Collaboration-Based Design

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ADAP C11

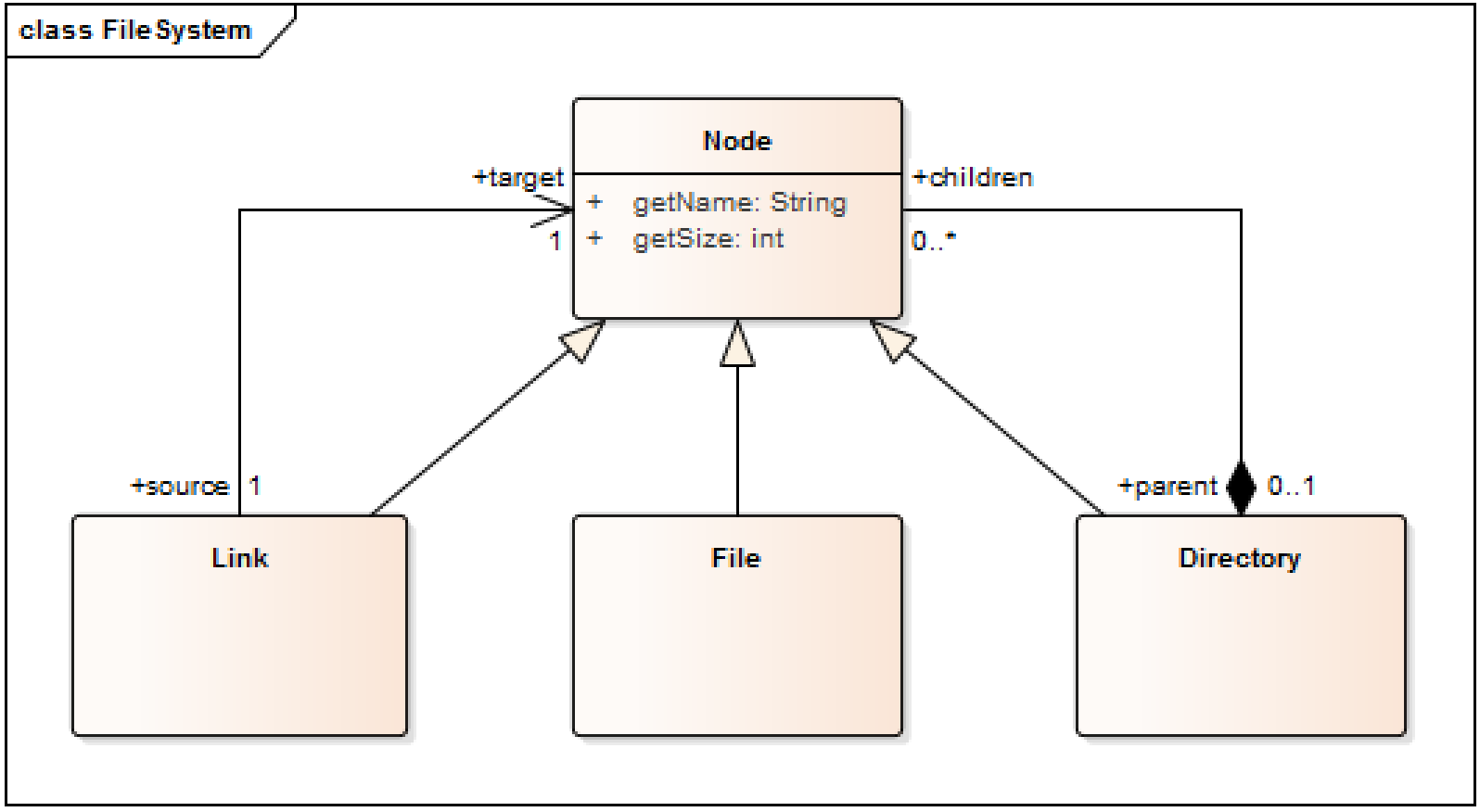
Collaboration-based Design

- **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

