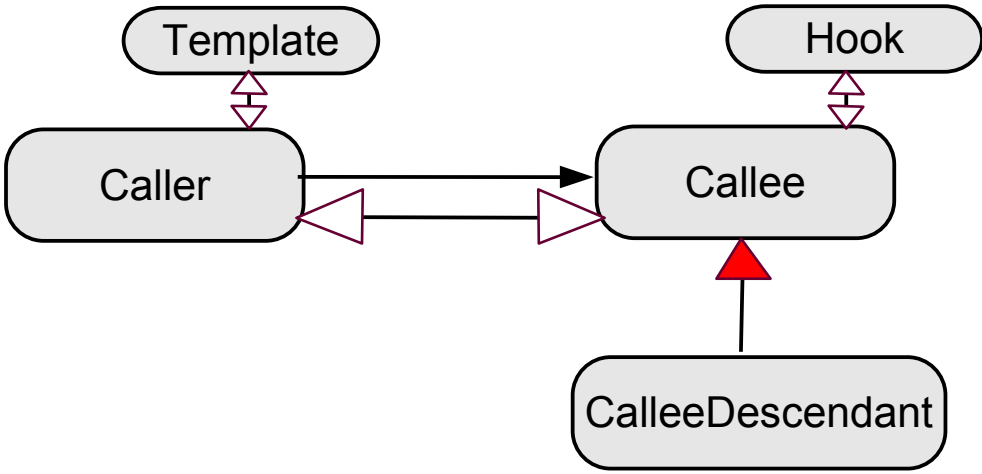


Derived Method and TemplateMethod

- TemplateMethod is a DerivedMethod that has
  - an additional Template/HookMethod role model
  - Inheritance hierarchy on right side (implied by role-class inheritance constraint)
  - The template role implies no hierarchy on left side

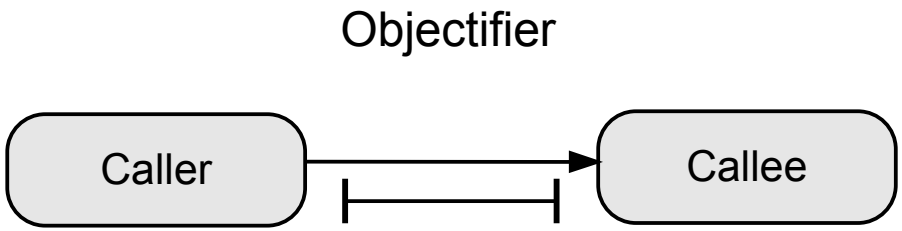


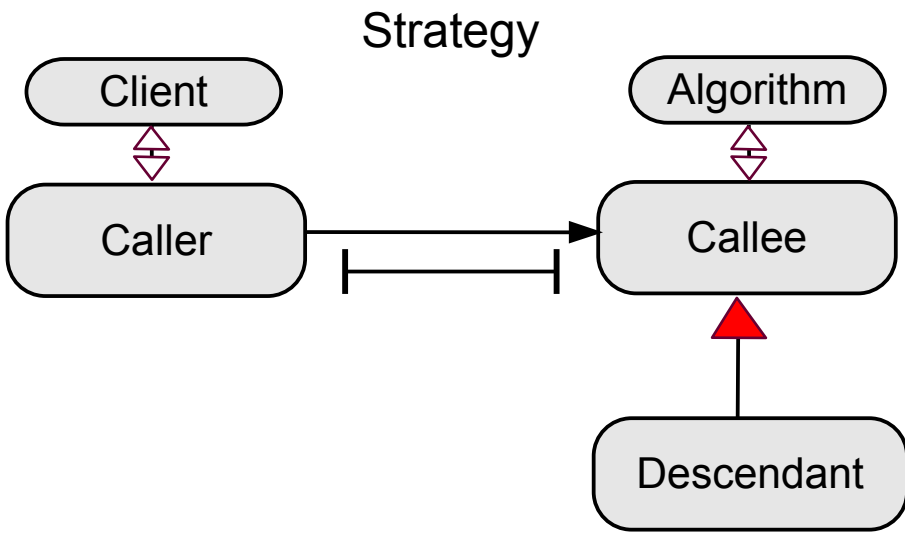
TemplateMethod



Objectifier and Strategy

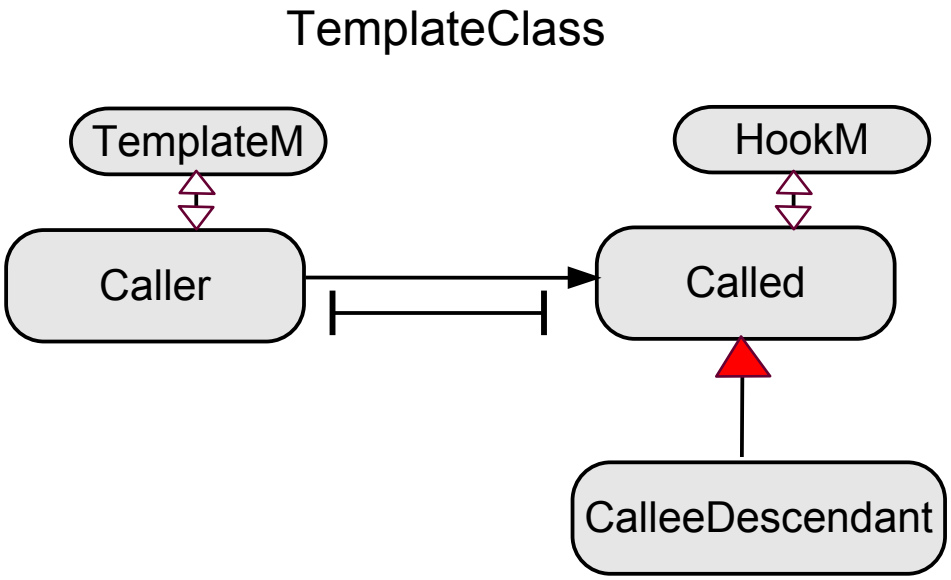
- Objectifier has
  - A prohibition constraint on Caller and Callee (instead of equivalence)
  - No template role
- Strategy is an Objectifier with
  - Client role
  - Algorithm role
  - Hierarchy on right side
  - No template role





