13. Frameworks and Patterns - Framework Extension Patterns

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Version WS17/18 - Jan 15, 2018

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1) Extension Object Pattern
2) Large Layered Frameworks
3) Role Object Pattern
4) GenVoca Pattern
5) Mixin Layer Pattern

Literature (To Be Read)

- E. Gamma. **The Extension Objects Pattern.** Conf. On Pattern Languages of Programming (PLOP) 97, ACM. http://portal.acm.org/citation.cfm?id=273448.273455
- Y. Smaragdakis and D. Batory. **Mixin layers: an object-oriented implementation technique for refinements and collaboration-based designs.** ACM Transactions on Software Engineering and Methodology, 11(2):215–255, 2002. http://dl.acm.org/citation.cfm?id=505148
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- 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://dl.acm.org/citation.cfm?id=286951
- D. Bäumer, G. Gryczan, C. Lilienthal, D. Riehle, H. Züllighoven. **Framework Development for Large Systems.** Communications of the ACM 40(10), Oct. 1997. http://dl.acm.org/citation.cfm?id=262804

Further Literature

- D. Bäumer. Softwarearchitekturen für die rahmenwerkbasierte Konstruktion grosser Anwendungssysteme. PhD thesis, 1997, Universität Hamburg.
- JWAM sites
  - http://www.c1-wps.de/forschung-und-lehre/fachpublikationen/
  - www.jwam.de
  - http://sourceforge.net/projects/jwamtoolconstr/
- U. Aßmann. Composing Frameworks and Components for Families of Semantic Web Applications. Lecture Notes In Computer Science, vol. 2901, Nov. 2003.
- U. Aßmann, J. Johannes, J. Henriksson, and I. Savga. Composition of rule sets and ontologies. In F. Bry, editor, Reasoning Web, Second Int. Summer School 2006, number 4126 in LNCS, pages 68-92, Sept 2006. Springer.
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Goal

- Studying extensible framework hook patterns
  - Understand patterns:
    - Extension Object,
    - Role Object, and
    - Genvoca
  - See how layered frameworks can be implemented by
    - Role Object and
    - Genvoca
- Understand these patterns as extension points of frameworks, i.e., framework hook patterns

Frameworks Must Be Extensible

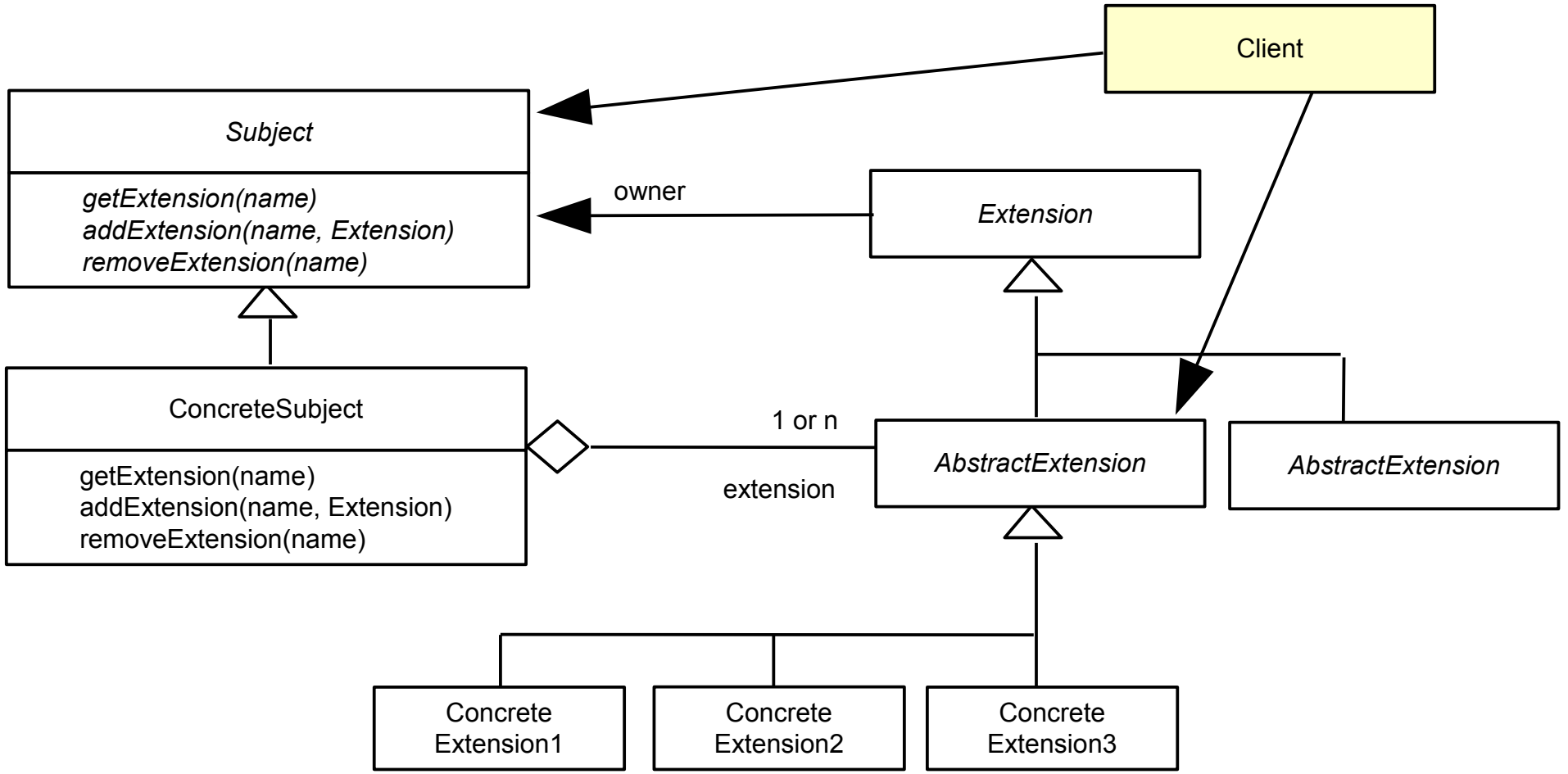
- Frameworks must evolve, be adapted
- Idea: instead of variability hooks, use extensibility hooks
  - based on basic extensibility patterns
- Presented in this lecture:
  - Gamma's Extension Object Pattern (EOP)
  - Layered frameworks
    - Riehle/Züllighoven's RoleObject pattern (ROP)
    - Batory's mixin layer pattern (GenVoca pattern)

13.1 The ExtensionObjects Pattern (EOP)

Extensions of Objects, visible for the Client

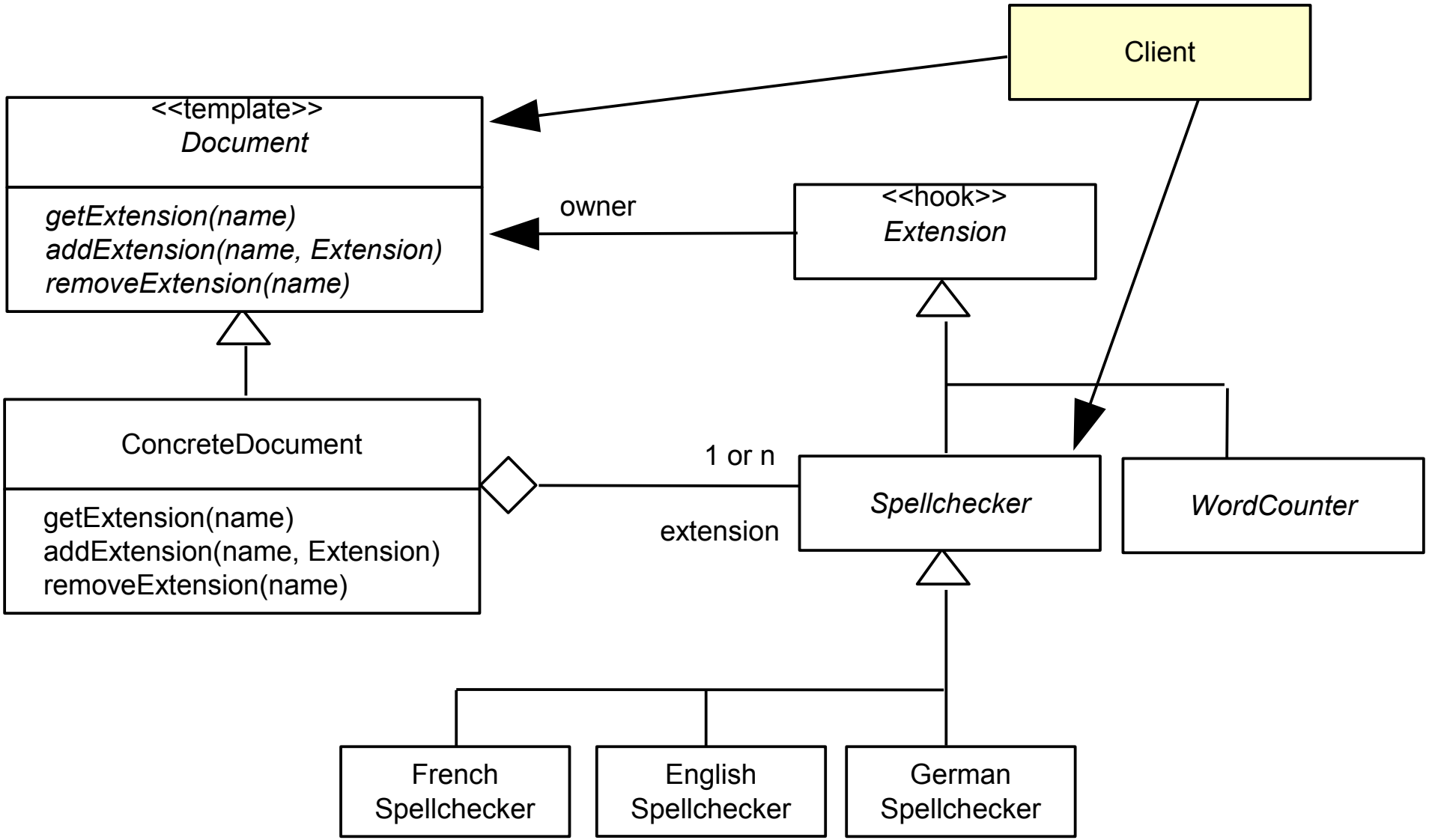
Structure of ExtensionObjects

- Whenever a complex object has non-mandatory parts that can be added, if necessary
- *Extension* is the base class of all extensions
- *AbstractExtension* defines an interface for a concrete hierarchy of extension objects
- Extensions can be added, retrieved, and removed by clients



