

Collaboration-Based Design

Prof. Dr. Dirk Riehle

Friedrich-Alexander University Erlangen-Nürnberg

ADAP C10

Licensed under [CC BY 4.0 International](#)

Agenda

1. Collaboration-based design
2. File system example revisited
3. Collaborations vs. classes
4. Flower collaborations
5. Collaborations in UML
6. Implementing collaborations
7. Collaborations and design patterns

1. Collaboration-Based Design

Collaboration-based Design

- **Collaboration-based design**
 - An approach to modeling and implementation using collaborations
- **Collaboration (specification / description)** a.k.a. role model
 - A model of objects collaborating for one particular purpose
- **Role (type / specification / description)**
 - A model of the behavior of one object within a collaboration
- **Collaboration (instance)**
 - A set of specific objects collaborating according to a collaboration specification
- **Object**
 - The representation of a phenomenon playing roles in collaborations

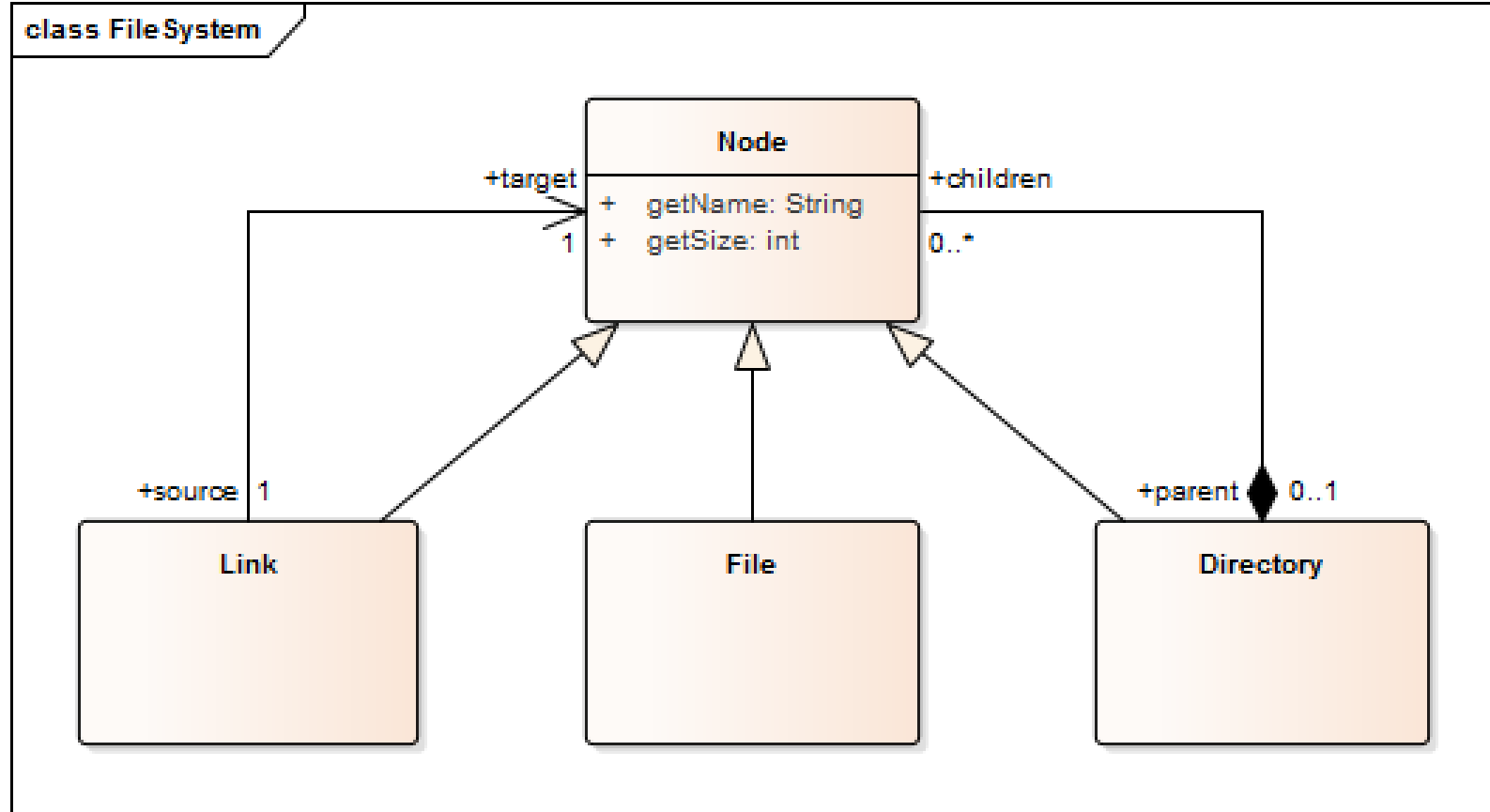
- 1. Separation of Concerns**
- 2. Better Reusable Models**