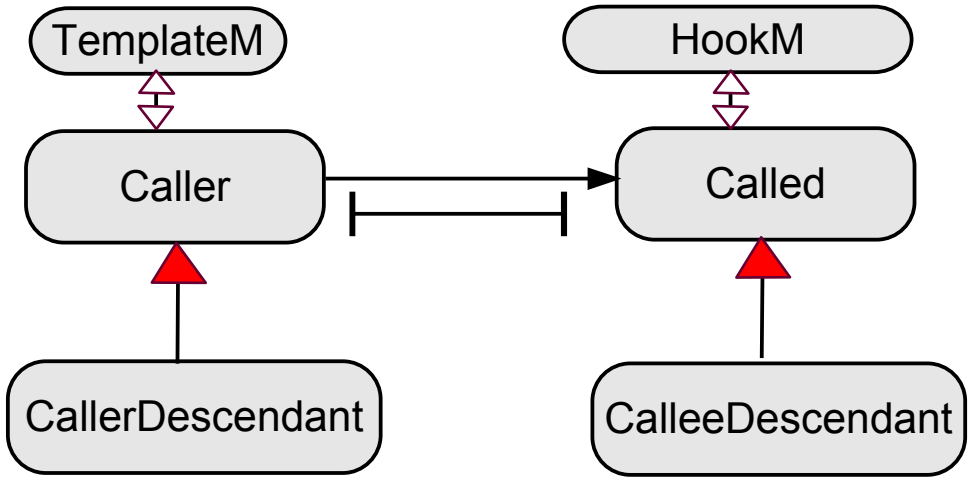
TemplateClass

- TemplateClass is an Objectifier with
  - An additional Template/ HookMethod role model
  - TemplateMethod role implies no hierarchy on left side
  - HookMethod role implies inheritance hierarchy on right side
  - *No client or algorithm role*, otherwise like Strategy



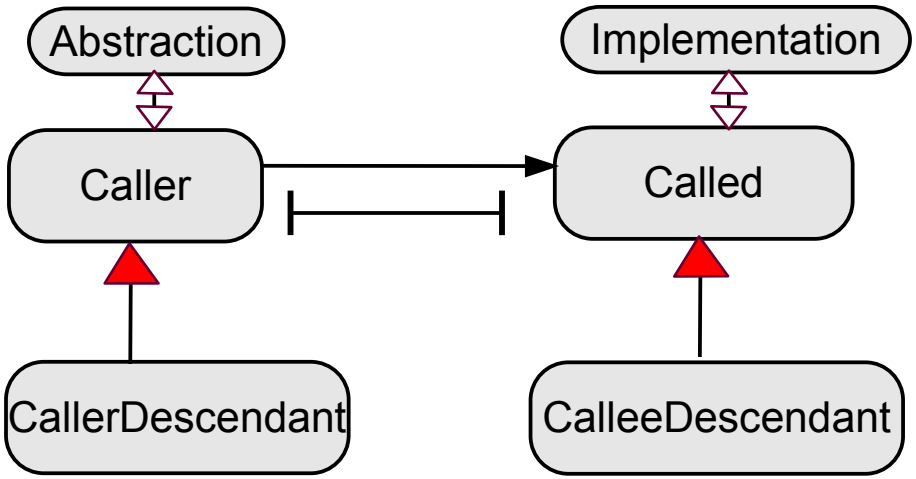
DimensionalClassHierarchies

- DimensionalClassHierarchies is a TemplateClass
  - With left hierarchy constraint



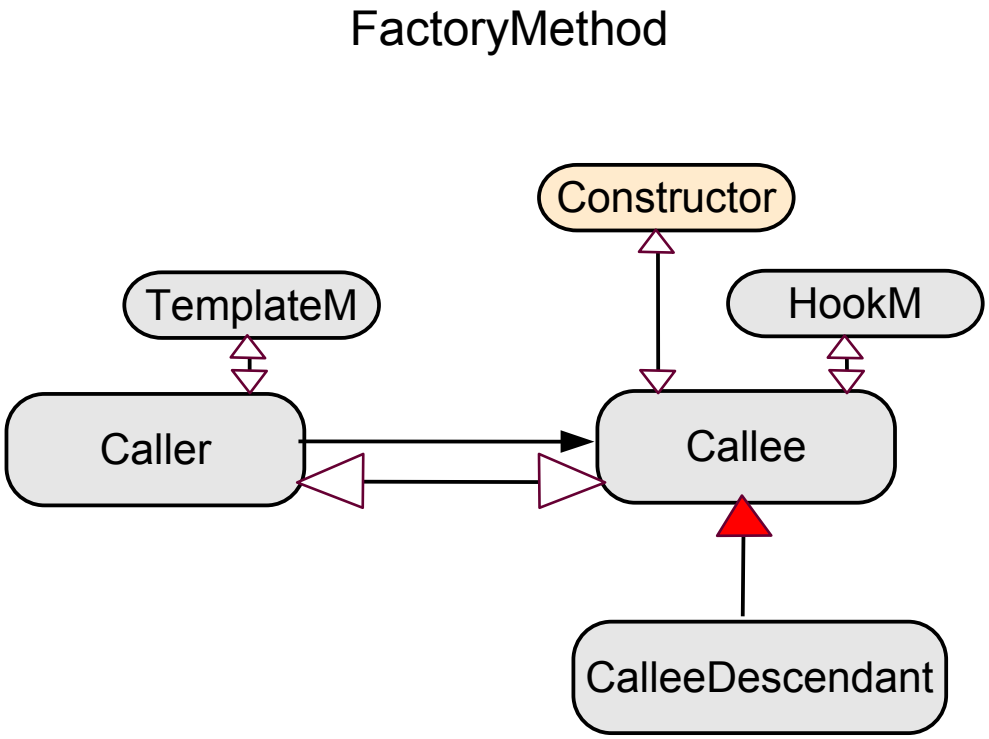
Bridge

- Bridge is a DimensionalHierarchies with
  - Abstraction/Implementation roles instead of T&H
  - *No template/hook role*