Example: Spellcheckers in Document Models

- E.g., OpenDoc or OLE documents

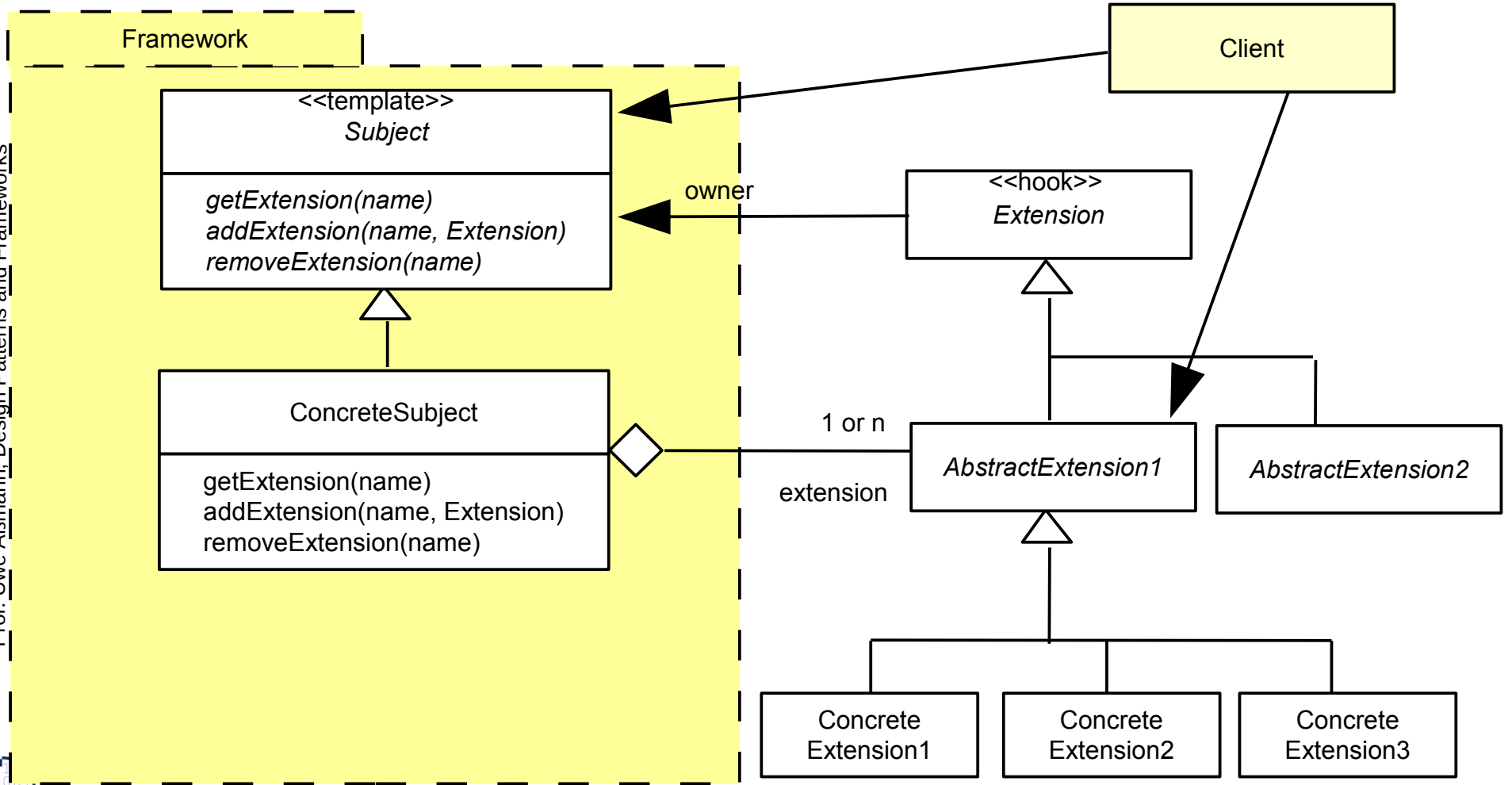


Discussion of EOP

- If there is 1 extension object, naming is not necessary
- If there are n extension objects, a dictionary (map) has to map names to extension objects
- Advantages
  - Complex objects can be split into simpler parts
  - Extensions can model (optional) roles of objects
  - Extensions can be added dynamically and unforeseen
- Disadvantage
  - **Clients have to manage extension objects themselves**, and hence, are more complex
  - Extension objects suffer from the *object schizophrenia* problem: the logical *this* of an extension object is the subject, but the physical *this* is the extension object
- **Relations to Other Patterns**
  - If many objects of an application have the same roles that are realized by extension objects, ExtensionObjects can be generalized to the Role Object Pattern

ExtensionObjects at Framework Borders

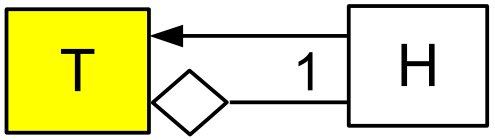
- Since with EOP, clients have to manage extensions themselves, the use of the template object in the framework does not help to use the hook objects



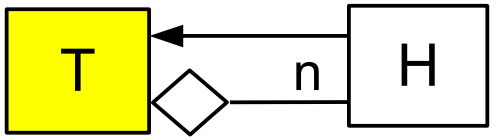
EOP as Framework Hook Pattern

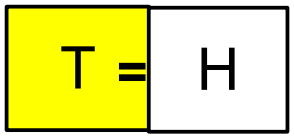
- Since the hook object is not mandatory, also 1-H=T is a real extensibility pattern for frameworks

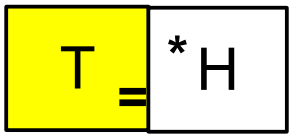
1-H=T
T has 1 H part
T owns H



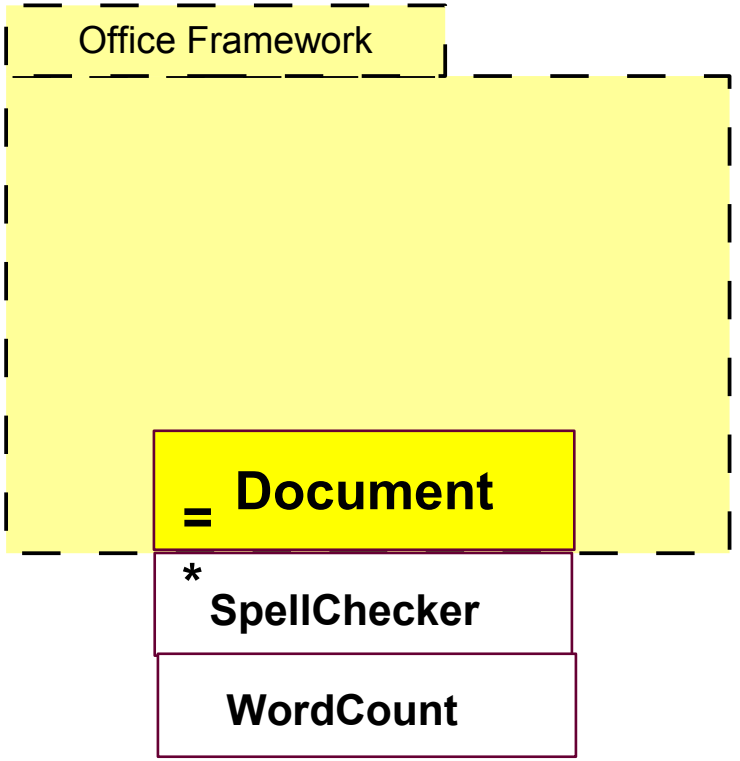
n-H=T
T has n H parts
T owns H parts







Optional Tools for Documents in an Office Framework



13.2 Extensibility of Frameworks with Layers

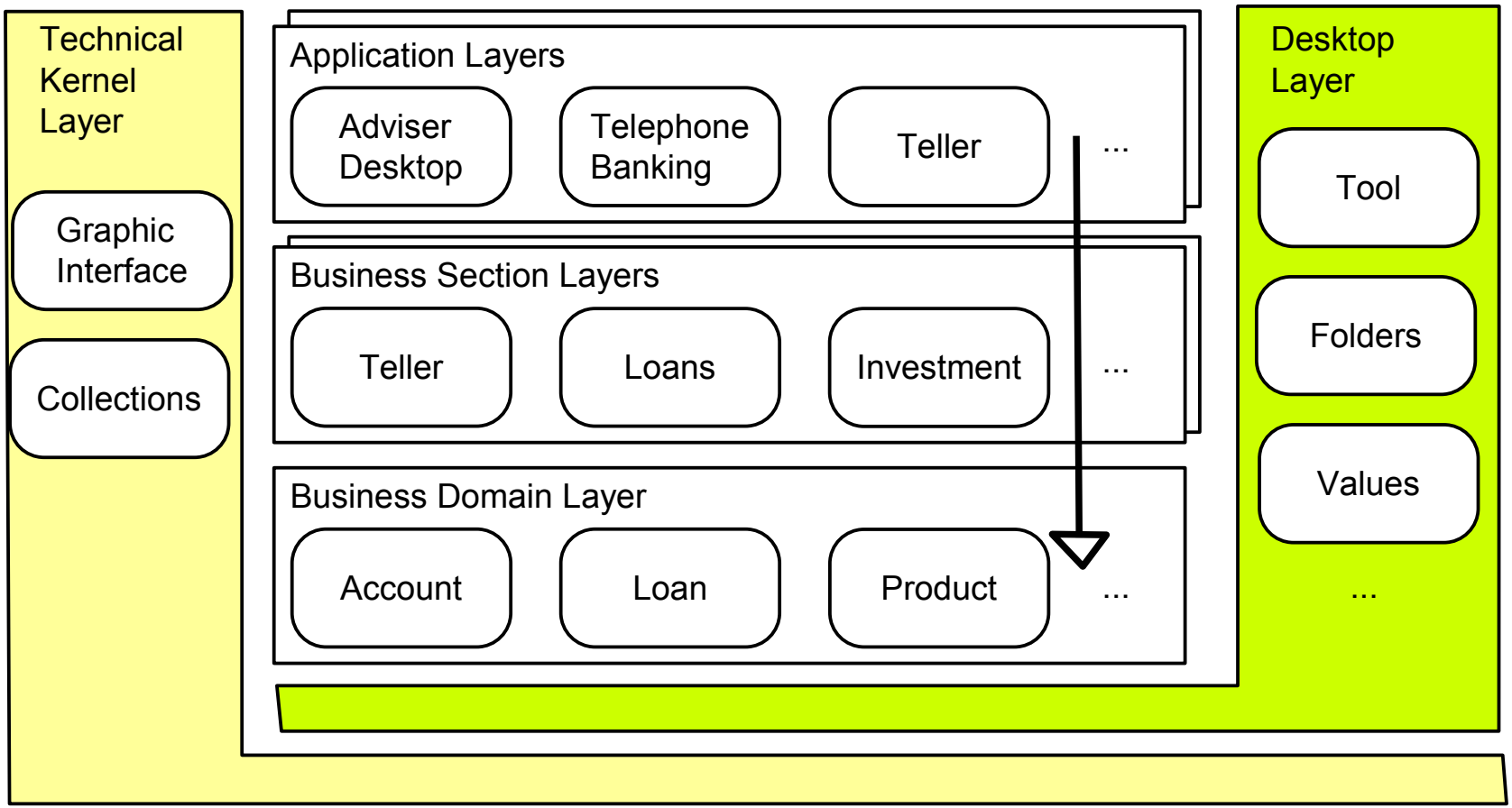
... with Layered Role Object Frameworks

Case Study GEBOS

- GEBOS is a banking application for RWG banking group with 450 banks, south of Germany
  - Banking applications, with services: tellers, loans, stocks, investment, self-service
  - 2500 C++ classes, arranged in frameworks, Arranged in layers
- Concepts of the bank application domain
  - Banks organize themselves in **business sections** (tellers, loans, etc.)
    - Department of specialists that have a certain expertise
  - **Workplace contexts**
    - Service centers offer customers an all-in-one service
    - Services of the business sections
    - Every workplace needs different application systems
  - **Business domain**
    - Business objects such as bill, order, account

Application Framework Layers

- GEBOS demonstrates that it is advantageous to structure an application framework into layers
  - Application layers, Business Section layers, Business domain layers
  - Desktop Layer, Technical kernel layer