Types of Collaborations

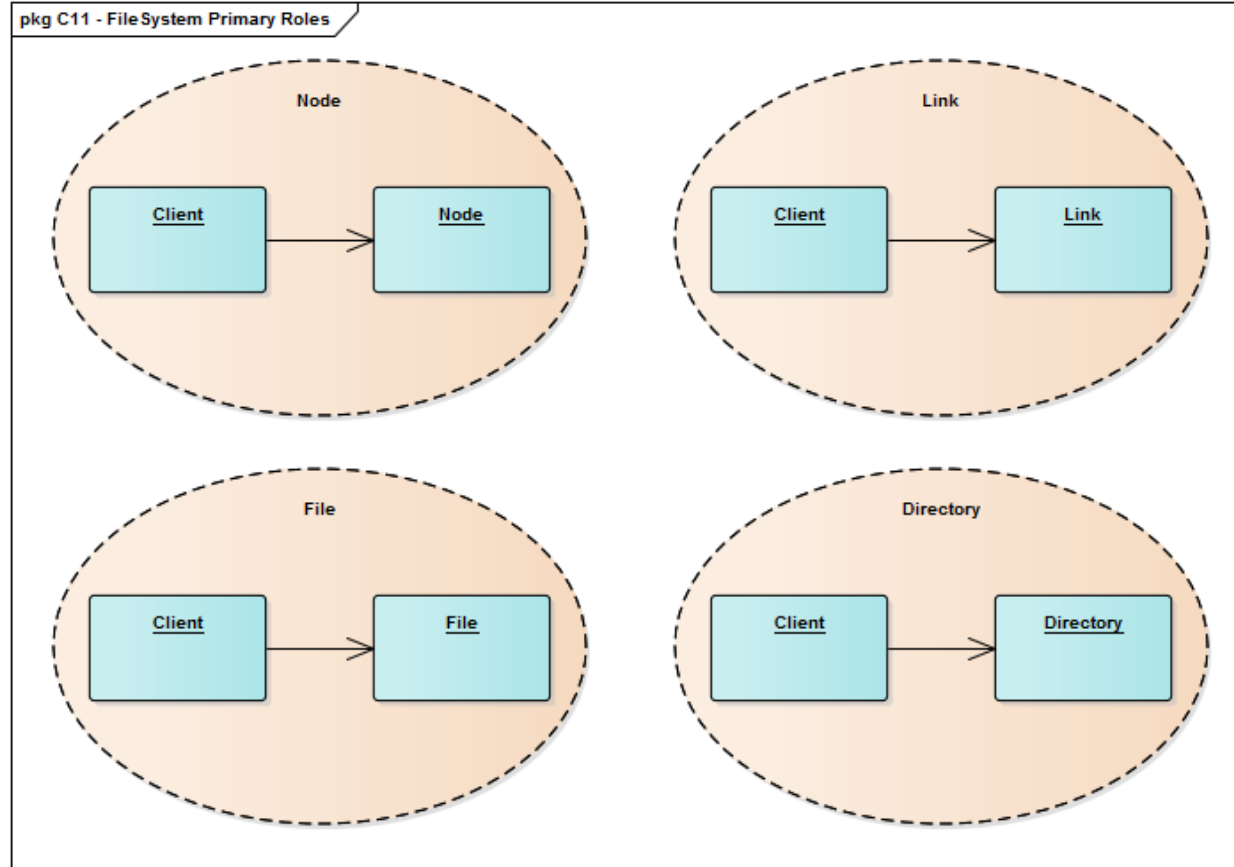
- **Primary service collaborations**
 - Typically, client-service-collaborations
 - The client role often has no methods
 - Visible to the outside (of the model)
- **Secondary service collaborations**
 - Client-service-collaborations used for technical purposes
 - Often follow design patterns to realize logic
 - Visible to the outside (of the model)
- **Maintenance collaborations**
 - Collaborations that maintain the domain logic within the model
 - Often follow design patterns to realize logic
 - Usually not visible to the outside

2. File System Example Revisited

File System Example Revisited



Primary Service Collaborations



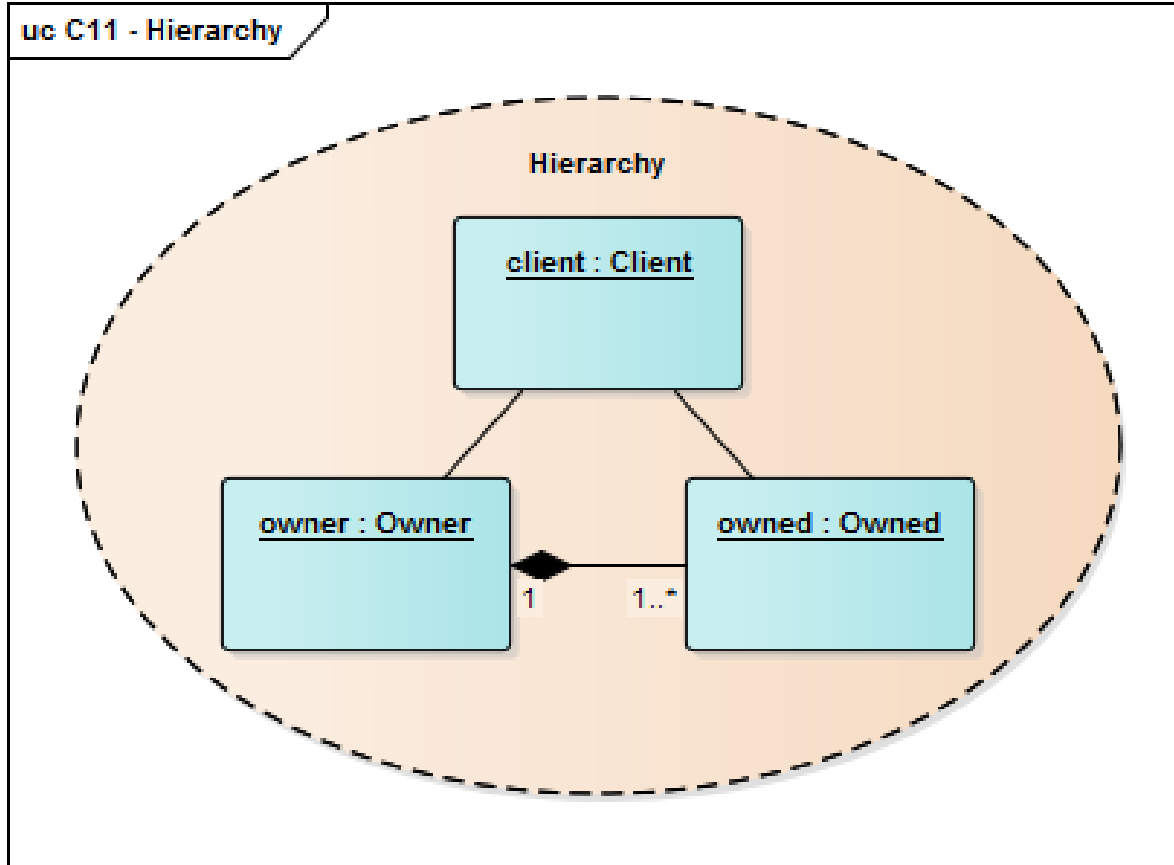
Primary Service Roles as Code

```
public class Node {  
    // Client-Node-Collaboration  
    public String getName();  
    public void setName(String name);  
    ...  
}
```

```
public class Link extends Node {  
    // Client-Link-Collaboration  
    public Node getTarget();  
    ...  
}
```

```
public class File extends Node {  
    // Client-File-Collaboration  
    public void write(byte[] data);  
    ...  
}
```