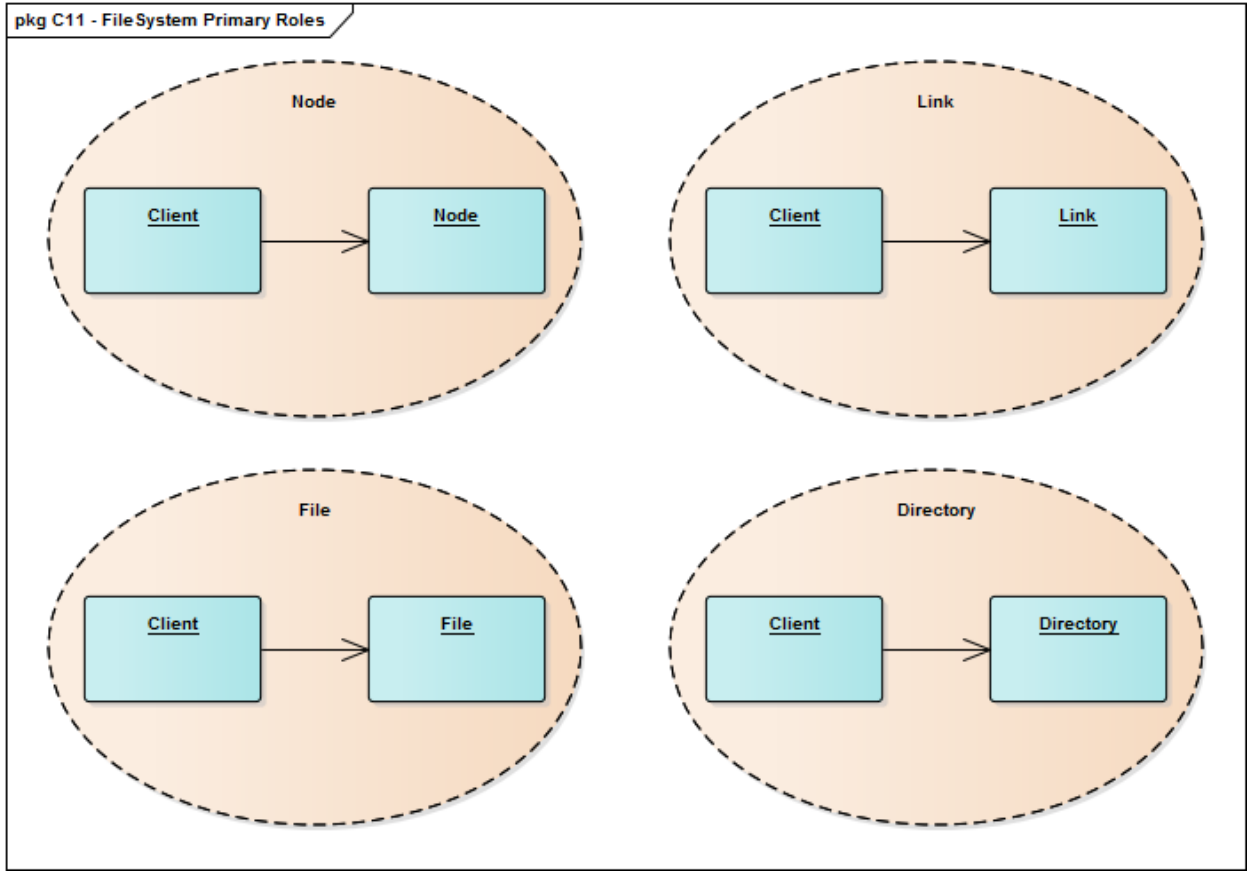
Benefits of Collaboration-based Design

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

File System Example Revisited



Primary Service Collaborations