Layers

- **Technical Kernel Layer**
  - Service layer, independent of other layers
  - Domain independent, application independent
  - Is a framework itself
    - Collections, Middleware, Wrappers
    - Garbage collection, late creation, factories, trace support
  - Is a blackbox framework
- **Desktop Layer**
  - Support for interactive workplaces
  - Contains a tool construction framework (for the Tools&Materials approach)
  - MVC framework, Folder framework, Value framework for business and domain values
    - AccountNumber, ClientNumber, Money etc
  - Look and feel, reusable for office domains with GUI applications

Layers

- **Business Domain Layer** contains the business core concepts: Account, customer, product, value types
  - Shares knowledge for all business sections
  - Think about how to divide the knowledge between business domain layer and business section layers
- **Business Section Layers**
  - Subclassing business domain and desktop layers, “inherits” knowledge from both
  - Business section concepts: Borrower, investor, guarantor, loan, loan account, tools. Organizational entities and notions
  - Distinguish from business domain
- **Application Layers**
  - Application concepts
  - Separate from Business Sections, because workplaces need different functionality from different business sections
  - Uses (and inherits) from all other layers

Goals in Framework Design of GEBOS

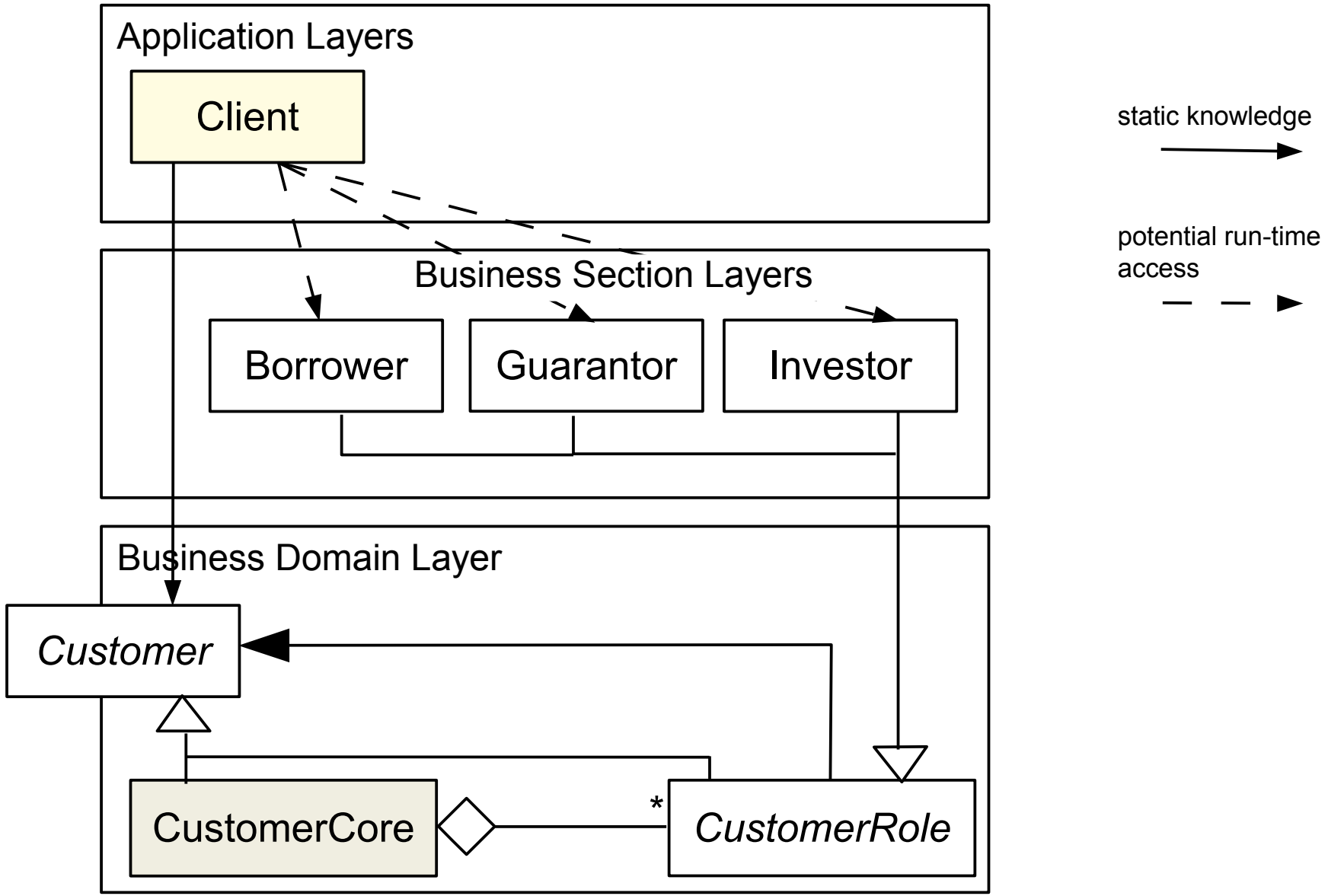
- Minimize coupling between frameworks and application systems
  - Frameworks should never be touched when developing an application system
- Model different facets of business sections, products, and business domain concepts
  - Use role-object design pattern
- Minimize coupling between the layers
  - Separate concepts from implementation
  - Move implementation to lower layers
- Achieved with the RoleObject pattern

13.3 The RoleObject Pattern

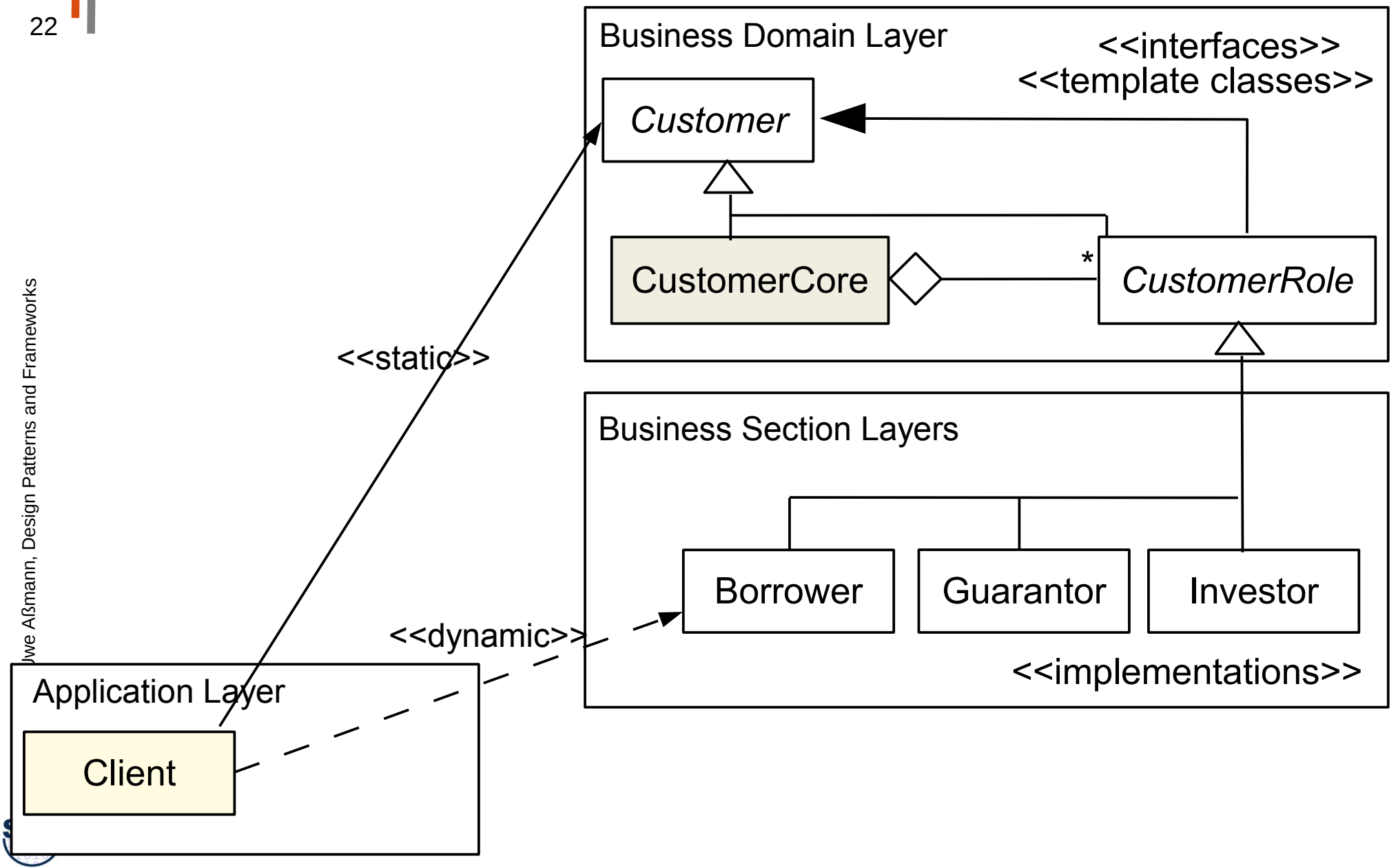
Framework Extensibility with Riehles Role-Object Layers

- The Role-Object Pattern (ROP) is both a variability and extensibility pattern
  - Realizes the “dispatch on all layers” for application frameworks
  - Can easily be extended with new layers
- Extension of a core layer (a blackbox framework of core objects) with layers of delegatees (role objects)
  - A **conceptual object (complex object, subject)** of the application is split over all layers
  - **Core** and **role** objects conceptually belong together to the **conceptual** object, but distribute over the layers
  - Role objects are *views* on the conceptual object

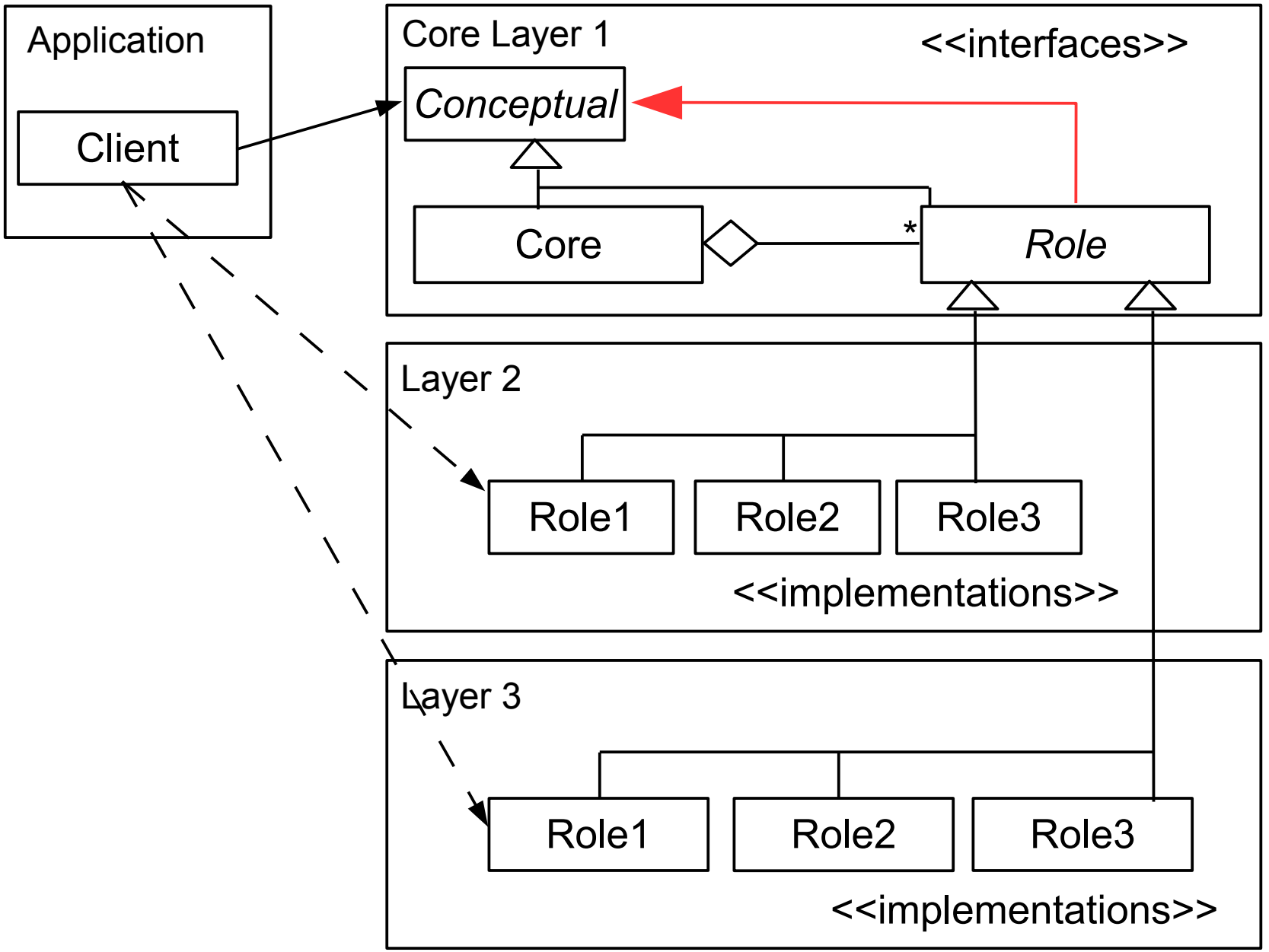
Riehle/Züllighovens Role Object Pattern (ROP)