Hierarchy Collaboration

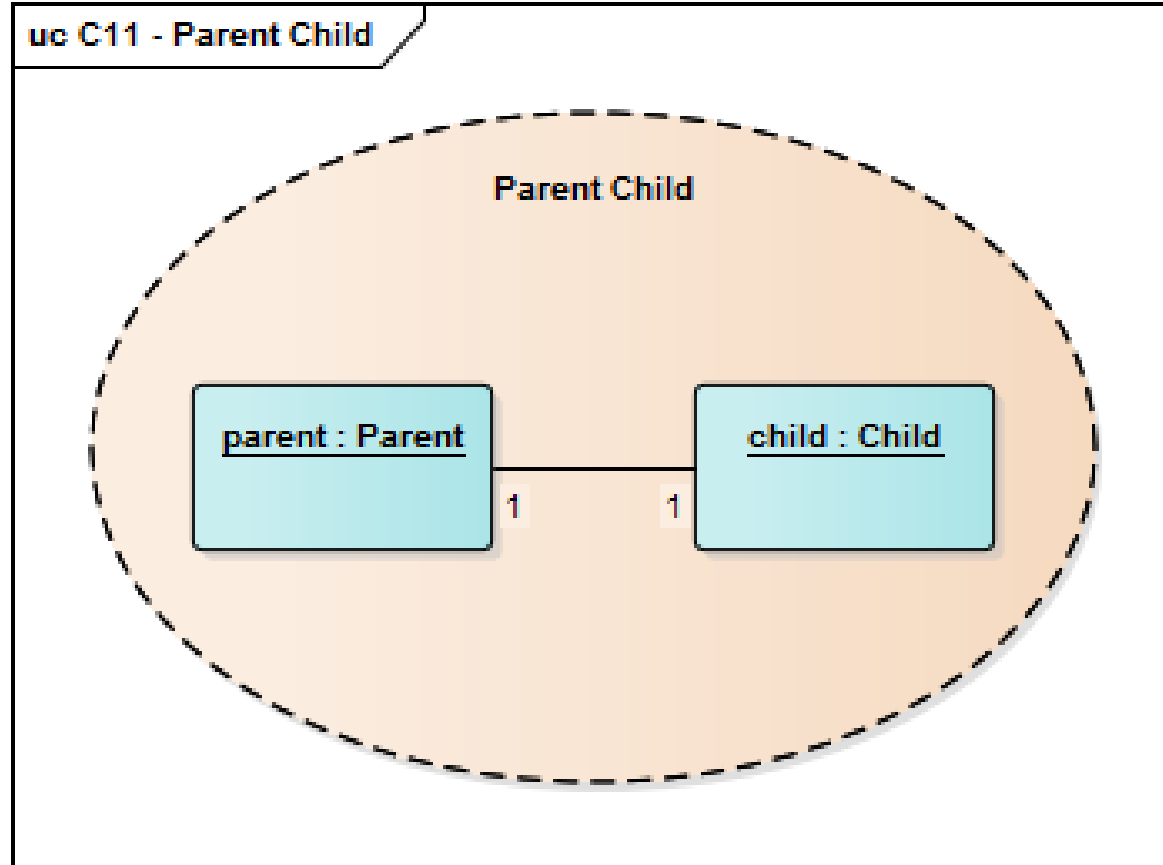


Secondary Service Roles as Code

```
public class Node {  
    // Hierarchy-Collaboration  
    public Node getOwner();  
    public void setOwner(Node n);  
  
    // Other collaborations  
    ...  
}
```

```
public class Directory extends Node {  
    // Hierarchy-Collaboration  
    public void addOwned(Node n);  
    public void removeOwned(Node n);  
    public Iterator getIterator();  
  
    // Other collaborations  
    ...  
}
```

Parent Child Collaboration



Maintenance Roles as Code

```
public class Node {  
    // Parent-Child-Collaboration  
    protected Node getParent();  
    protected void setParent(Node n);  
  
    // Other collaborations  
    ...  
}
```

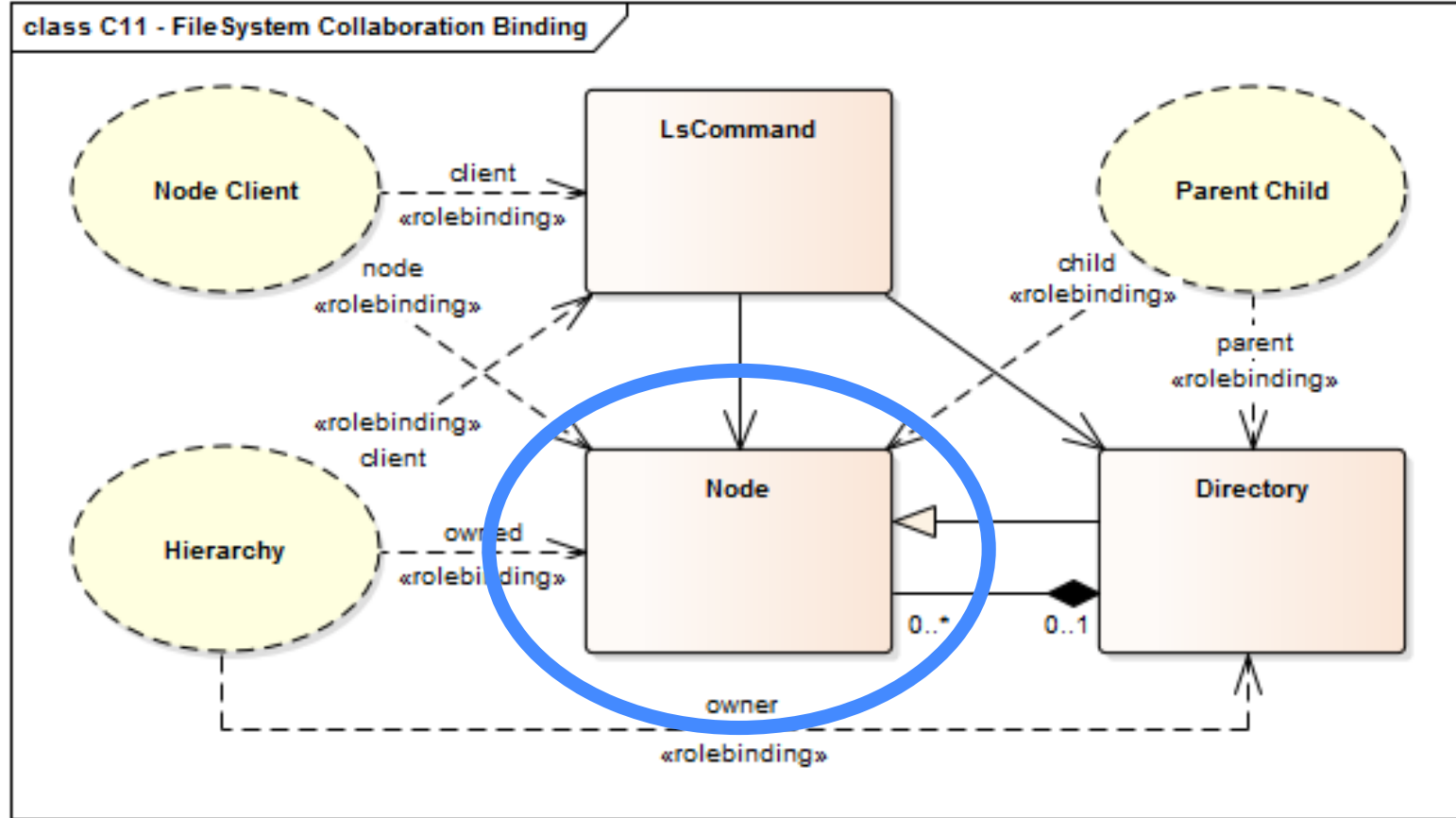
```
public class Directory extends Node {  
    // Parent-Child-Collaboration  
    // No methods  
  
    // Other collaborations  
    ...  
}
```