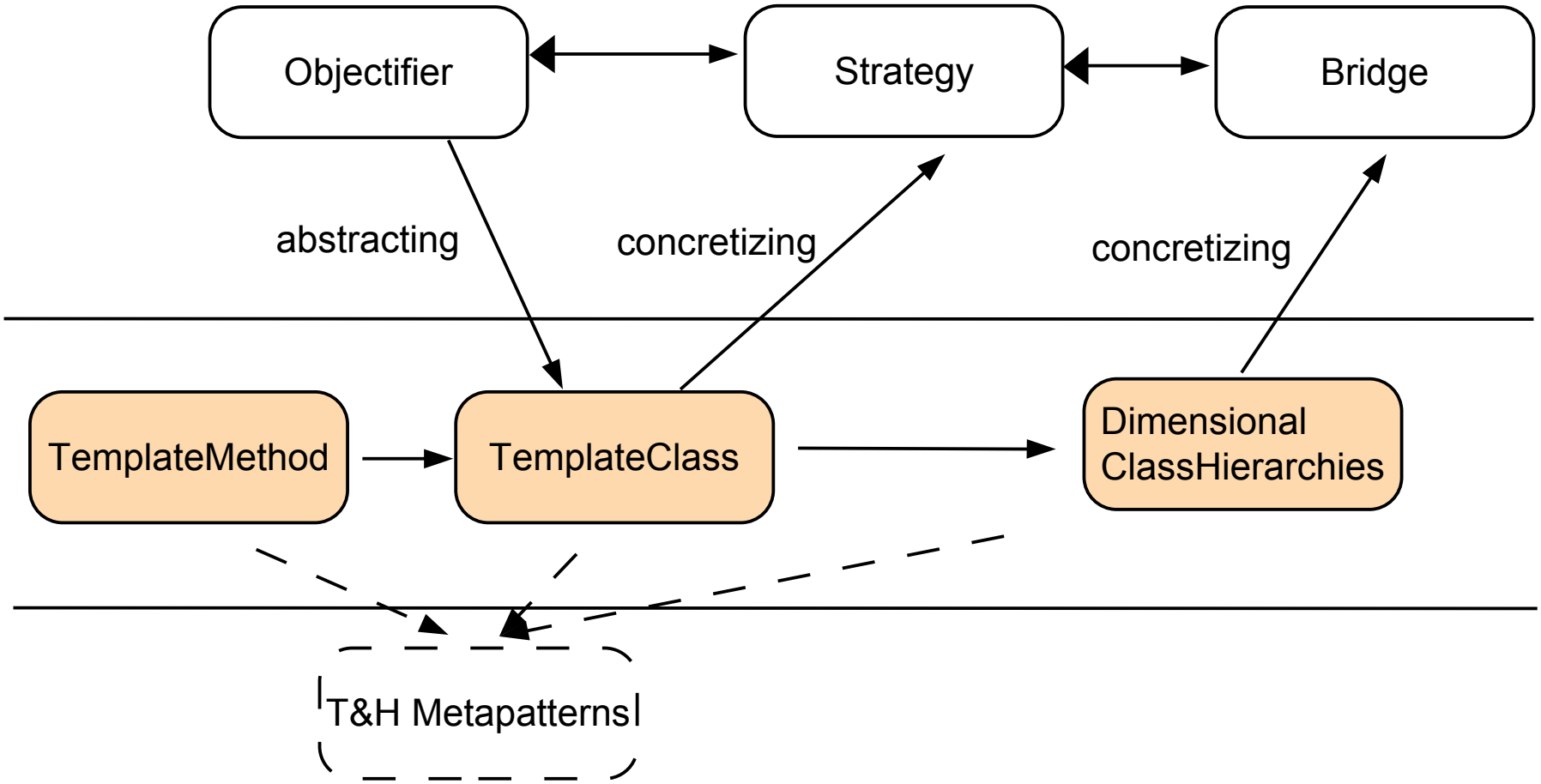
Creational Patterns

- Add more roles with semantics about creation
- E.g., FactoryMethod is a TemplateMethod with a creational role model



Remember: Relation TemplateMethod, TemplateClass, Strategy, Observer

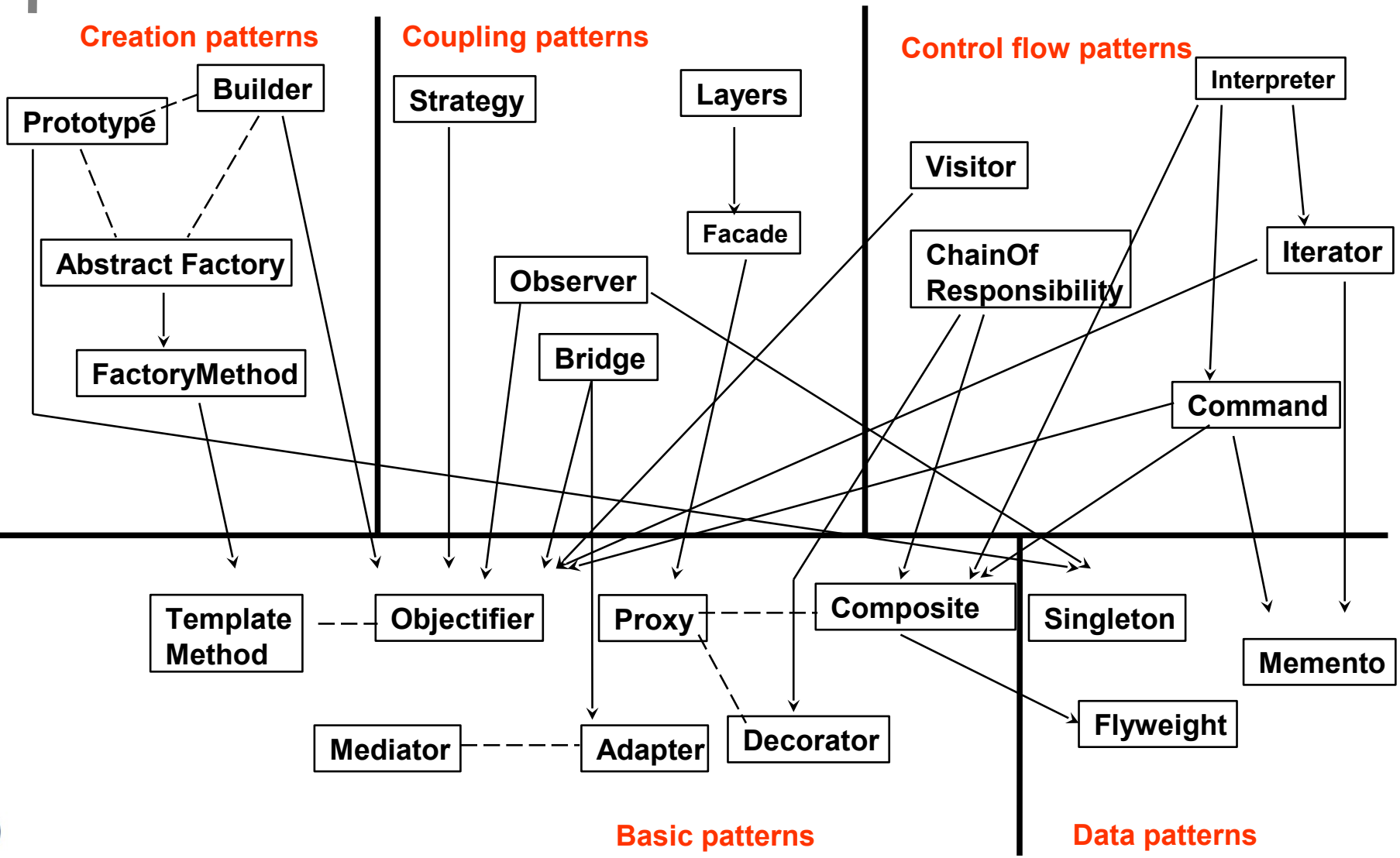
More specific patterns (with more intent, more pragmatics, specific role denotations)