Role Object Pattern with Inheritance Drawn Upwards

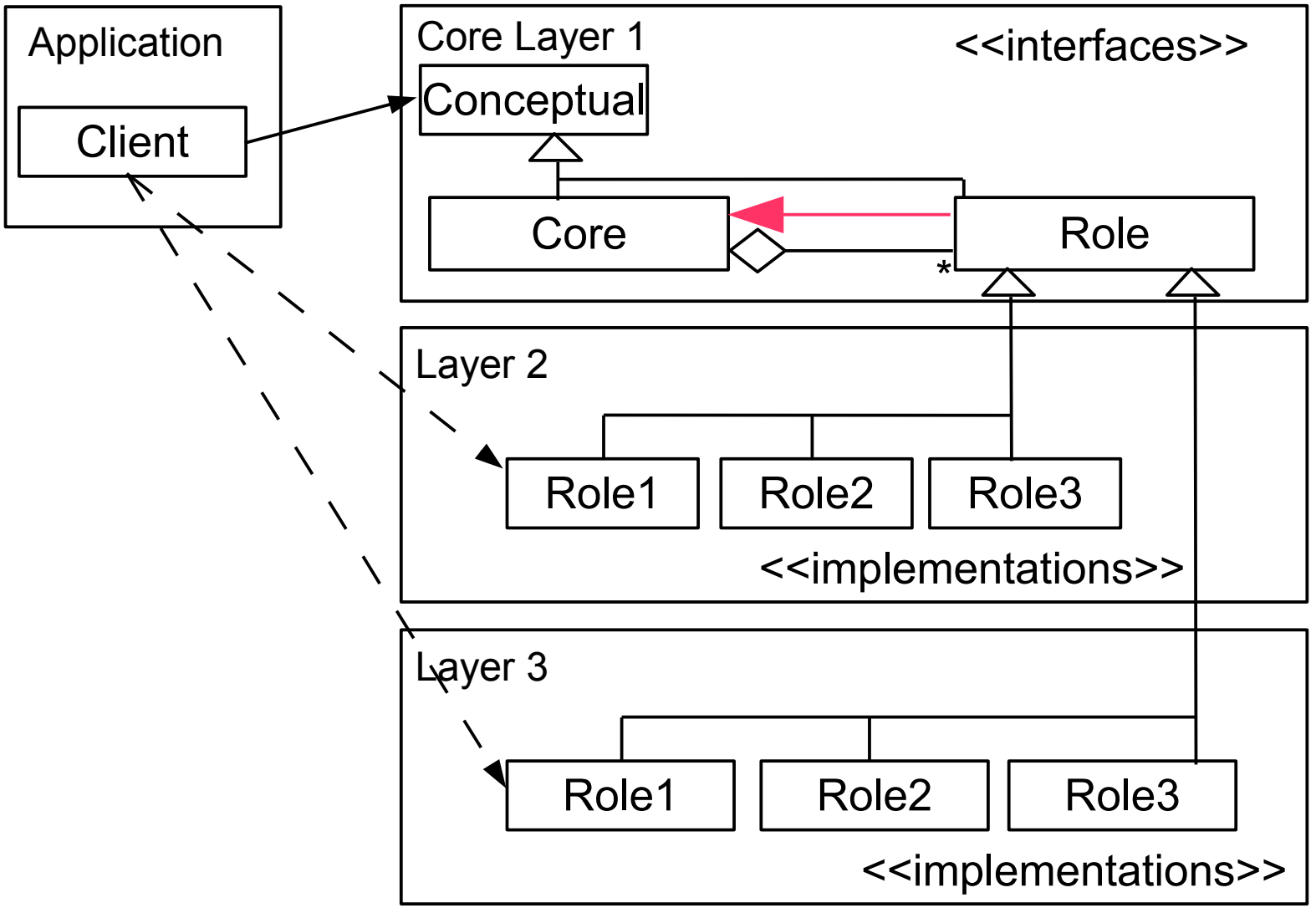


Riehle/Züllighovens Role Object Pattern Abstracted ("Deep Roles")



Riehle/Züllighovens Role Object Pattern Variant 2 ("Flat Roles")

- Variant 2 has no Decorator; roles only know cores

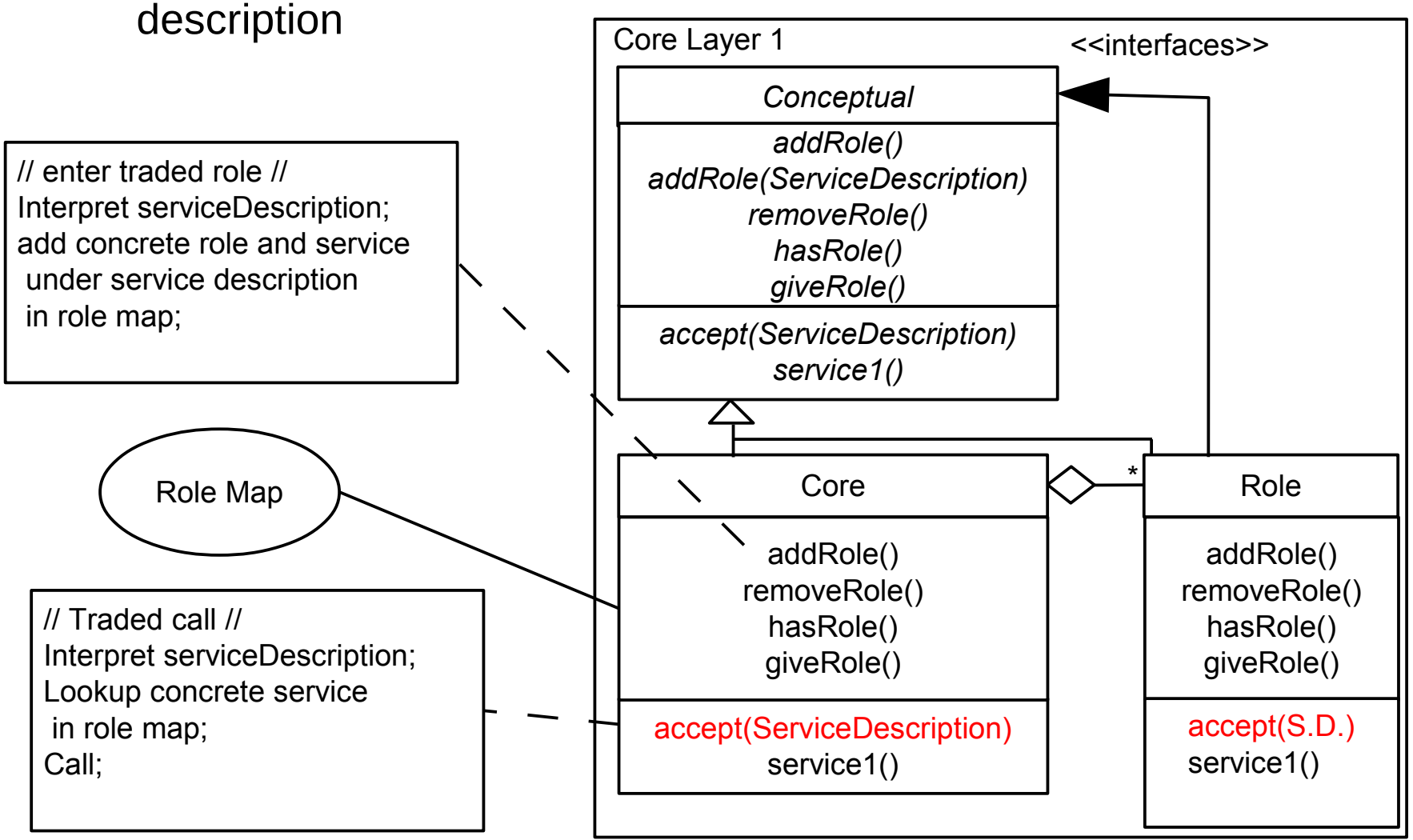


Run-time Behavior of ROP

- **Change of role:**
  - Different Role Objects may belong to the same role type (e.g., working for multiple companies)
  - Over time, the role object for a player may change
  - This expresses states of the player in the application
    - E.g., Borrrower --> UnsafeBorrower --> TrustedBorrower
- Roles are **created on-demand**
  - In the beginning, the Subject is *slim,* i.e., carries no roles.
  - At service requests, the core creates roles and enters them in the role map

Variant 3: Core Layer with Traded Call

- To add services dynamically (beyond the service interfaces in the conceptual object), add a *trader* to the core
  - A **trader** is a method that interprets a service request based on a service description