3. Collaborations vs. Classes

Collaboration / Class Duality

- A collaboration focuses on
 - The interaction of objects for one purpose
- A class focuses on
 - The integration the roles an object plays in multiple collaborations

Collaborations and Role Binding to Classes



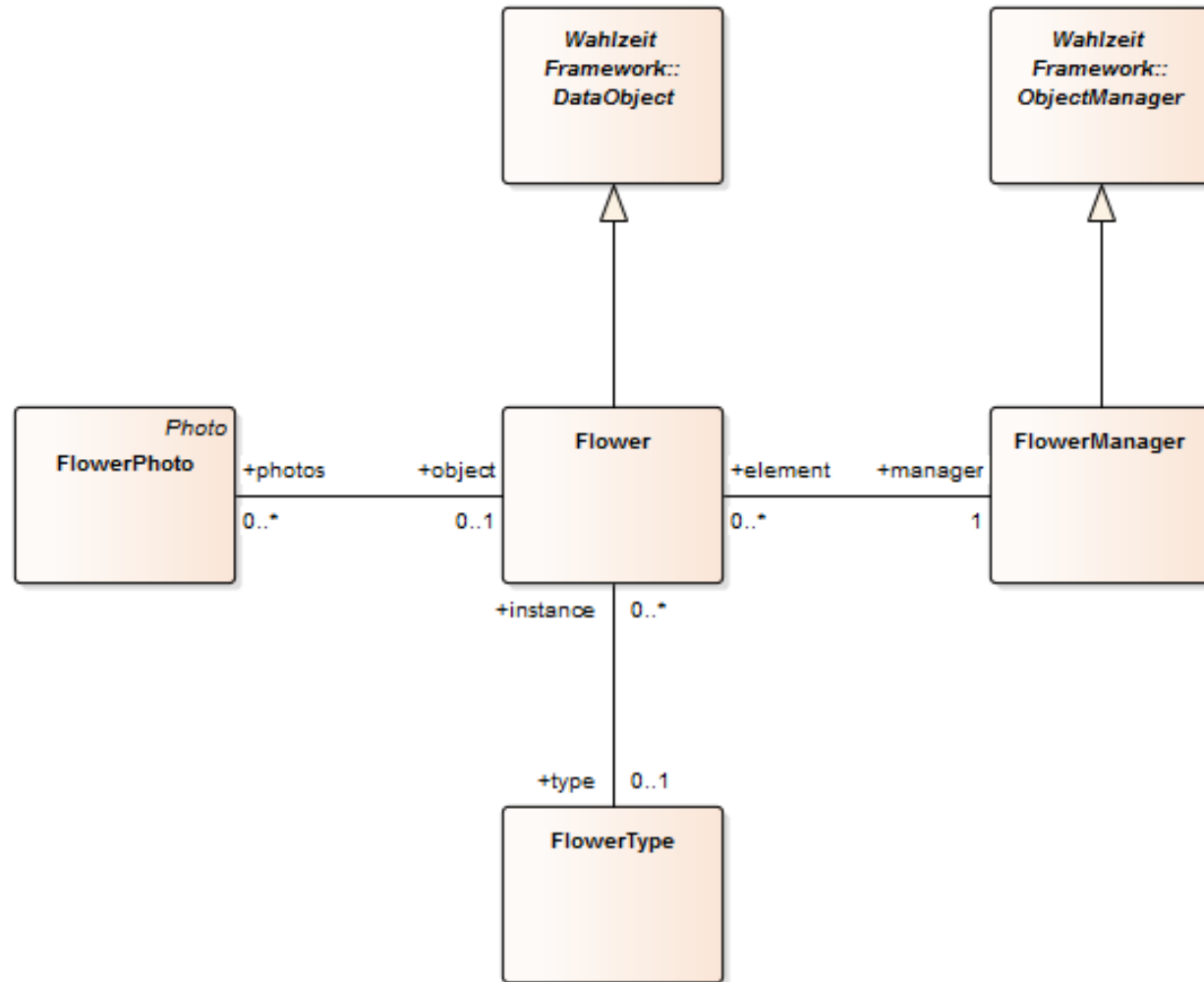
Collaboration-based Design and Reuse

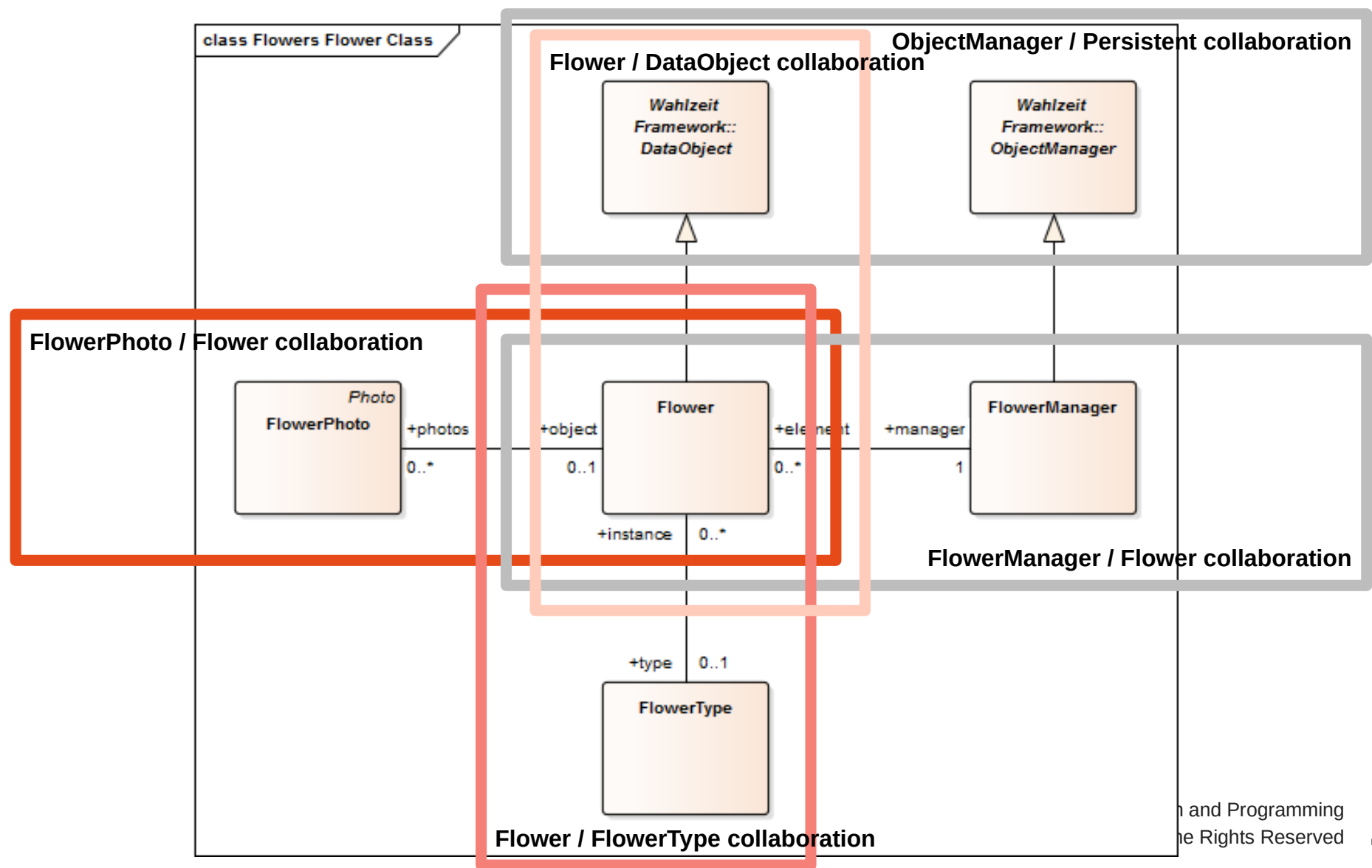
- For a collaboration to be used in multiple contexts
 - It needs to be independent of those contexts
 - Naming cannot be context-specific → Node becomes Owned
 - It must be possible to apply it to those contexts
 - Naming should be adjustable (method renaming) → Owned becomes Node
 - Role composition (in one class) needs to be made explicit
 - Composition has important domain analysis meaning
- Reusable models need programming language support
- Collaboration-based design and design by contract work together well