Framework Patterns (with TemplateM/HookM role model)

11.2.5 Consequences of the Riehle/Gross Law

Relations between Patterns [Zimmer, PLOP 1]



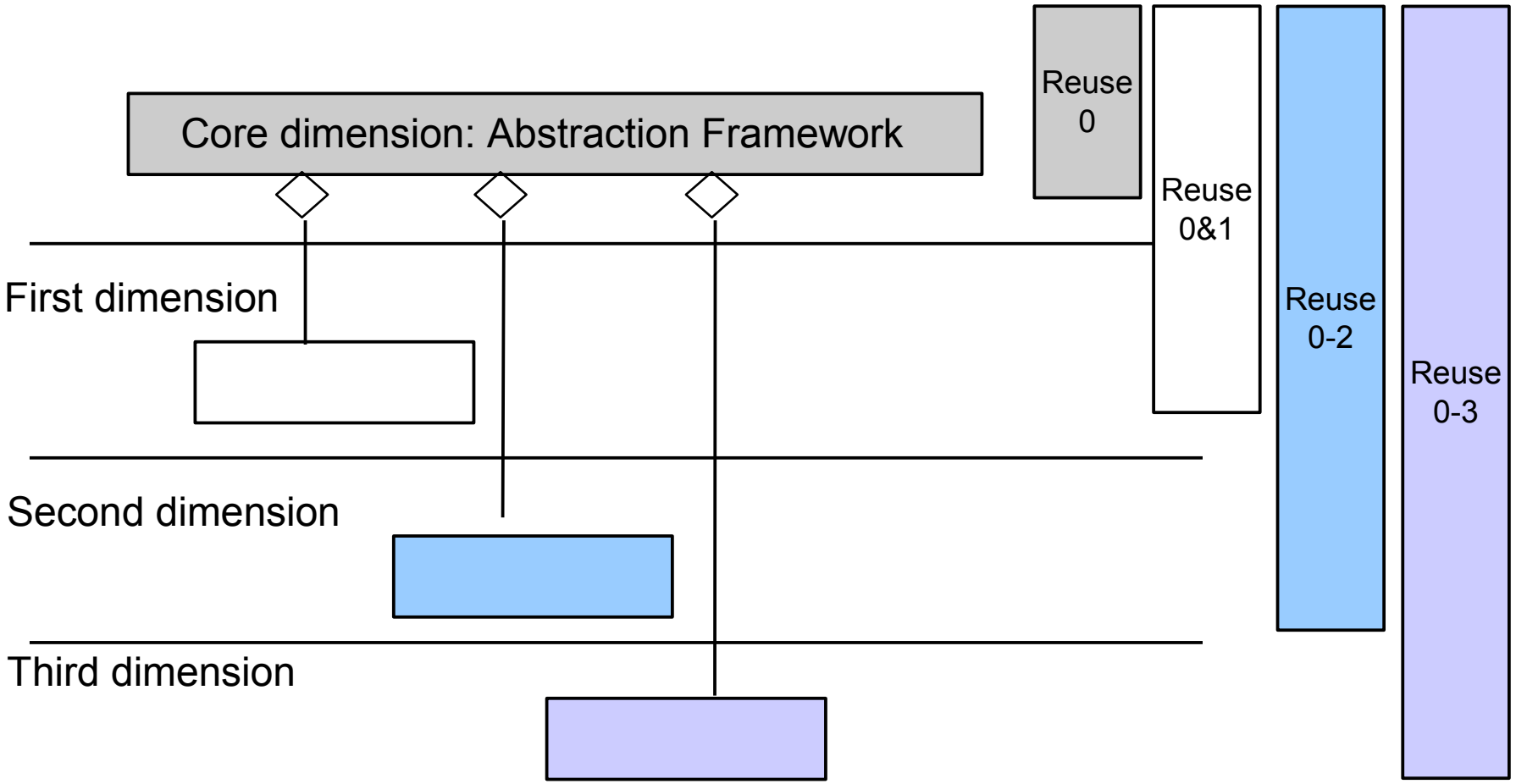
Vision for Pattern-Based Design

- With different role models, the fine semantic differences between several patterns can be expressed syntactically
  - A role model can capture *intent (pragmatics)* of a pattern
  - While patterns can have the same structure, the intent may be different
  - It is possible to distinguish a Strategy, TemplateClass, a Bridge or DimensionalClassHierarchy
- This makes designs more explicit, precise, and formal
- Prerequisite: role types have to be formally specified (which is current research)