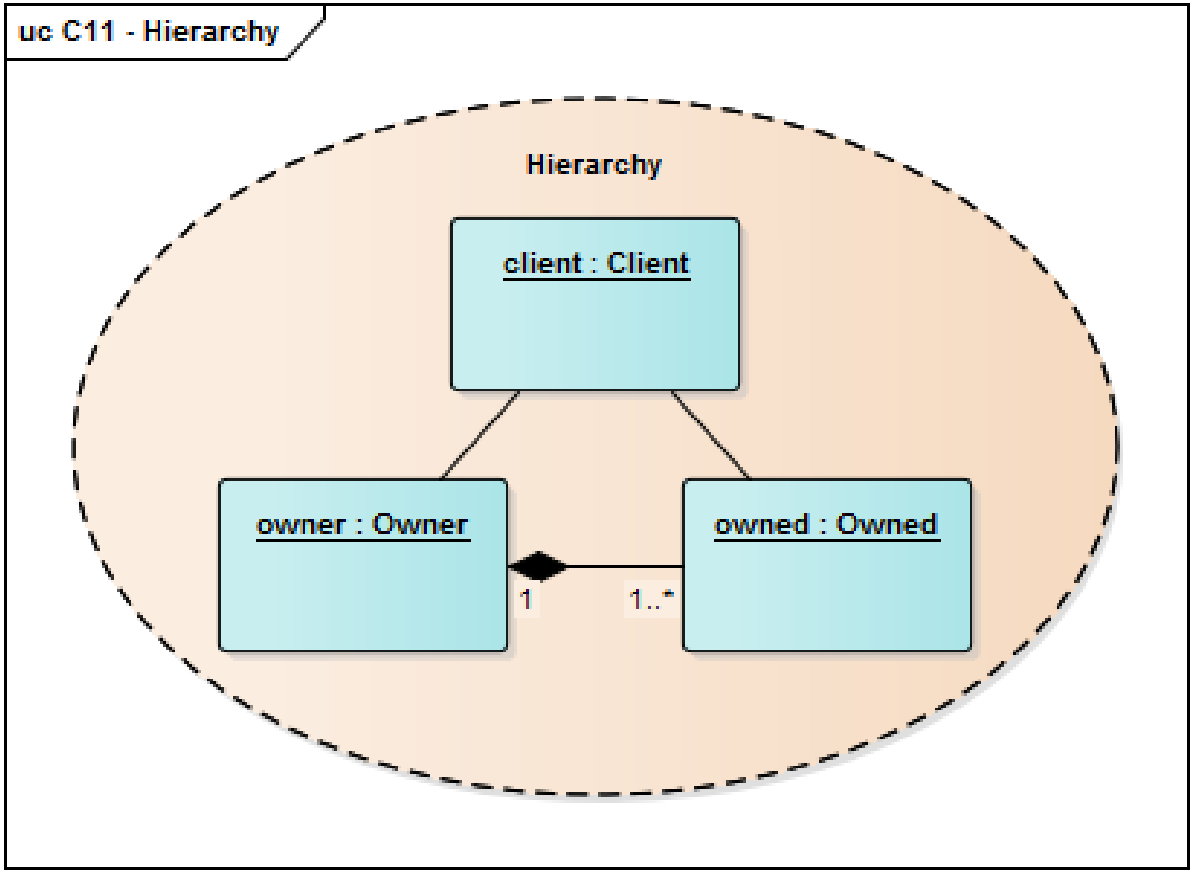
Primary Service Roles as Code

```
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);
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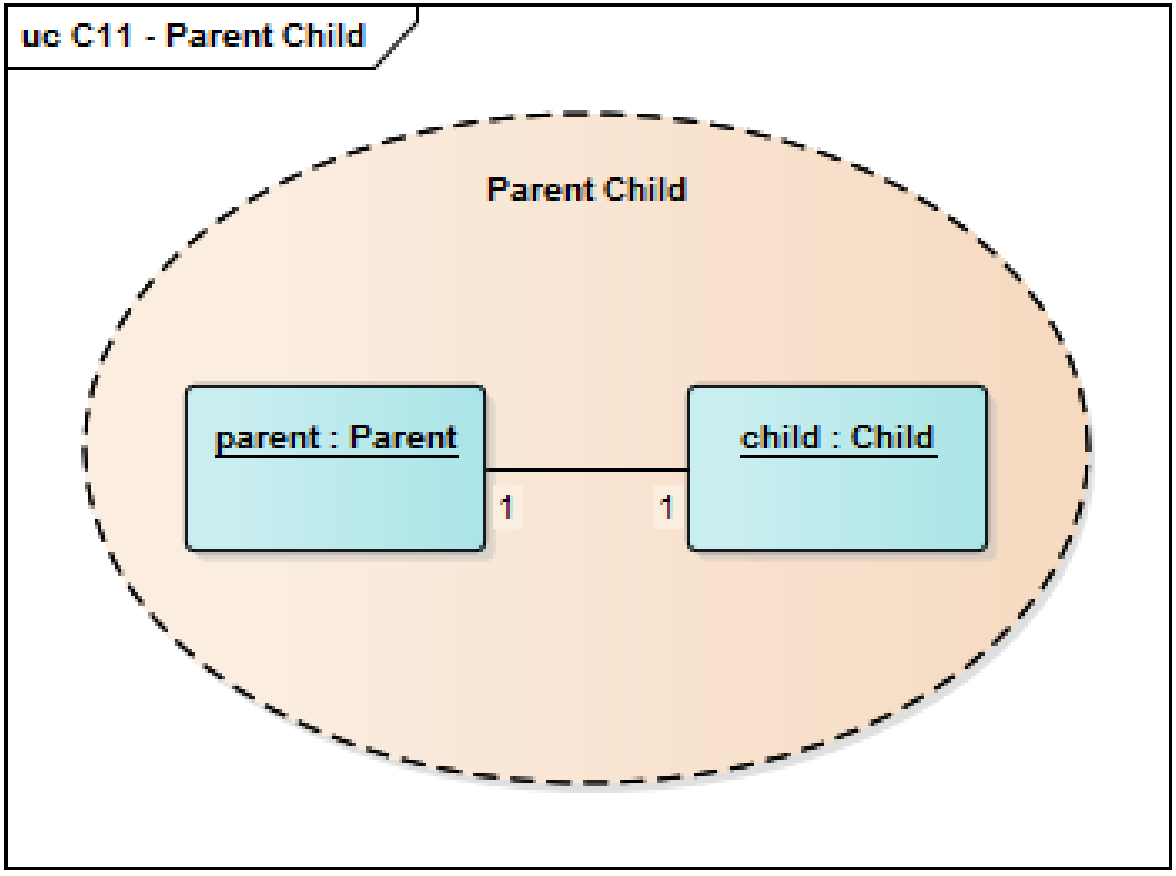
  ...