Levels of Abstraction

	Design Pattern	Design Template	Class Model
Level	Design illustration	Design template	Specific model
Language	No formal language available	UML-Collaboration	UML-Class-Model, UML-Collaboration-Use
Use in CBD	N/A	Collaboration	Role binding
Example	N/A	Hierarchy = { Client, Owner, Owned } ParentChild = { Parent, Child }	Hierarchy.Owner → Directory ParentChild.Parent → Directory

4. Flower Collaborations





Flower Collaborations

- **FlowerPhoto / Flower Collaboration**
 - Purpose: Provide main domain functionality
 - Role types: FlowerPhoto (Client), Flower (Service)
- **Flower / FlowerType Collaboration (Type Object)**
 - Purpose: Provide information common to all instances of a type
 - Role types: Client, Flower (Base Object), FlowerType (Type Object)
- **FlowerManager / Flower Collaboration (Manager)**
 - Purpose: Centralize object management in one place
 - Role types: Client, FlowerManager (Manager), Flower (Element)

Lessons from the Flower Collaborations

- Collaborations
 - Often have an implicit Client role
 - Almost always overlap when applied to a class model
 - There can be inheritance between collaborations
 - Many collaborations are design pattern applications

5. Collaborations in UML

UML and Collaboration-based Design [1]

11.7 Collaborations

11.7.1 Summary

The primary purpose of Collaborations is to explain how a system of communicating elements collectively accomplish a specific task or set of tasks without necessarily having to incorporate detail that is irrelevant to the explanation. Collaborations are one way that UML may be used to capture design patterns.

A CollaborationUse represents the application of the pattern described by a Collaboration to a specific situation involving specific elements playing its collaborationRoles.

11.7.2 Abstract Syntax

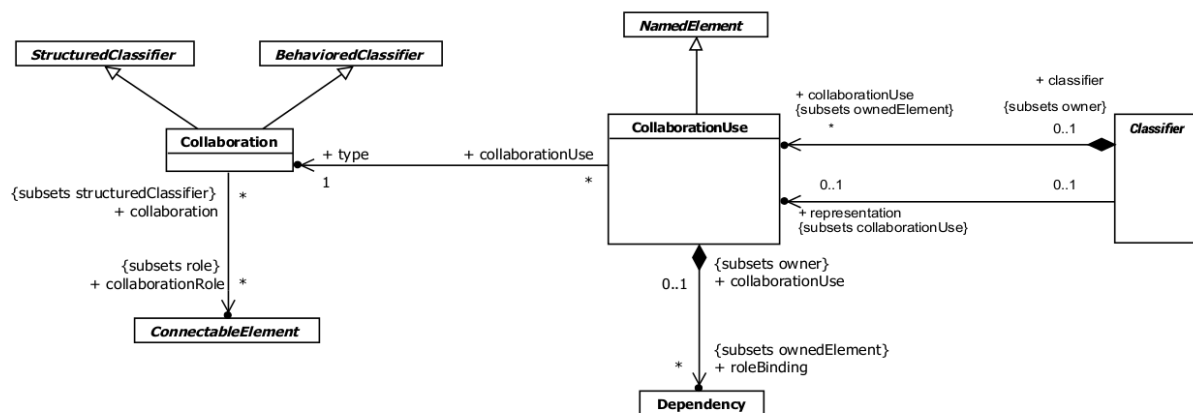
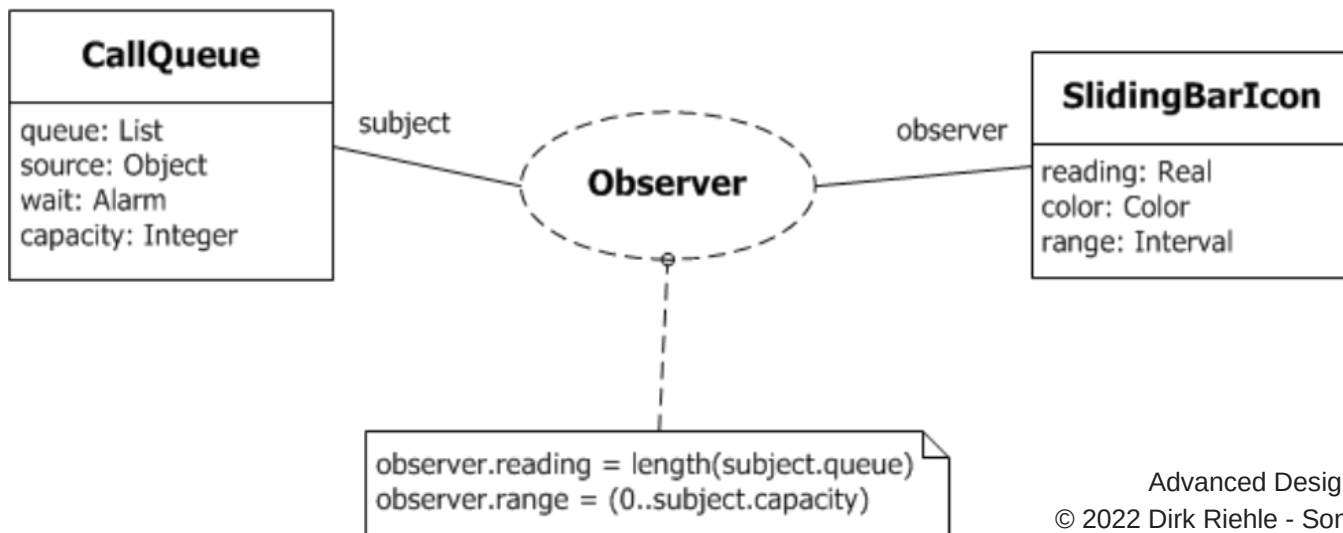
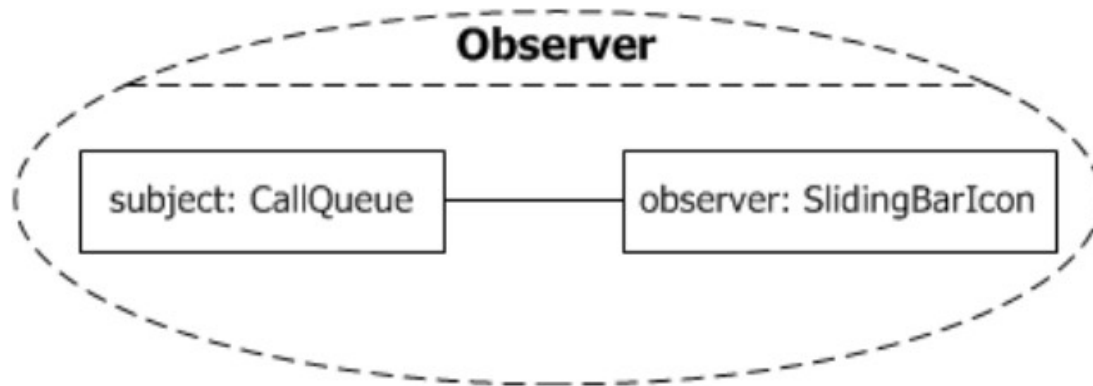