11.3 Effects of Role-Based Design Patterns on Frameworks and Applications

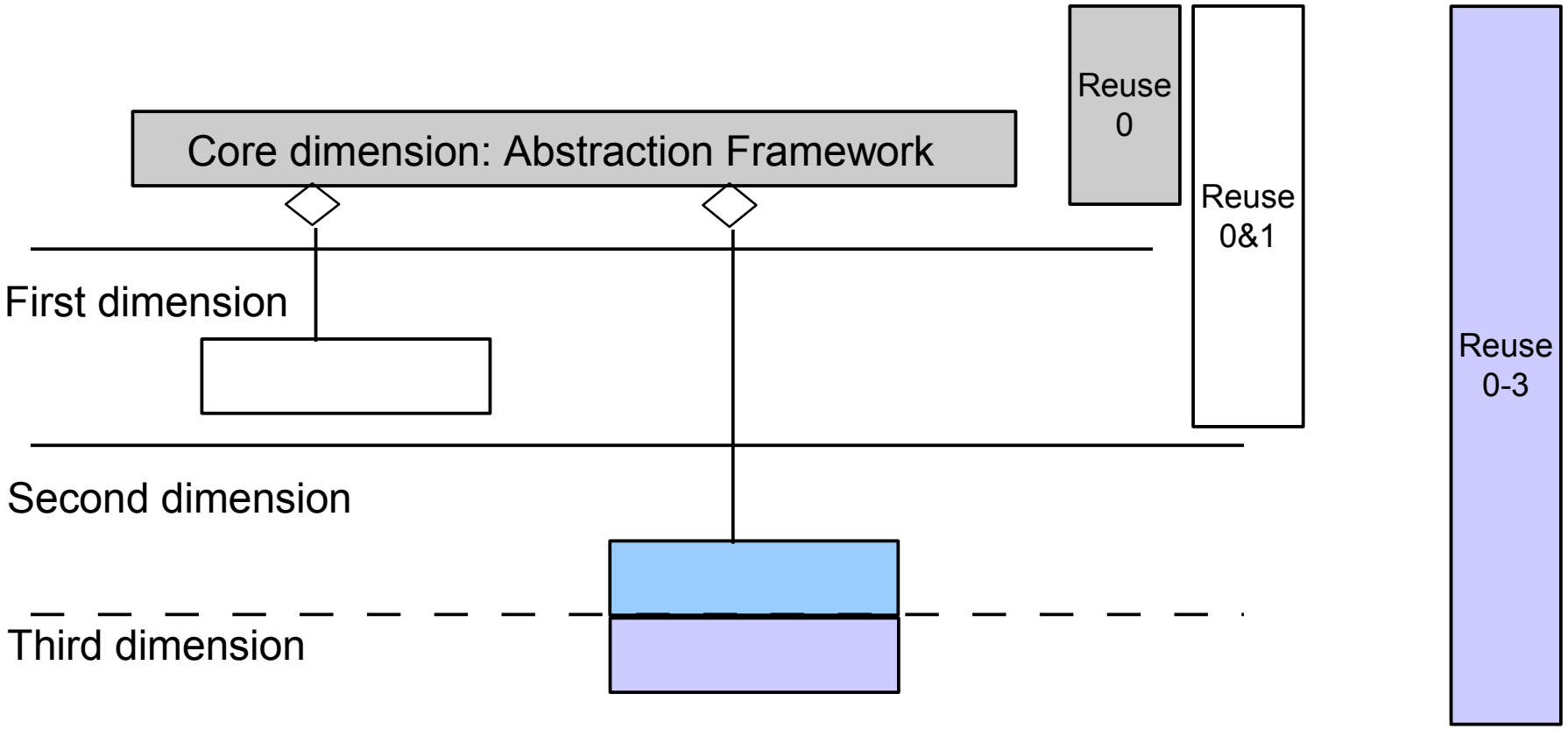
Role Models and Facet/Layered Frameworks

- Remember: An n-Bridge framework maintains roles (role models) in every facet (because a facet model is based on a class-role model)
- Similar for Chain-Bridges and layered frameworks



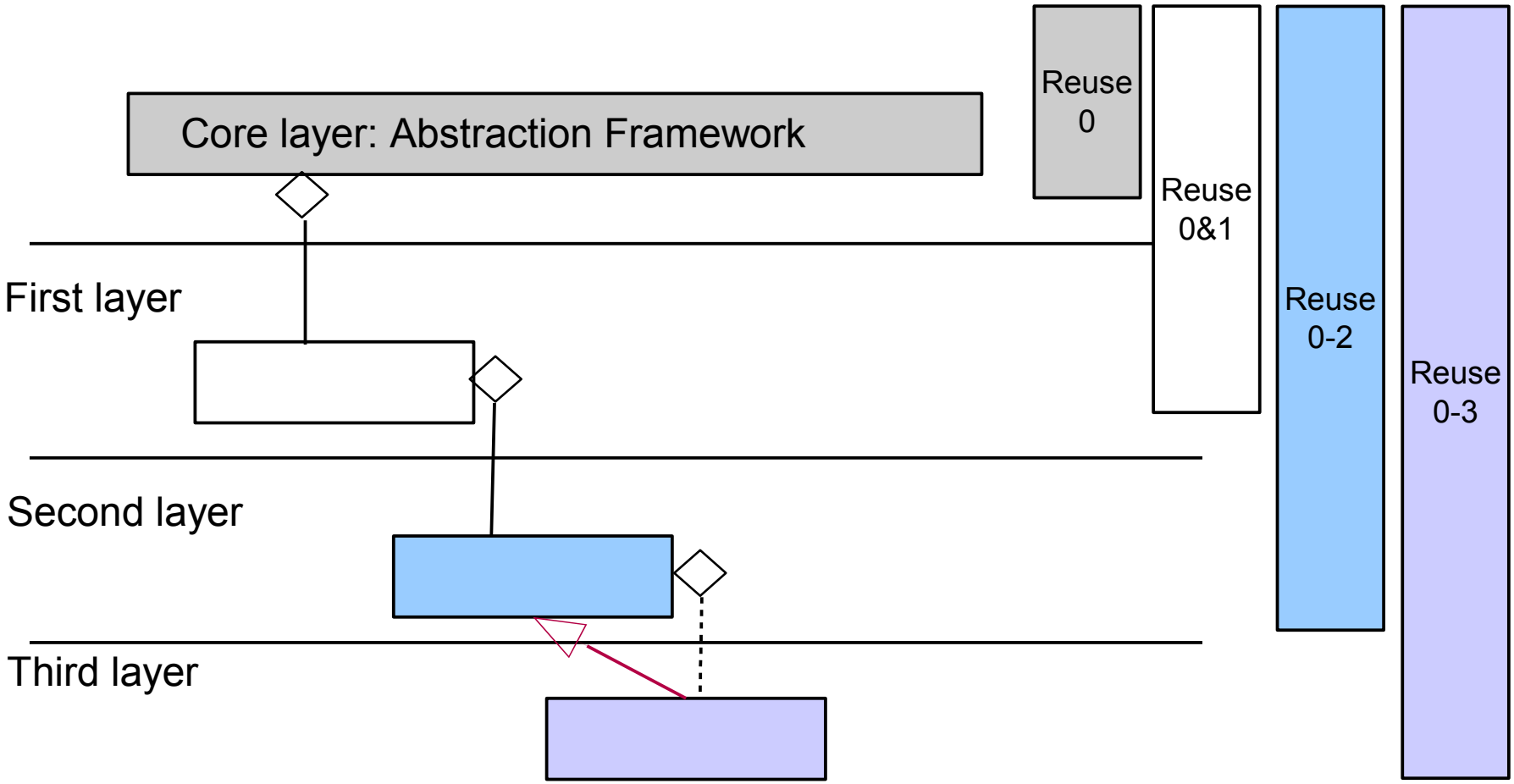
Merging dimensions of Facet/Layered Frameworks