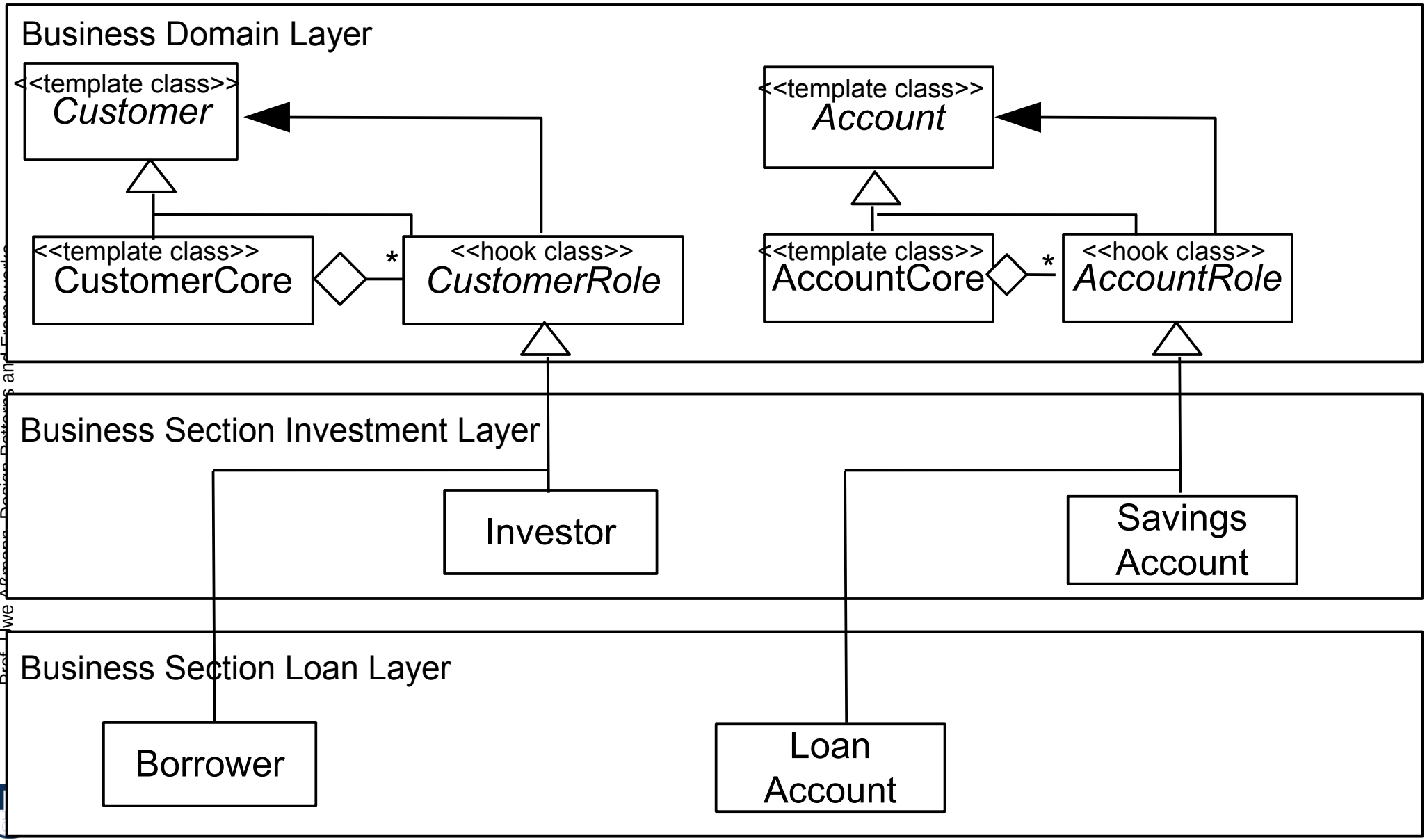
RoleObjectPattern and Other Patterns

- ROP is not only a Decorator
  - It is based on 1-H<=T, i.e., 1-ObjectRecursion
    - All role objects inherit from the abstractum
  - Remember, 1-ObjectRecursion based patterns lend themselves to extension
  - And 1-H<=T framework hook patterns provide extensible frameworks
  - 1:n relationship between core and role objects
  - Role objects decorate the core object, and pass requests on to it

Comparison of Role Objects with Inheritance

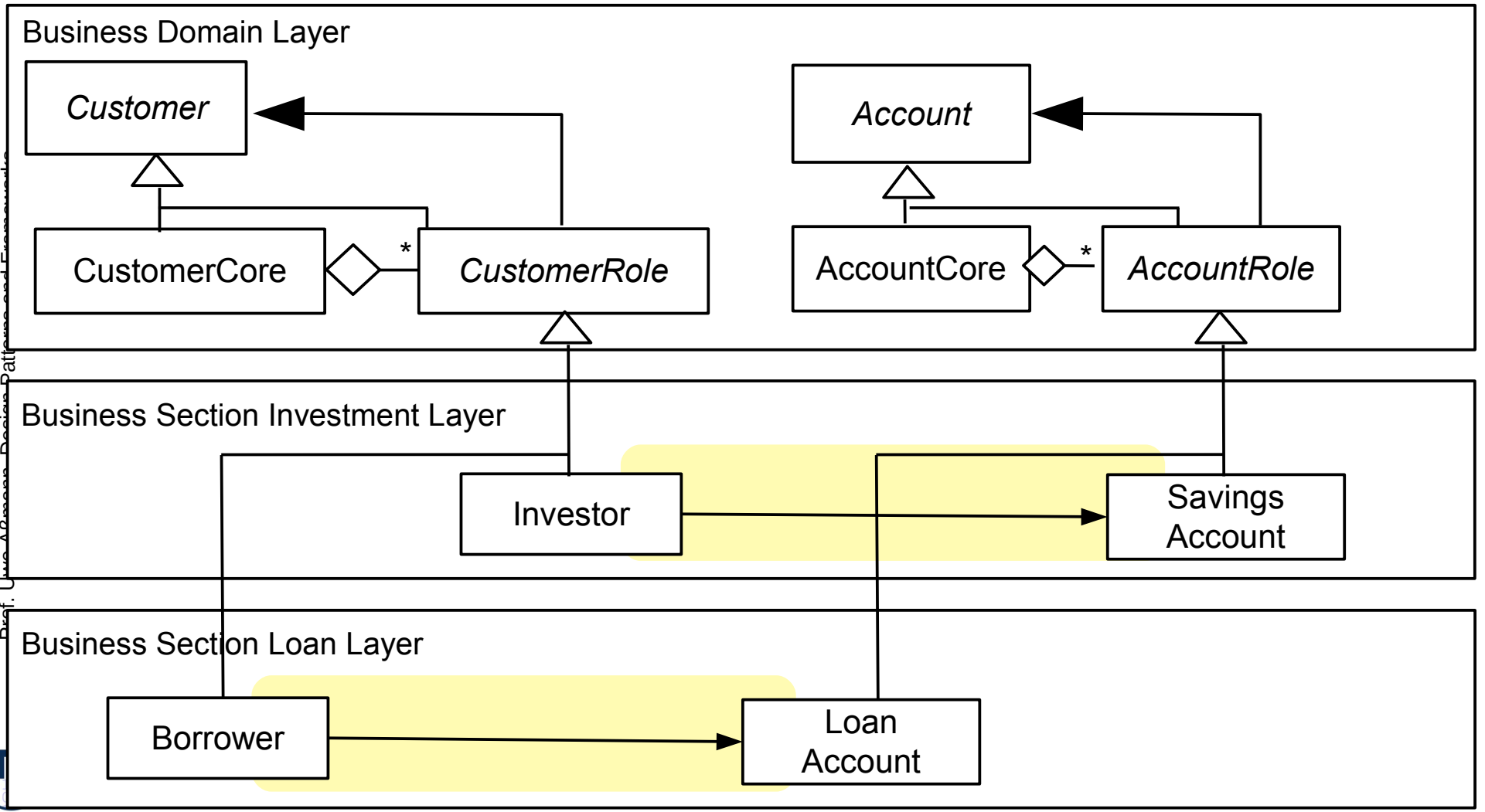
- Simple inheritance has one instance of a subclass at a time
  - Subclass can change over time (polymorphism)
- The role object has many of them at the same time
  - All role objects can change (role polymorphism)
- Only changes in the base layers (technical, presentation, business) affect other layers
  - Changes in the business section layers do not affect the business domain layers
- The relation of core and role objects is a special form of part-of (combined with inheritance)

Role Object Pattern with Template and Hook Stereotypes



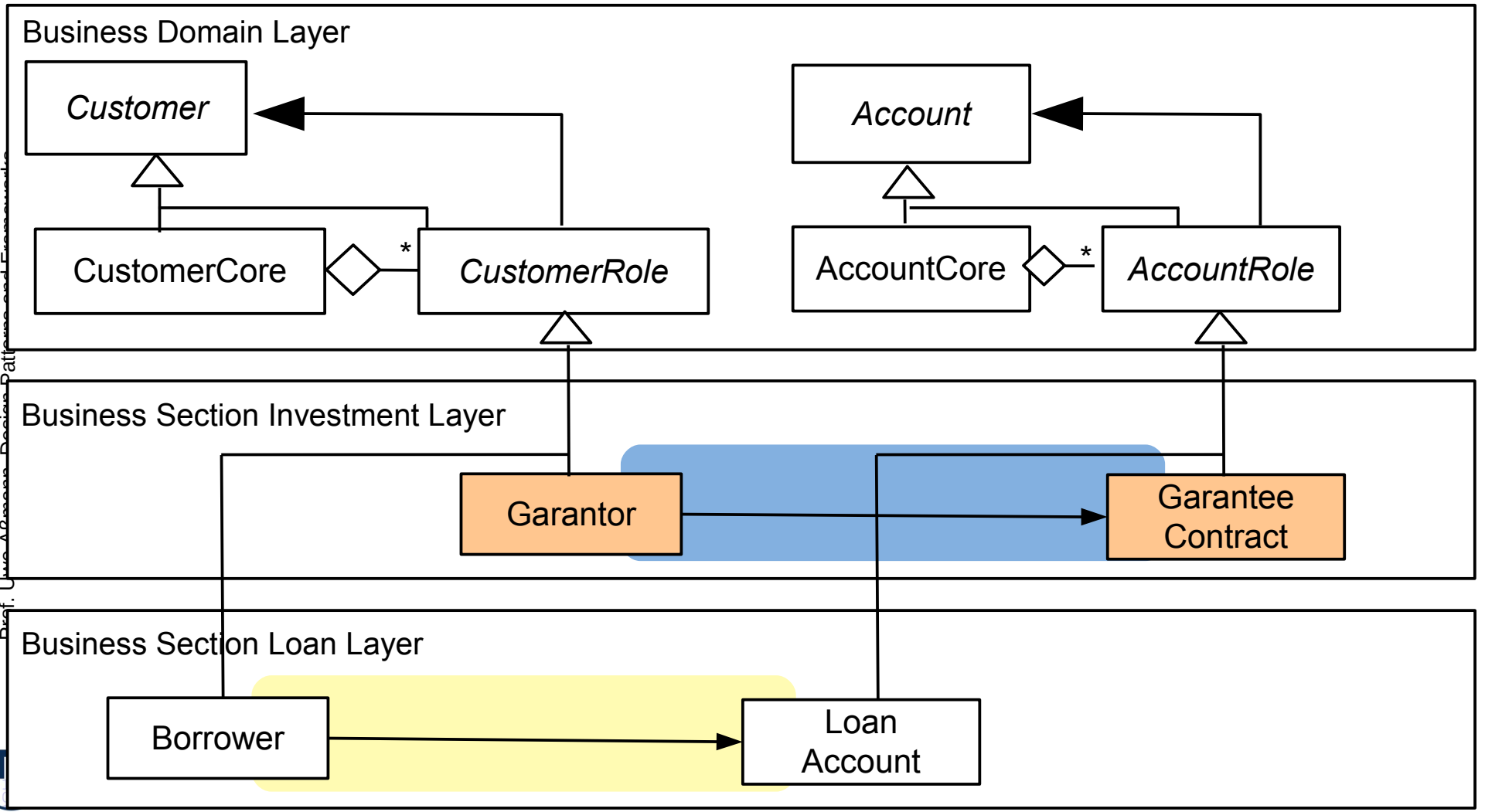
Role Object Pattern and Role Models on Role Layers

- Usually, roles of one subject talk to other roles of another subject on the same layer (within a role model)
- Cores never talk to each other directly