}
```

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
  ...
}
```

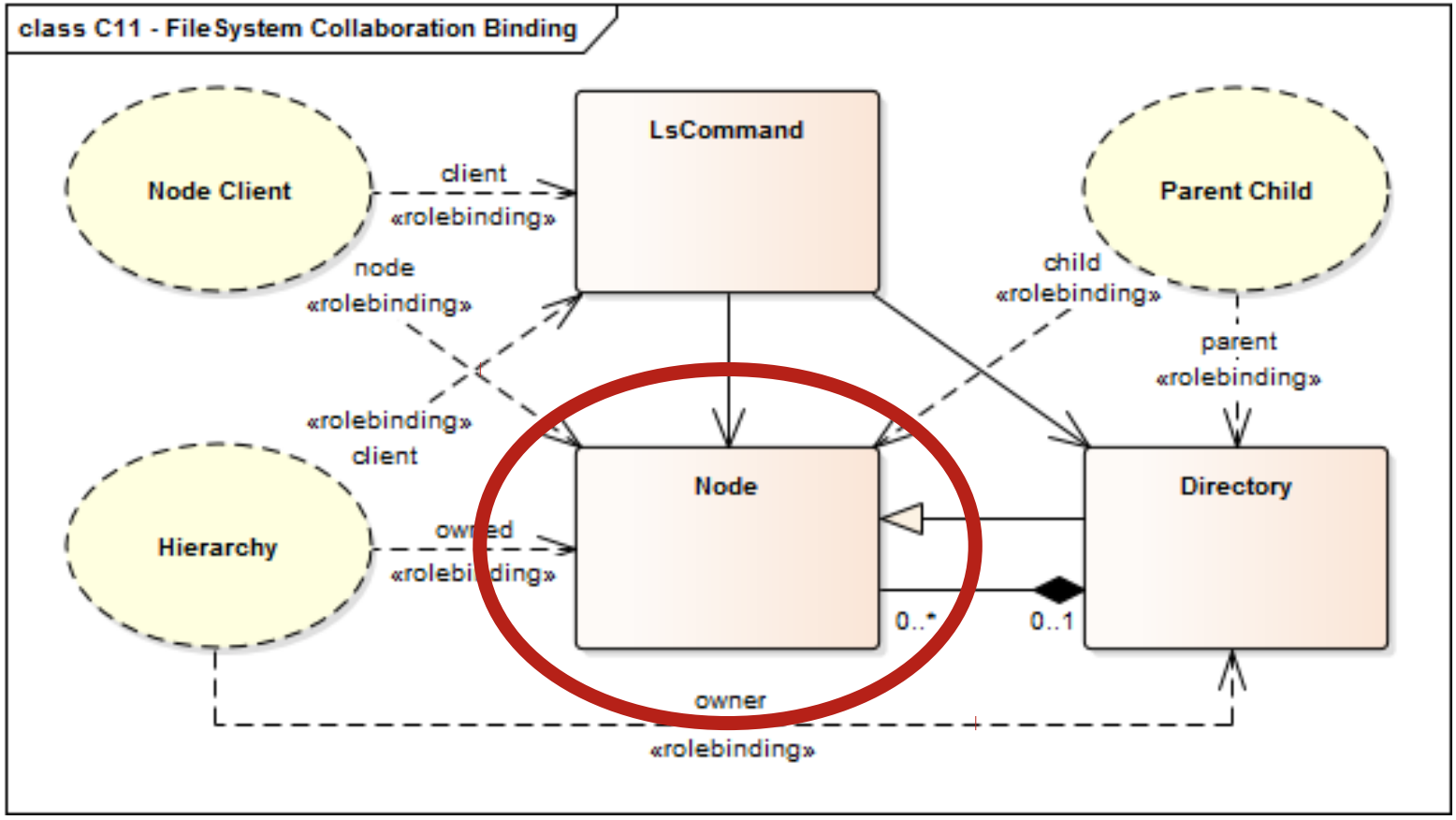
Types of Collaborations

- 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

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

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