Figure 11.49 Collaborations

Concrete Syntax for Collaborations



Extensions

Properties...

New Element or Connector

Insert Other Element ...

Advanced

Paste Element(s) as Link

Paste Element(s) as New

Paste Image from Clipboard Ctrl+Shift+Insert

View as List

View as Gantt

Swimlanes, Matrix and Kanban...

Roadmap Options

Context Filtering

Make all Elements Selectable

Modify Element Z Order ...

Lock Diagram

Find in Project Browser Shift+Alt+G

Add to Working Set...

Import from source file(s)

Import DB schema from ODBC

Other

Package

Class

Interface

Data Type

Enumeration

Primitive

Table

Signal

Association

Associate

Generalize

Compose

Aggregate

Association Class

Assembly

Realize

Template Binding

Nesting

Use Case

Class

Object

Composite

Communication

Interaction

Timing

State

Activity

Component

Deployment

Profile

Metamodel

Analysis

Business Modeling

Custom

Requirements

Maintenance

User Interface

WSDL

XML Schema

Documentation

Test Domain

Dashboard

XMLTransform

ArcGIS

ArchiMate

ArchiMate2

BPMN 1.1

BPMN 2.0

BPMN1.0

Basic UML 2 Technology

Activate Composite Toolbox

Class

Interface

Part

Port

Collaboration

Collaboration Use

Expose Interface

Connector

Assembly

Delegate

Role Binding

Represents

Occurrence

ParentNode

child: ChildNode

owned: Element

Project Browser Resources

tes

I U A

x² x₂

6. Implementing Collaborations

Collaborations in Programming [R00]

```
public collaboration ParentChild {  
    public role Parent {  
        public void addChild(Child c);  
        public void removeChild(Child c);  
        public Iterator<Child> getIterator();  
    }  
  
    public role Child { ... }  
    ...  
}
```

```
public class Node binds ParentChild.Child {  
    ...  
}
```

```
public class Directory extends Node binds ParentChild.Parent {  
    ...  
}
```

Roles as Code Templates [V97]

```
public interface Owner<C> {  
    public void addOwned(C c);  
    public void removeOwned(C c);  
    public Iterator<C> getIterator();  
}
```

```
public class Node {  
    protected Node parent = null;  
    protected Node getParent() { ... }  
    protected void setParent(Node n) { ... }  
    ...  
}
```

```
public class Directory extends Node, implements Owner<Node> {  
    public void addOwned(Node n);  
    public void removeOwned(Node n);  
    public Iterator<Node> getIterator();  
    ...  
}
```