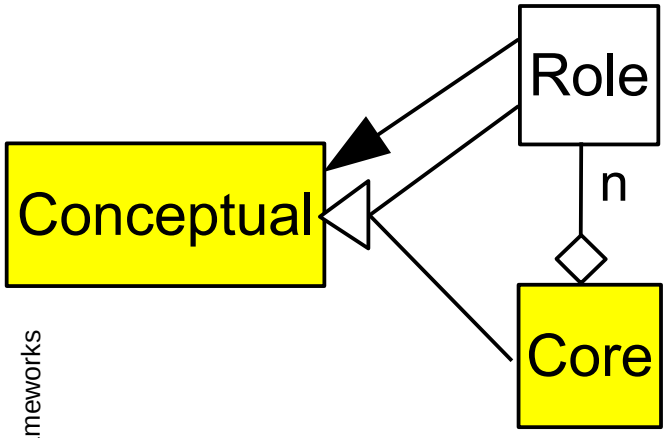


Switching Variable Role Layers

- At run time, entire role models on role layers can be exchanged (**variable role layers**)

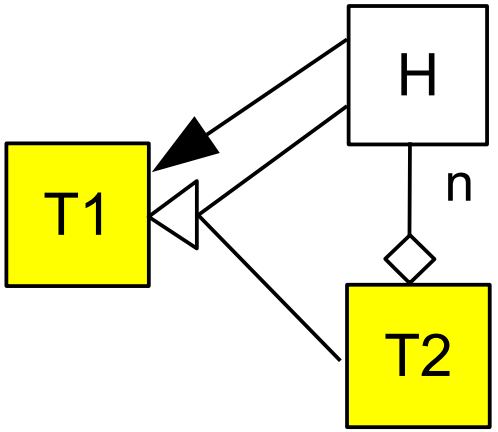


Riehle/Züllighovens Layer Pattern As Framework Hook Pattern

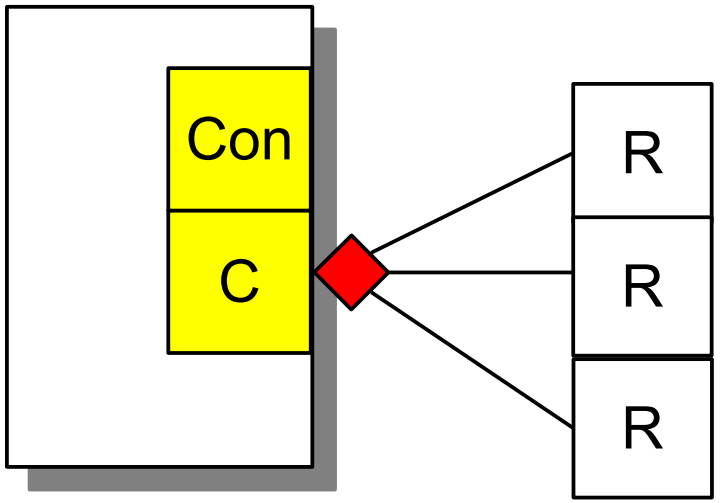


n-TrH
T2 has H parts

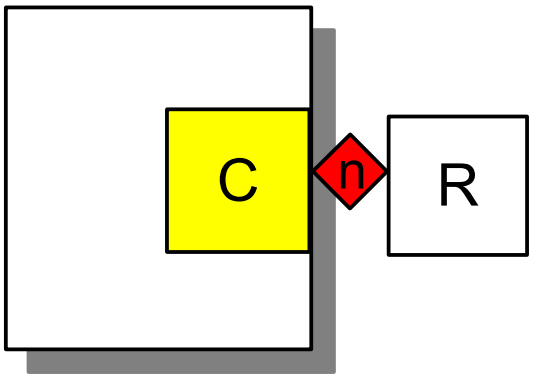
H and T2 inherit from T1
H knows T1



Core-Role-Pattern



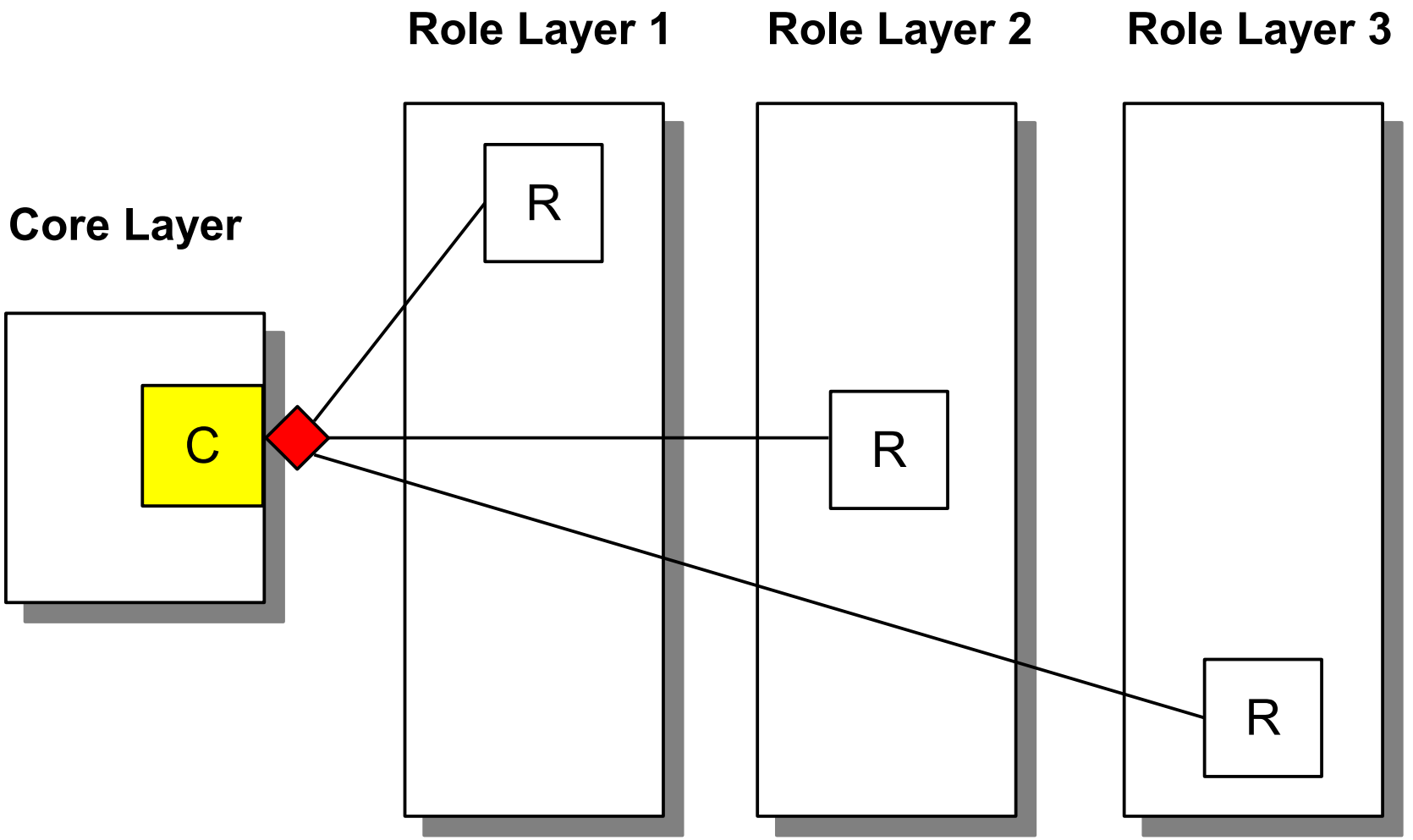
n-TrH mini-connector



ROP Ensures Extensibility

- The ROP lends itself not only to variability, but also to **dynamic extensibility**
  - If a framework hook is a role object pattern, the hook can be extended in unforeseen ways **without** changing the framework!
  - New layers of the application or the framework can be added at design time or runtime
- Powerful extension concept with ROP-Trader
  - Whenever you have to design something complex which should be **extensible in unforeseen ways**, consider Role Object

Riehle/Züllighovens Layered Role Object Framework



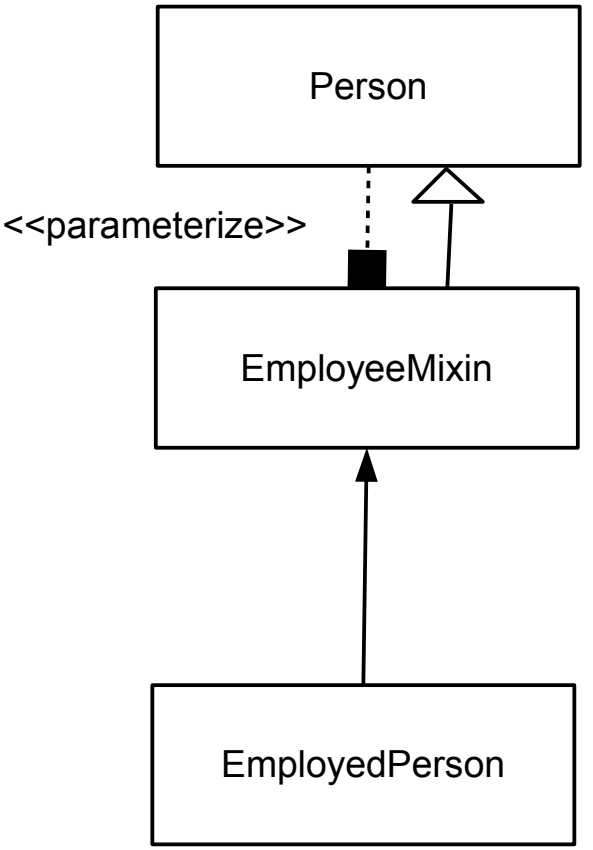
13.4 The GenVoca Pattern, Mixin Layers, and Layered Mixin Frameworks

The Mixin Concept

- A **mixin** is a partial class, for an extension of another class
- A **mixin-base** is a class with a generic super class, a mixin parameterizes this
- Some languages have mixins (Scala, C#, Eiffel); otherwise, mixins can be expressed as class fragments that can be parameterized with a superclass (C++)
- Mixins can implement (static) roles and facets

```
template <class S>
class EmployeeMixin extends S {
   // class extension..
   Salary salary;
   Employer emp;
}
```

```
EmployeeMixin<Person> employeeOfPerson;
EmployeeMixin<German> employeeOfGerman;
EmployeeMixin<Club>   employeeOfClub;
```

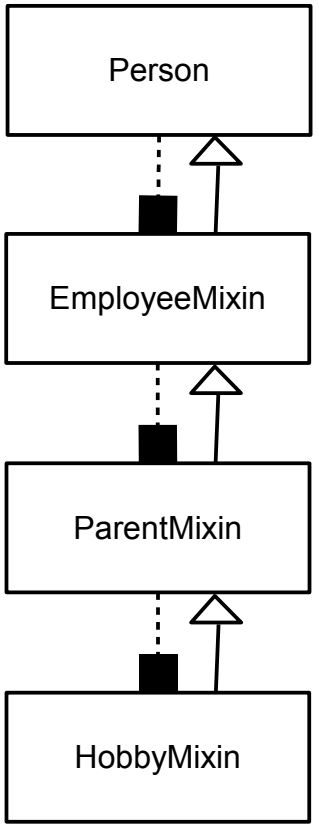


The GenVoca Pattern

- If several mixin parameterizations are nested, the GenVoca pattern results [Batory]

```
template <class S> class EmployeeMixin extends S {
    Salary salary;
    Employer emp;
}
template <class S> class ParentMixin extends S {
    Child child;
    Money kindergeld;
}
template <class S> class HobbyMixin extends S {
    Hobby hobby;
}
// Persons composed with GenVoca pattern
HobbyMixin<ParentMixin<EmployeeMixin<Person>>>> assmann;
EmployeeMixin<ParentMixin<HobbyMixin<Person>>>> assmann2;

// Have assmann and assmann2 the same type?
```