- If the dimensions are seen as role models, it can be chosen to merge them, i.e., the role models
- Here: merge second and third dimension into one physical implementation



Role Models and Layered Frameworks

- Similar for Chain-Bridges and layered frameworks

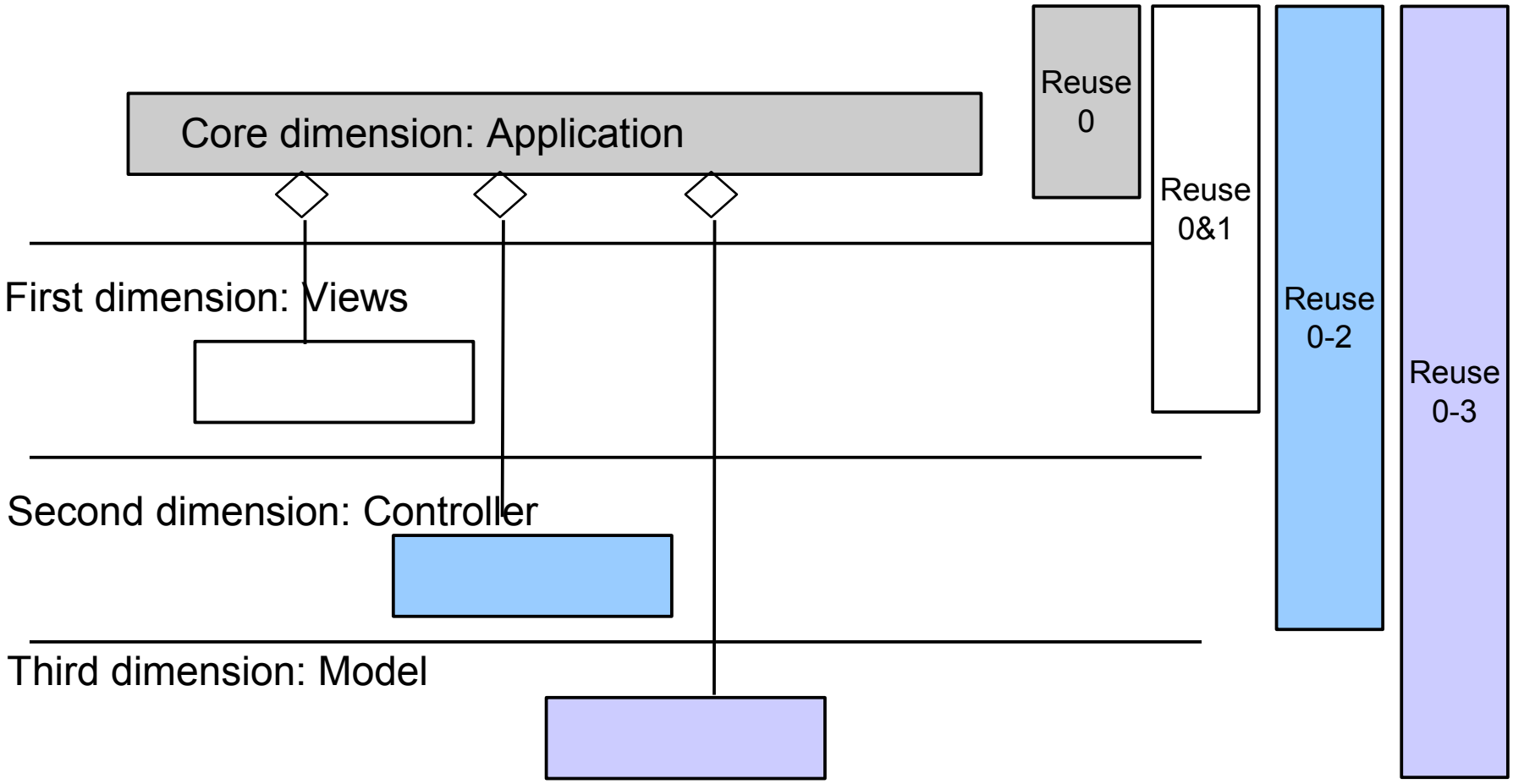


Merging Dimensions/Layers of Dimensional/Layered Frameworks

- When two layers are merged, the variability of a framework decreases
- But its applications are more efficient:
  - Less delegations (less bridges)
  - Less allocations (less physical objects)
  - Less runtime flexibility (less dynamic variation)