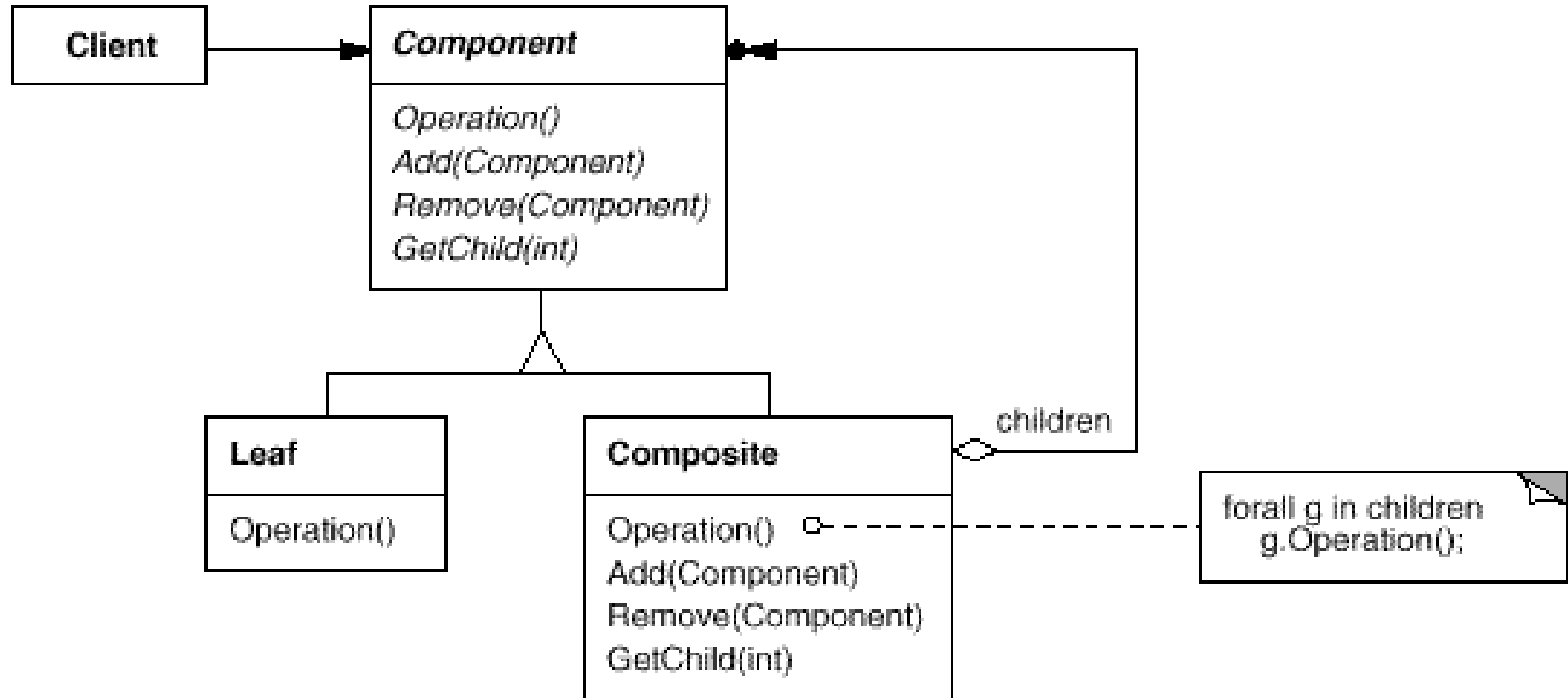
Client-side Role Specifications

```
public collaboration File {  
    public role Client {  
        // no methods, but specification of  
        // behavioral constraints, e.g.  
        // no read or write before open or after close  
    }  
  
    public role File {  
        public void open();  
        public byte[] read(int);  
        public void write(byte[]);  
        public void close();  
        ...  
    }  
}
```


- **Interfaces**
- **Protocols**
- **Mix-ins**
- **Traits**

7. Collaborations and Design Patterns

Composite Pattern Revisited [G+95]



Participants Section of Composite Pattern

- **Component (Graphic)**
 - Declares the interface for objects in the composition
 - Implements default behavior for the interface common to all classes, as appropriate
 - Declares an interface for accessing and managing its child components
 - (Optional:) Defines an interface for accessing a component's parent in the recursive structure [...]
- **Leaf (Rectangle, Line, Text, etc.)**
 - Represents leaf objects in the composition; a leaf has no children
 - Defines behavior for primitive objects in the composition
- **Composite (Picture)**
 - Defines behavior for components having children
 - Stores child components
 - Implements child-related operations in the Component interface
- **Client**
 - Manipulates objects in the composition through the Component interface

8.3 Composite

The Composite pattern defines the roles in a tree, that is a hierarchical structure. It defines two roles, Parent and Child, each of which are Nodes, too. The additional Root role serves as a handle for the whole tree.