GenVoca Variations

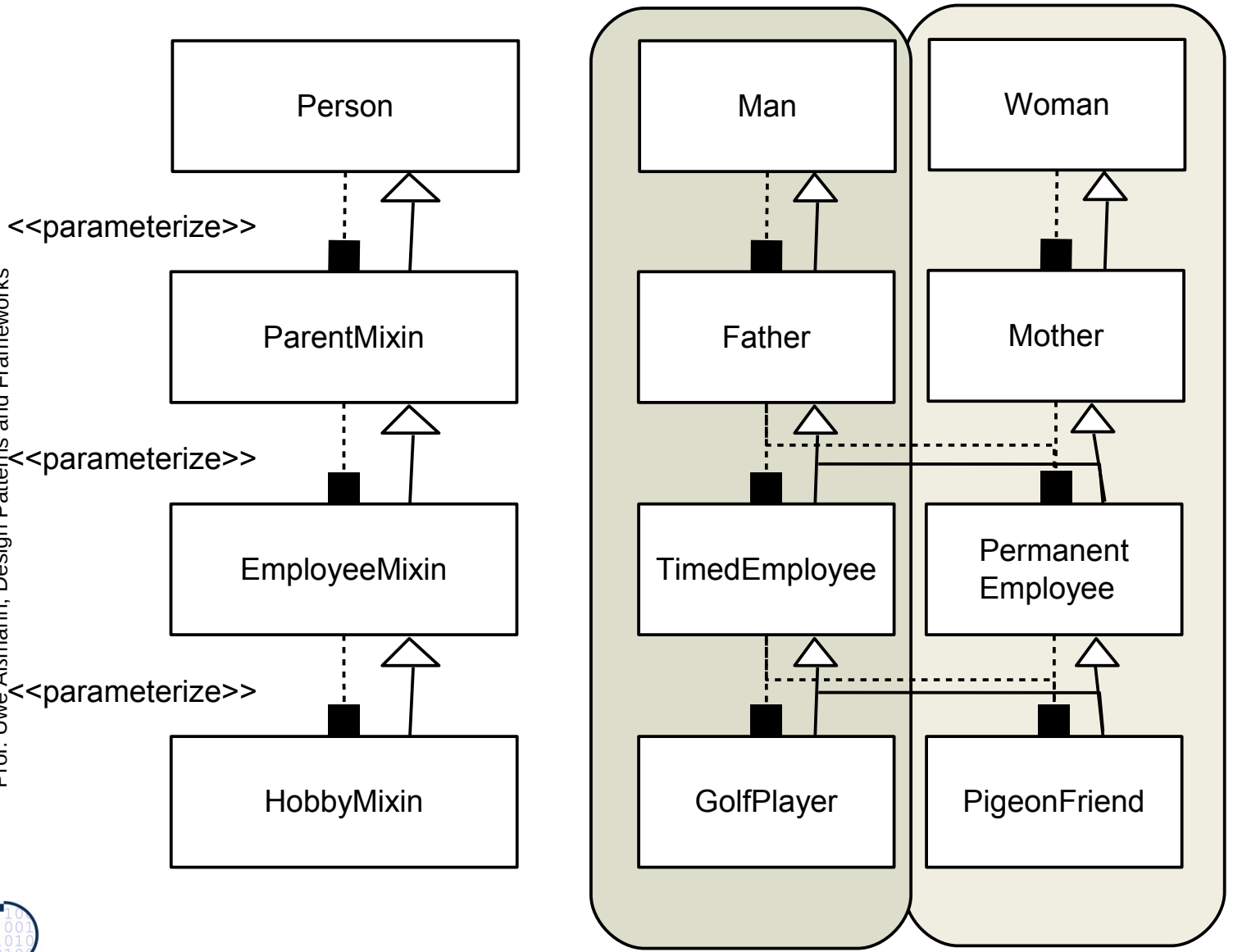
- When different variants exist for an “abstraction layer”, parameterizations express configurations of a product line

```
// Variants
Person: Man, Woman
ParentMixin: FatherMixin, MotherMixin
EmployeeMixin: TimedEmployee, PermanentEmployee
HobbyMixin: Gamer, Sportsman, GolfPlayer

// Compositions
GolfPlayer<PermanentEmployee<Father<Man>>>> assmann;
Gamer<TimedEmployee<Father<Man>>>> miller;
GolfPlayer<PermanentEmployee<Mother<Woman>>>> brown;
```

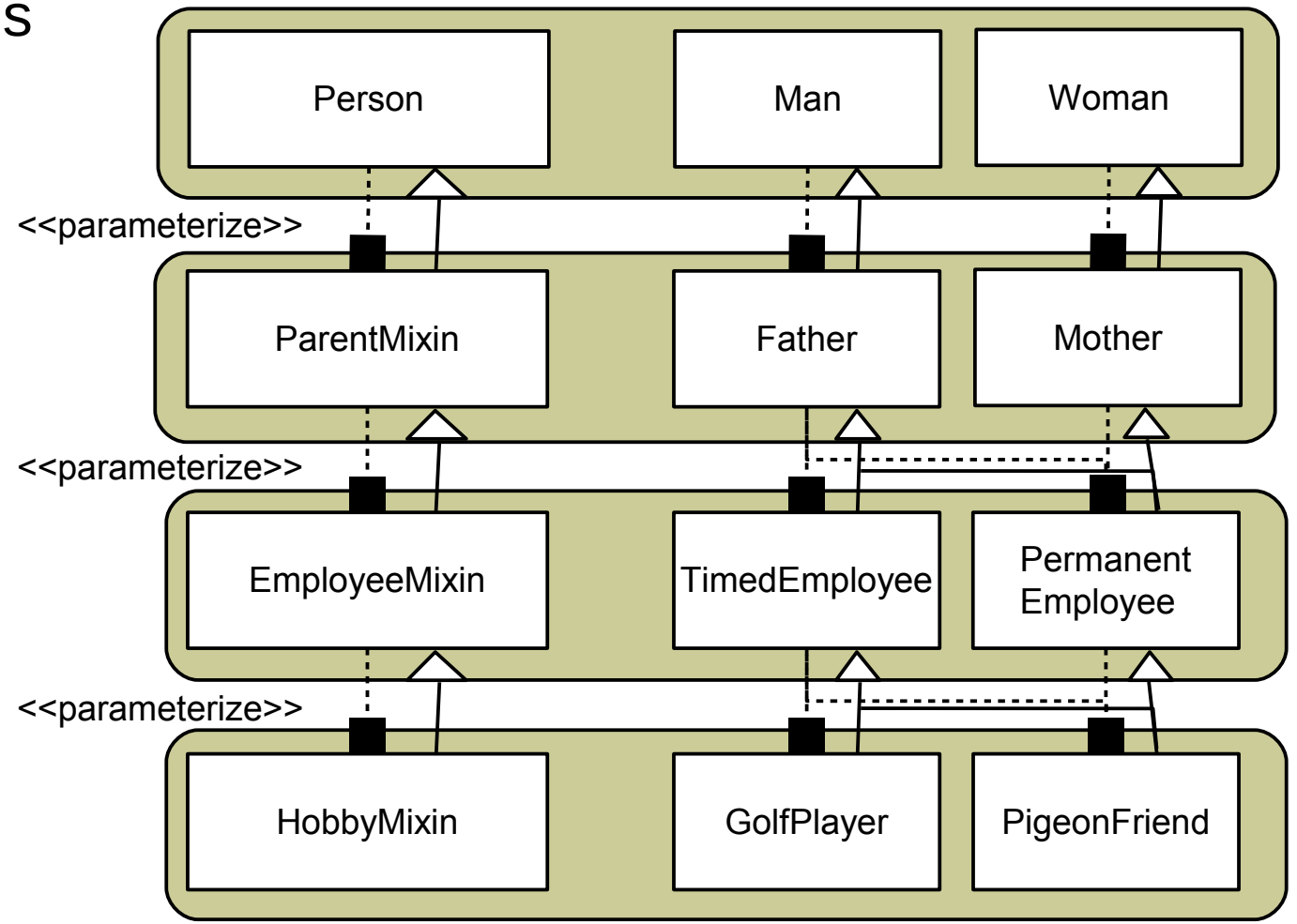
Variations on Different Abstraction Layers form Product Variants

- Variants can be formed on every layer



Variations on Different Role Layers

- Abstraction layers correspond to *role layers* of complex objects
- Roles *collaborate*, but are not implemented by role objects, but by mixins

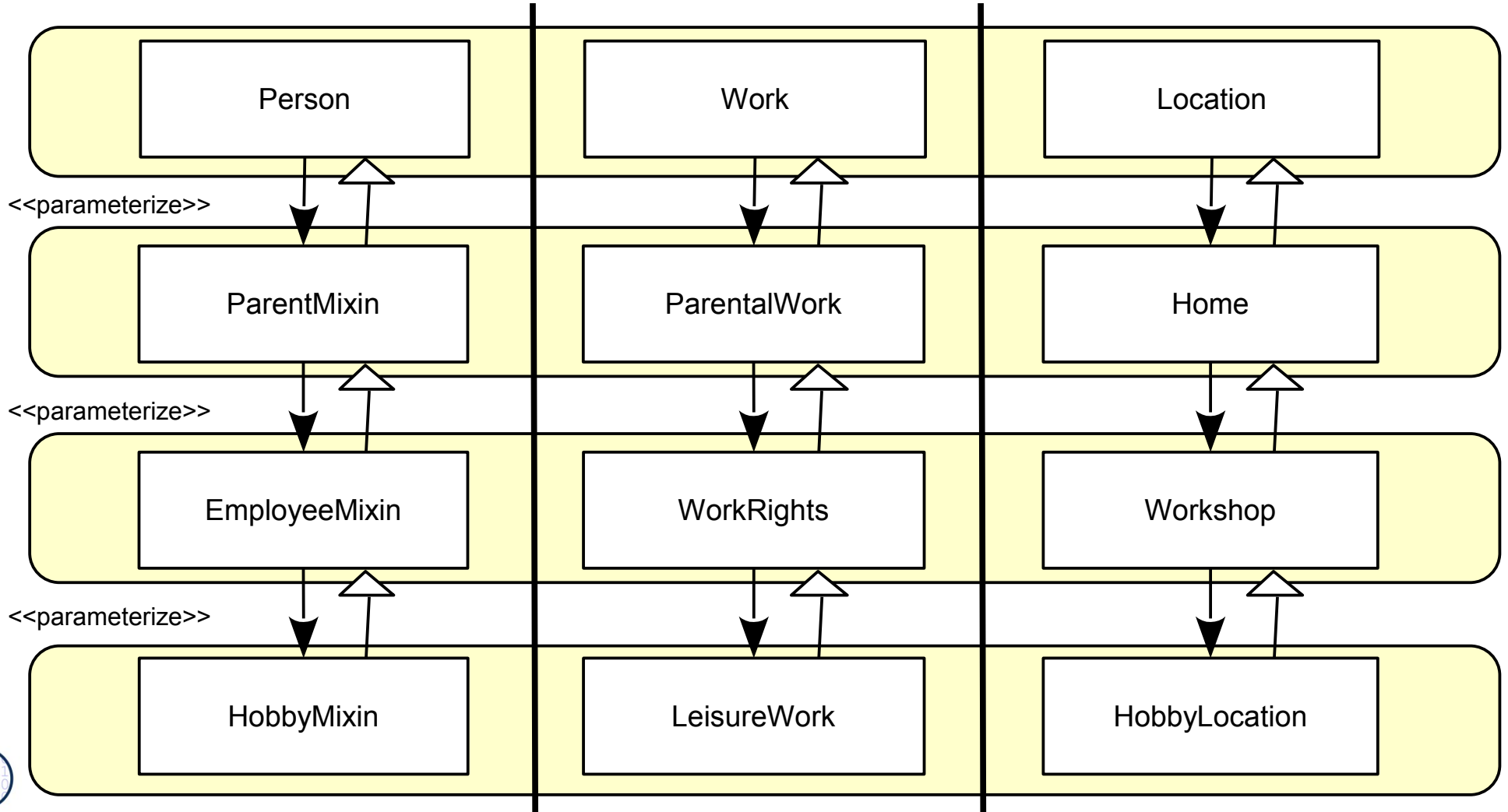


Discussion

- A *mixin layer* groups all mixins of a role abstraction layer
- Mixins play in the GenVoca pattern the same role as role objects in the role object pattern and layered role frameworks
  - However, all role objects are *embedded* into one physical object
  - There is a physical identity for the entire logical object
  - No object schizophrenia to be avoided
  - GenVoca applications are more efficient, since they merge all roles together into one physical object (see the Aßmann's law on role merging)
  - **But**: only static extensibility!
- Similarly to layered role object frameworks, layered GenVoca frameworks can model big product lines
  - Every abstraction layer (mixin layer) expresses variability
  - New mixin layers model extensibility