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

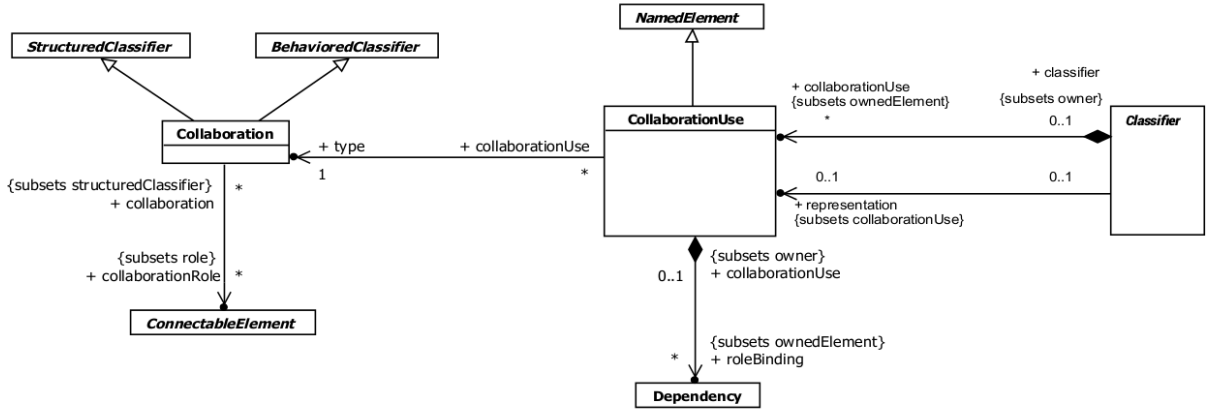
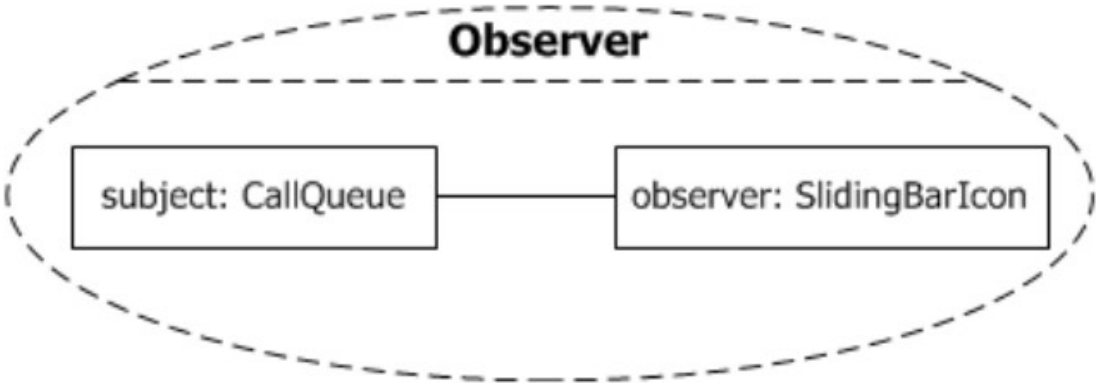
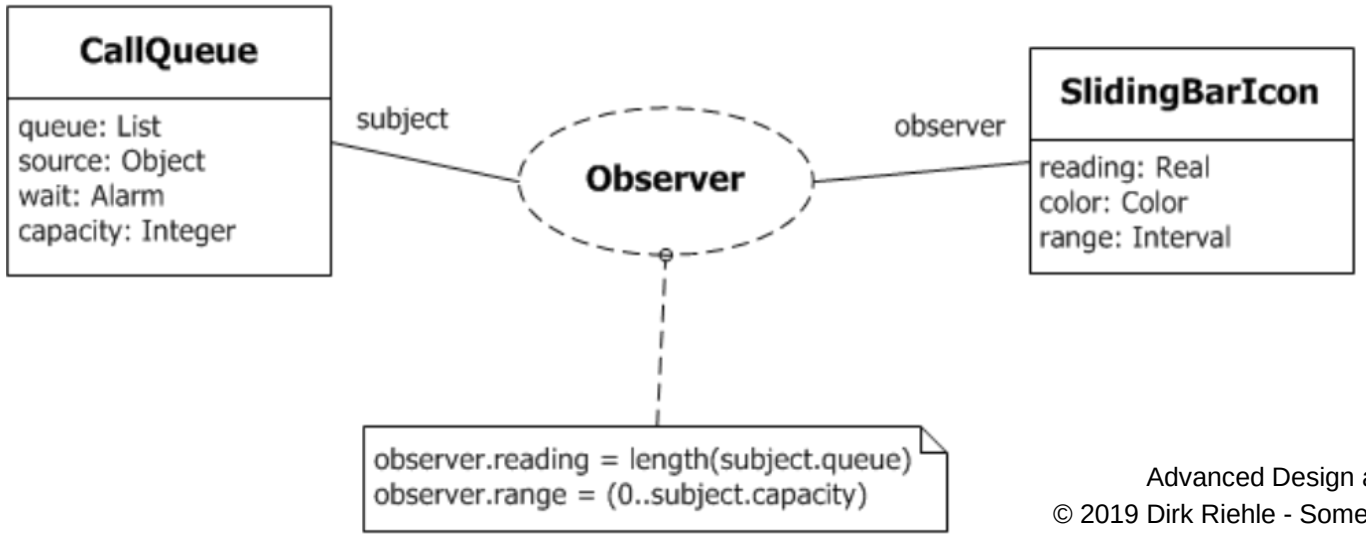


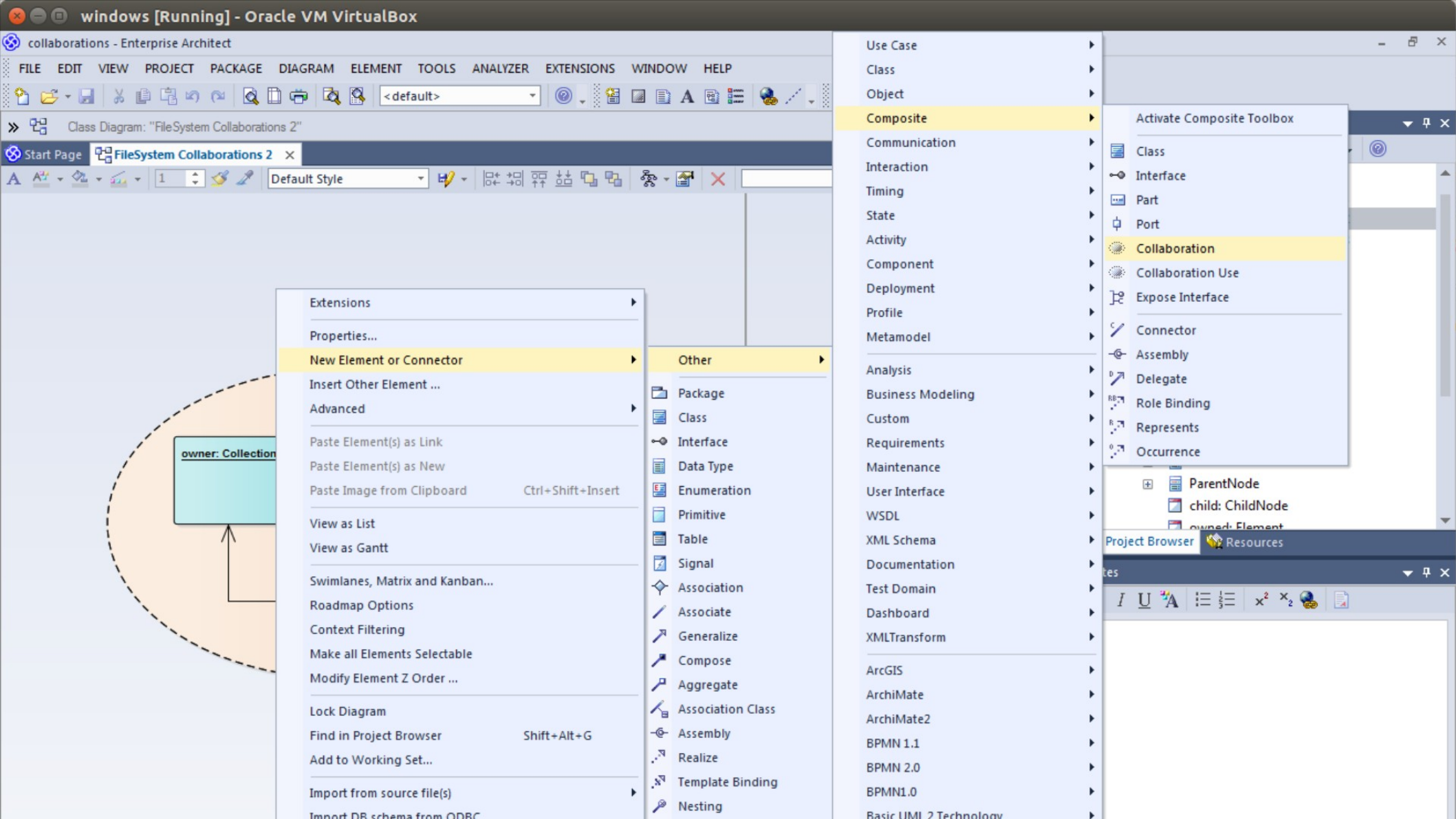
Figure 11.49 Collaborations

[1] From the UML 2.5 specification (May 2011)