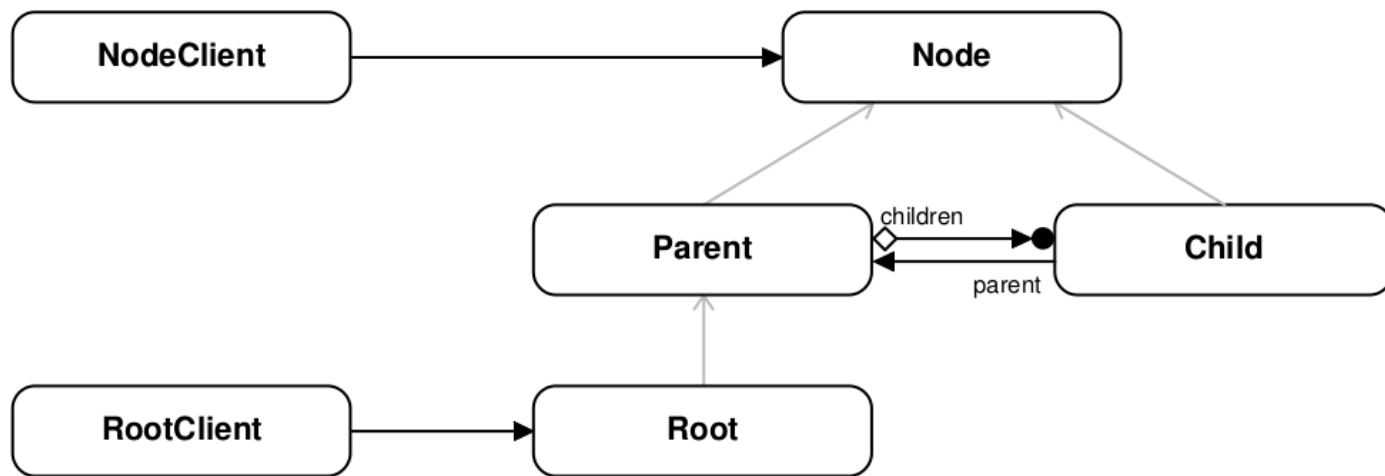
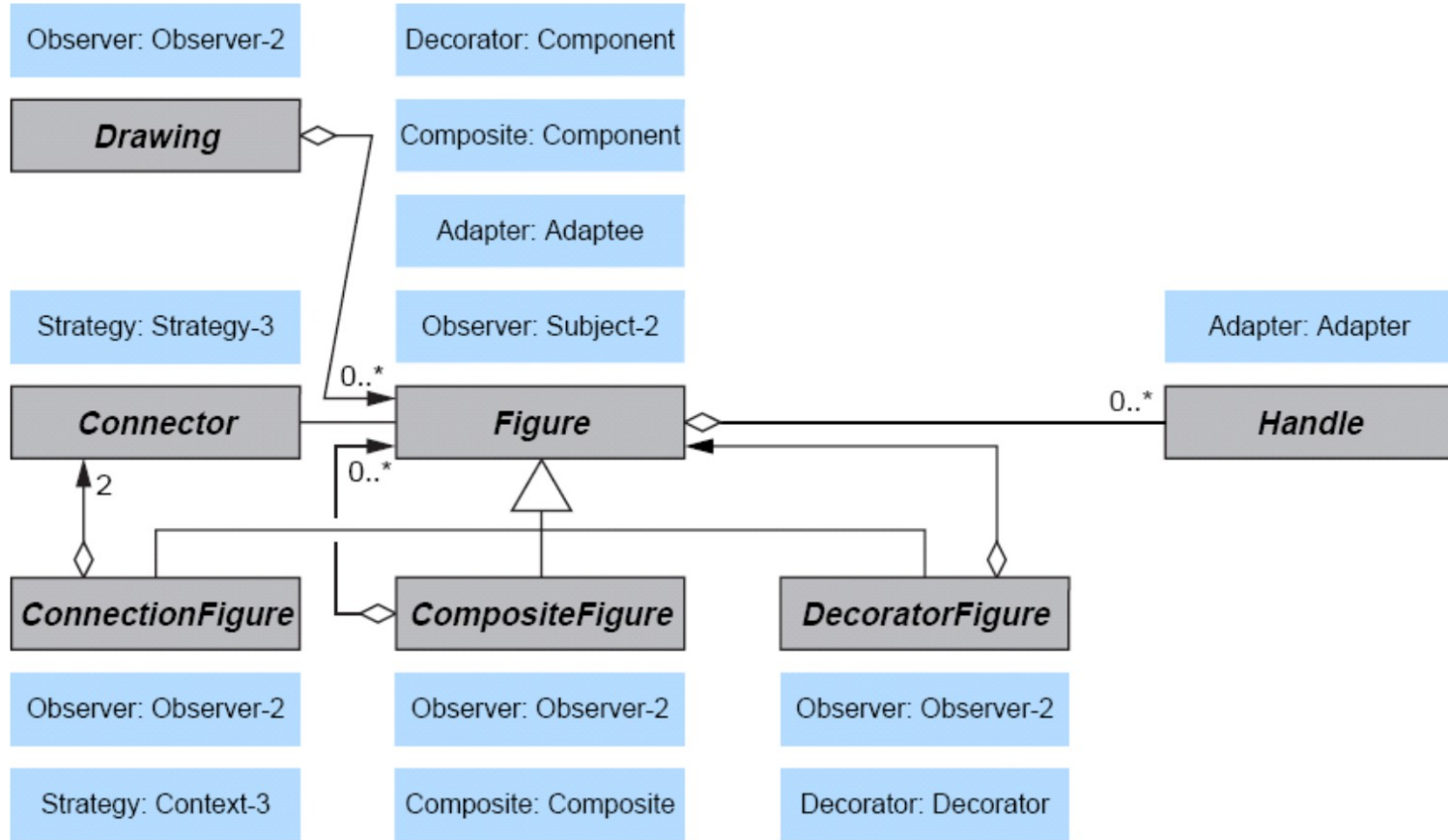
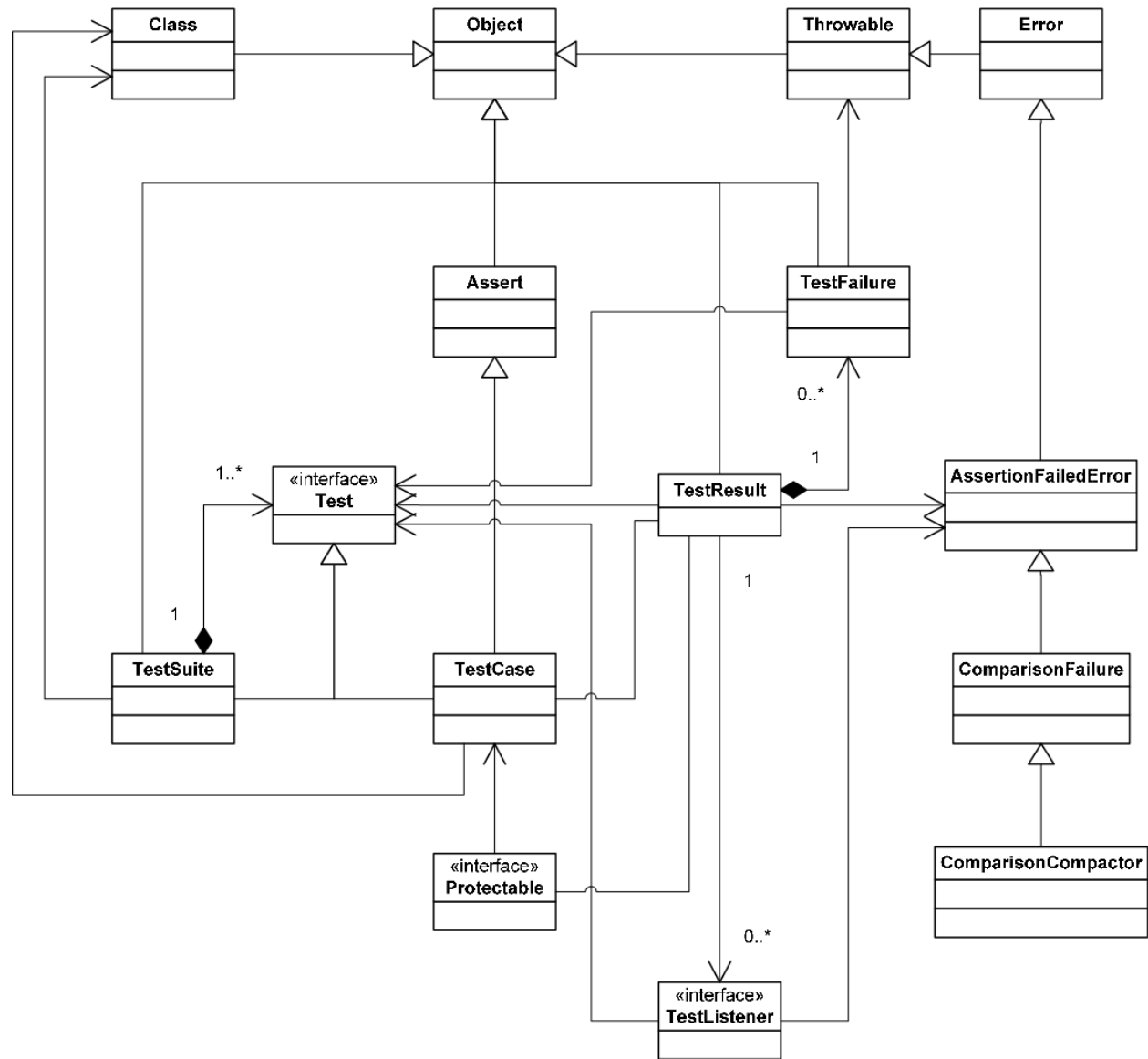


Figure 8-5: Role diagram of the Composite pattern

Design Pattern Composition [R11]





Summary

1. Collaboration-based design
2. File system example revisited
3. Collaborations vs. classes
4. Flower collaborations
5. Collaborations in UML
6. Implementing collaborations
7. Collaborations and design patterns

Thank you! Questions?

`dirk.riehle@fau.de` – `https://oss.cs.fau.de`

`dirk@riehle.org` – `https://dirkriehle.com` – `@dirkriehle`

Legal Notices

- License
 - Licensed under the **CC BY 4.0 International** License
- Copyright
 - © 2012-2022 Dirk Riehle, some rights reserved