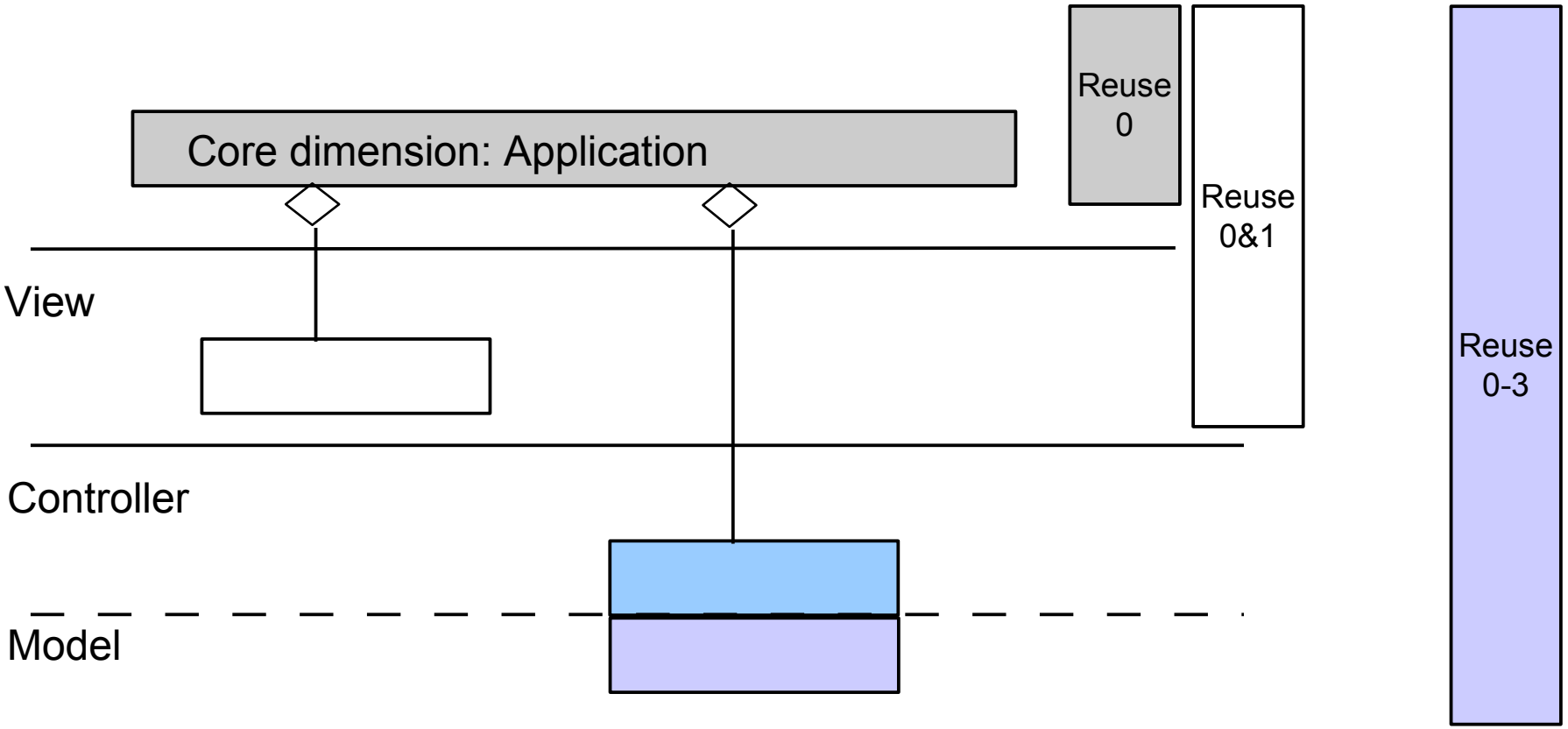
MVC as Multi-Bridge Framework

- The roles of MVC can be ordered in a n-Bridge framework



MVC as Optimized Multi-Bridge Framework

- Model and Controller layer can be merged
- Less variability, but also less runtime objects