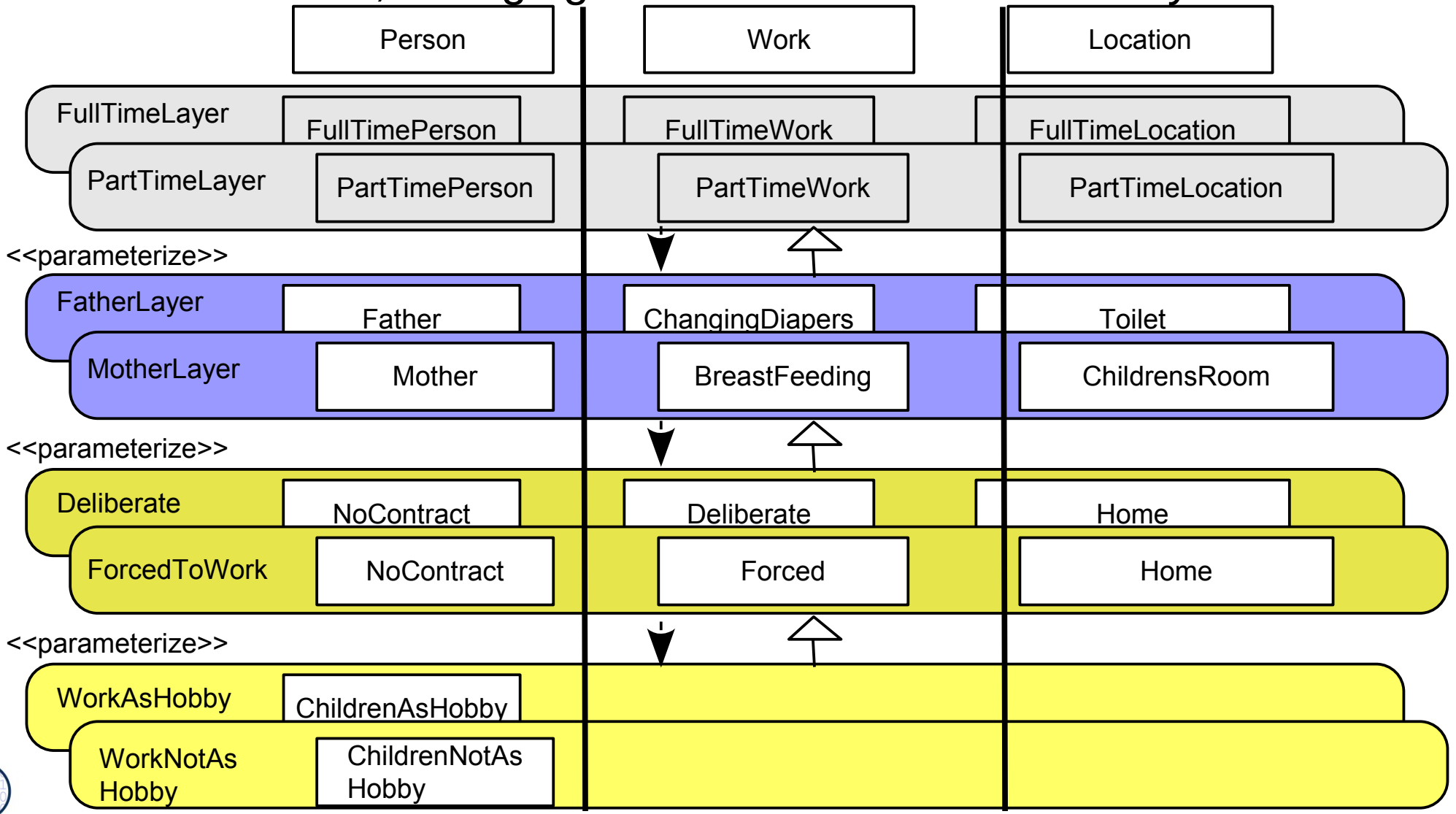
13.5 The Mixin Layer Pattern

- While the GenVoca pattern deals with single stacking of parameterizations, the MixinLayer pattern groups all roles of an abstraction layer together and composes entire layers
- MixinLayer treats all logical objects of an application



Mixin Layers as Compositional Unit

- A mixin layer gets a name and can be exchanged consistently for a variant, changing the behavior of the entire layer



Composition of Mixin Layers

- Mixin layers are composed similarly to single GenVoca mixins
  - Meaning: All role classes are consistently exchanged with their layer

```
CoreLayer: FullTime, PartTime
ParentLayer: FatherLayer, MotherLayer
EmployeeLayer: Deliberate, ...
HobbyLayer: WorkAsHobby, Slave....

// This is now mixin layer composition!
WorkAsHobby<Deliberate<FatherLayer<FullTime>>>> assmann;
```

Implementation of Mixin Layers with GenVoca Pattern and Inner Classes

- The role classes of upper layers form super classes of the layer class
- The following pattern allows for separate parameterization of all role mixins, *not* the layer as a whole

```
class Layer <class Super, class RoleSuper1, .., class RoleSupern>
   extends Super {
   class Role1 extends RoleSuper1 { .. }
   ..
   class Rolen extends RoleSupern { .. }

   .. additional classes..
}
```

Implementation of Mixin Layers with Designated Inner Classes

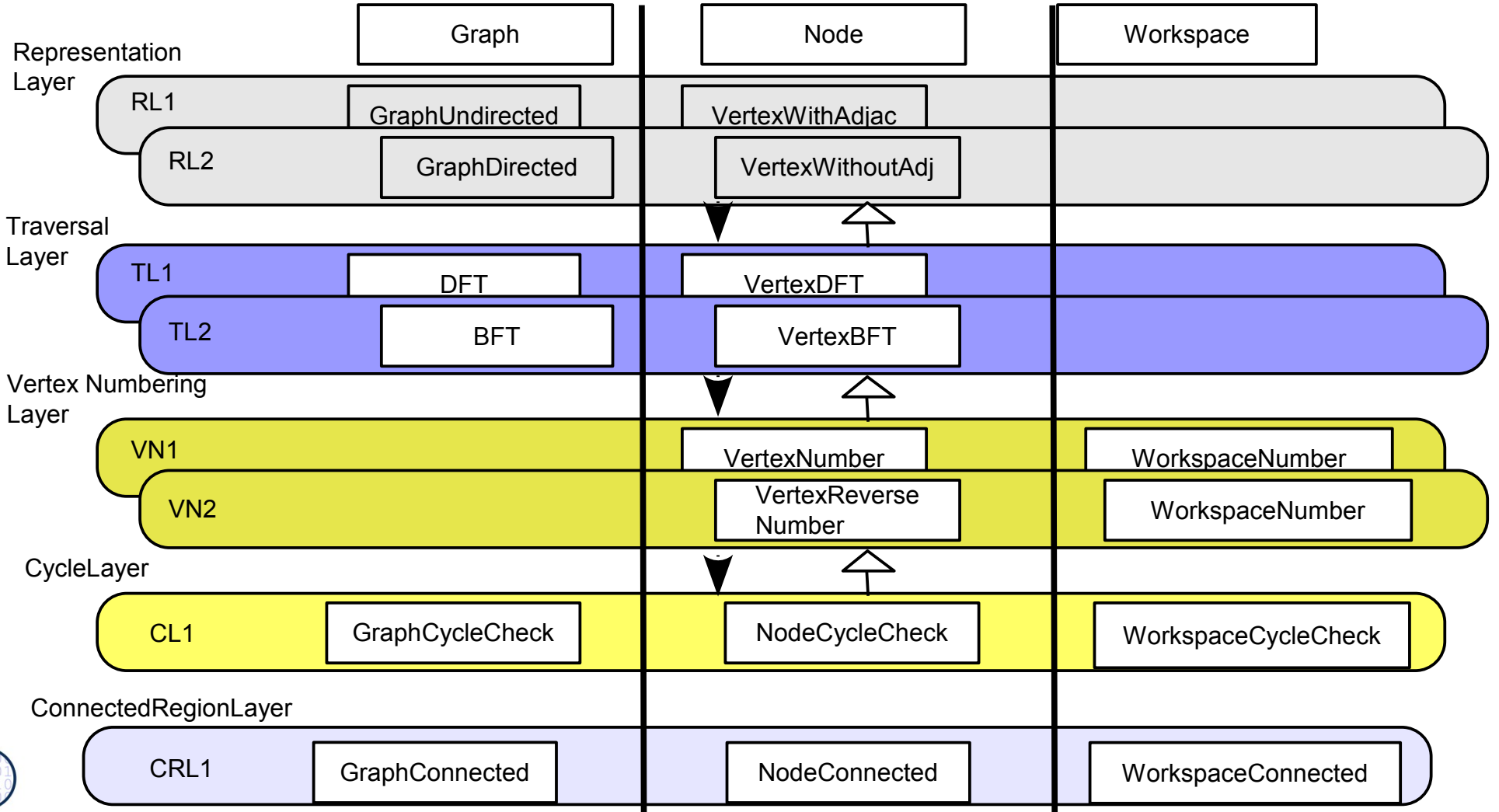
- If the target language permits to have inner classes that can be designated by an expression, mixin layers can be inherited as a whole
- The super mixin layer can be selected by one single expression L<L1>

```
class Layer <class Super>
// The class Super has n inner role classes RoleSuper1, ..,
// RoleSupern
extends Super {
   class Role1 extends Super.RoleSuper1 { .. }
   ..
   class Rolen extends Super.RoleSupern { .. }

   .. additional classes..
}
```

Example: A Graph Framework [Herrejon Batory]

- Graph applications can be structured into mixin layers
- ConnectedOnDFTUndirected = CRL1<CL1<VN1<TL1<RL1>>>>>
- ConnectedOnBFTRevDirected = CRL1<CL1<VN2<TL2<RL2>>>>>



What Have We Learned?

- Extension Objects Pattern
- Extensible Framework Hook Patterns
  - Using Role Object Pattern
  - Using Genvoca (MixinLayers)
- Role Object Pattern for dynamic extensibility
- Genvoca for static extensibility

The End