11.4 Optimization of Design Patterns with Role Models

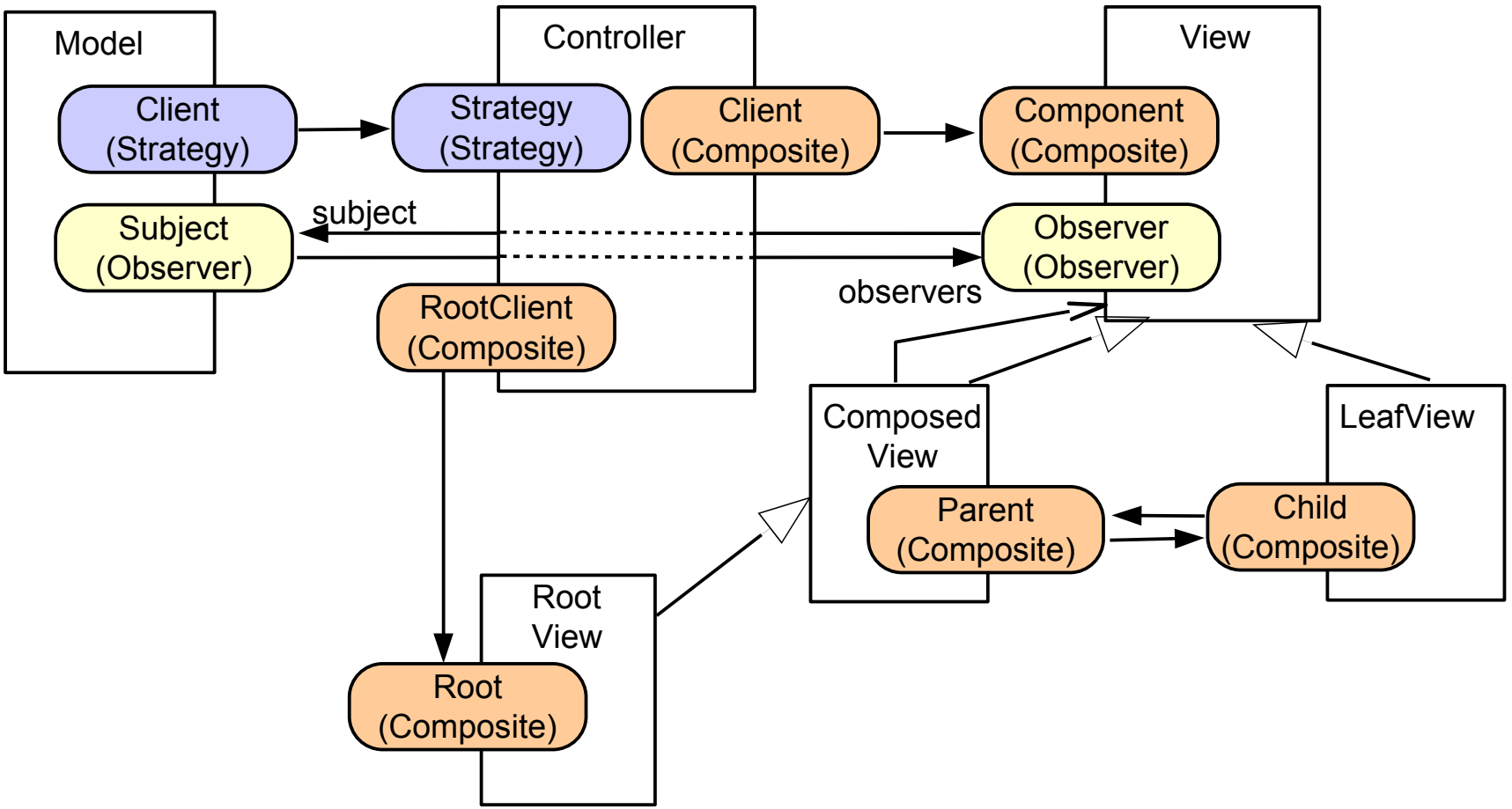
Optimization for Design Patterns

Whenever you need a variant of a design pattern that is more efficient, investigate its role model and try to merge the classes of the roles

- Effect:
  - Less variability
  - Less runtime objects
  - Less delegations

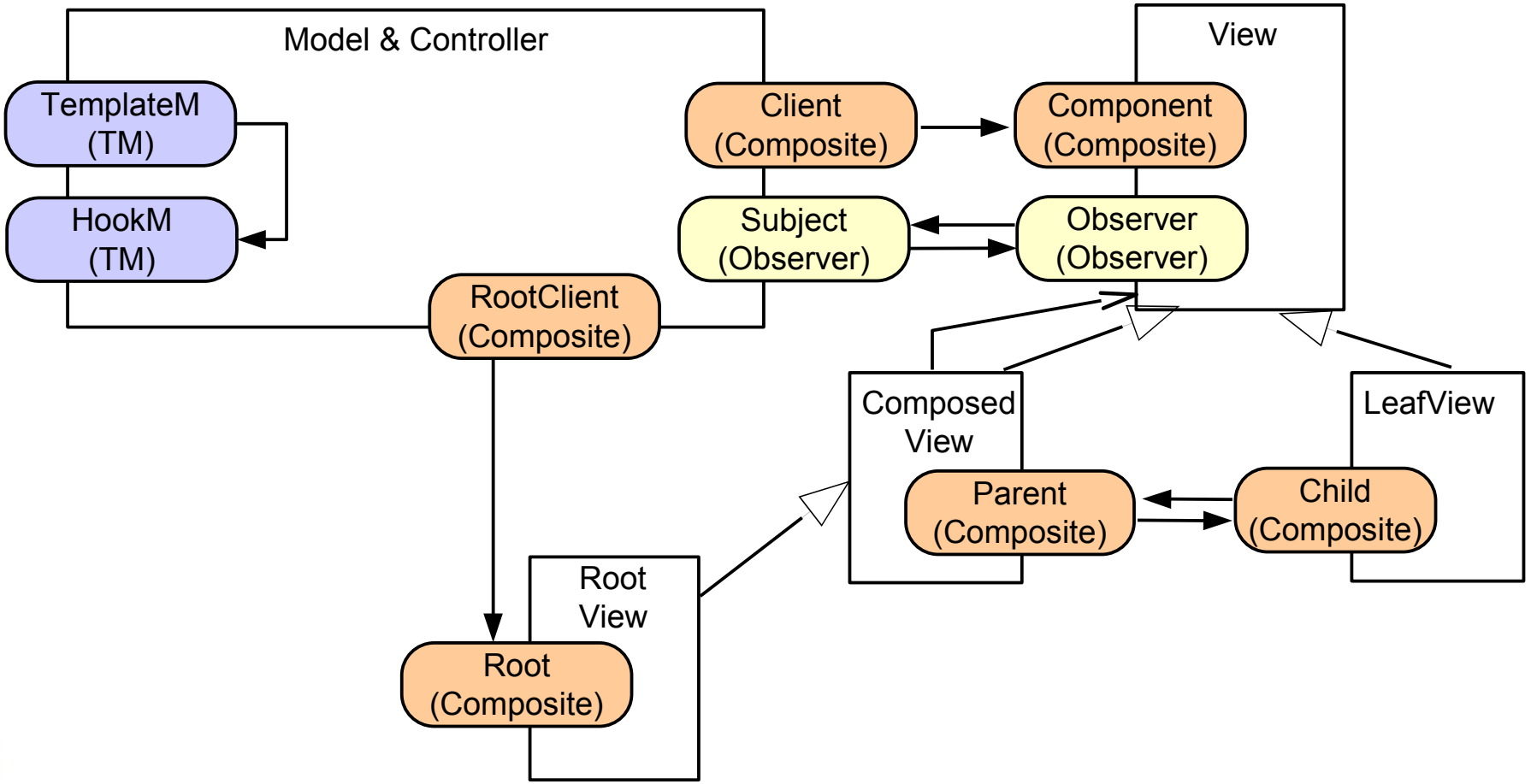
Original Role-Class Model of MVC

- Separate classes for almost each role



Optimized Role-Class Model of MVC

- Merging model and controller class leads to less delegations (i.e., a performance improvement)
- Strategy pattern is to be exchanged with TemplateMethod pattern



The End: Summary

- Roles are important for design patterns
  - If a design pattern occurs in an application, some class of the application plays the role of a class in the pattern
- Role mapping is the process of allocating roles to concrete implementation classes
- Hence, role mapping decides how the classes of the design pattern are allocated to implementation classes (and this can be quite different)
- Composite design patterns are based on role model composition
- Layered frameworks and design patterns can be optimized by role merging