Concrete Syntax for Collaborations






windows [Running] - Oracle VM VirtualBox
collaborations - Enterprise Architect
FILE EDIT VIEW PROJECT PACKAGE DIAGRAM ELEMENT TOOLS ANALYZER EXTENSIONS WINDOW HELP
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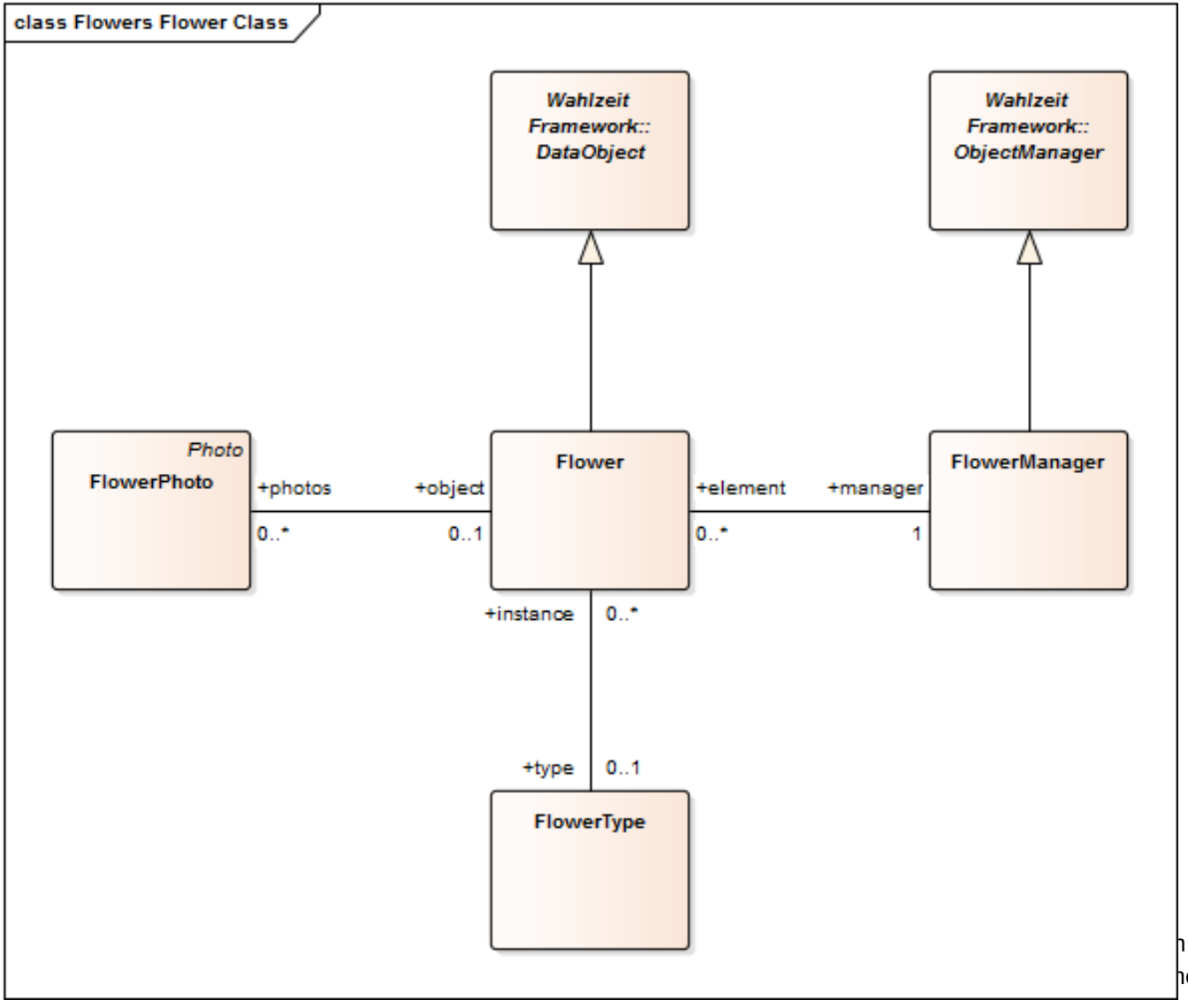
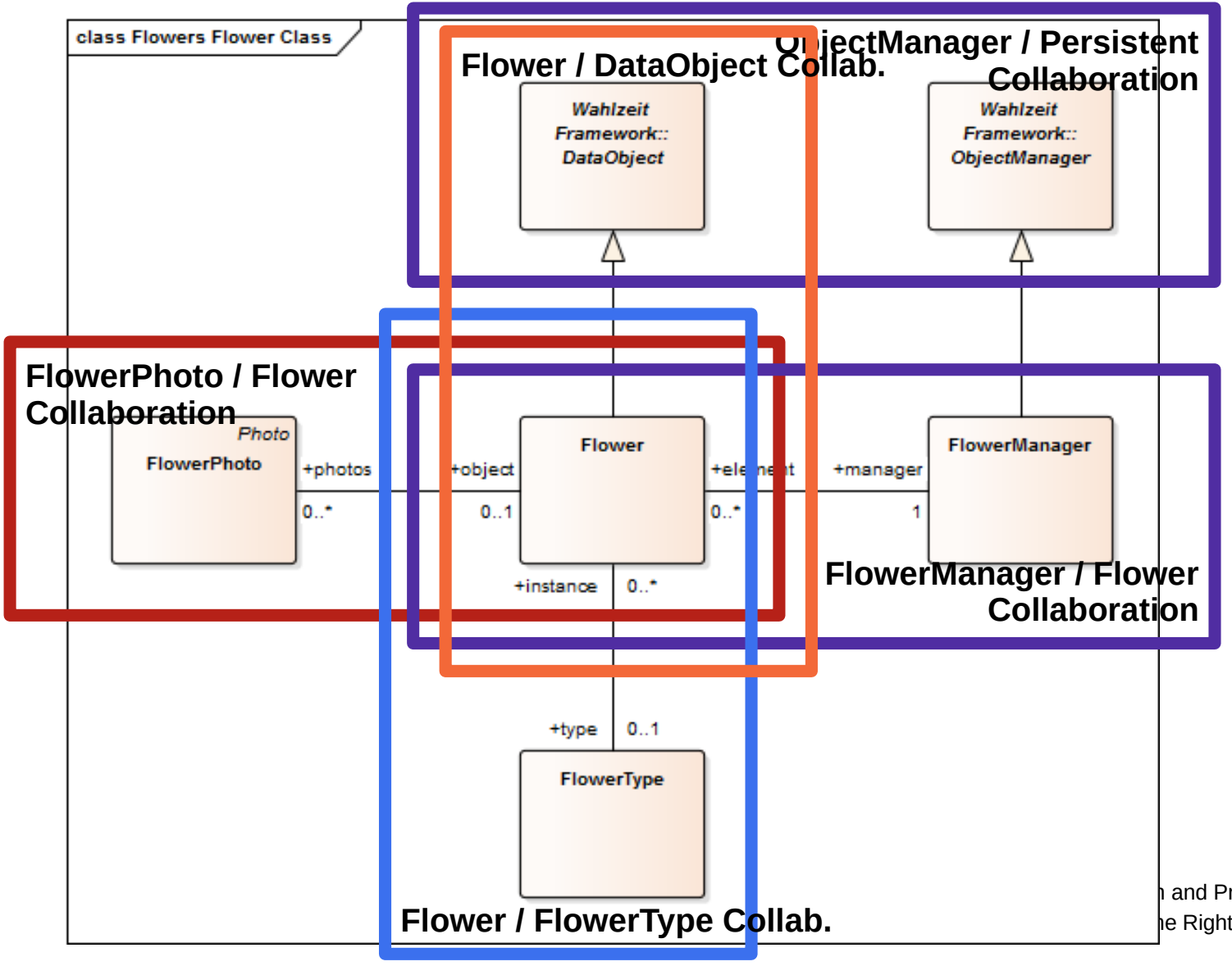
Class Diagram: "FileSystem Collaborations 2"
Start Page
FileSystem Collaborations 2
Default Style
owner: Collection
Extensions
Properties...
New Element or Connector
Insert Other Element ...
Advanced
Paste Element(s) as Link
Paste Element(s) as New
Paste Image from Clipboard Ctrl+Shift+Insert
View as 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
Project Browser
Resources





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 should be inheritance between collaborations
  - Many collaborations are design pattern applications

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 Specifcations

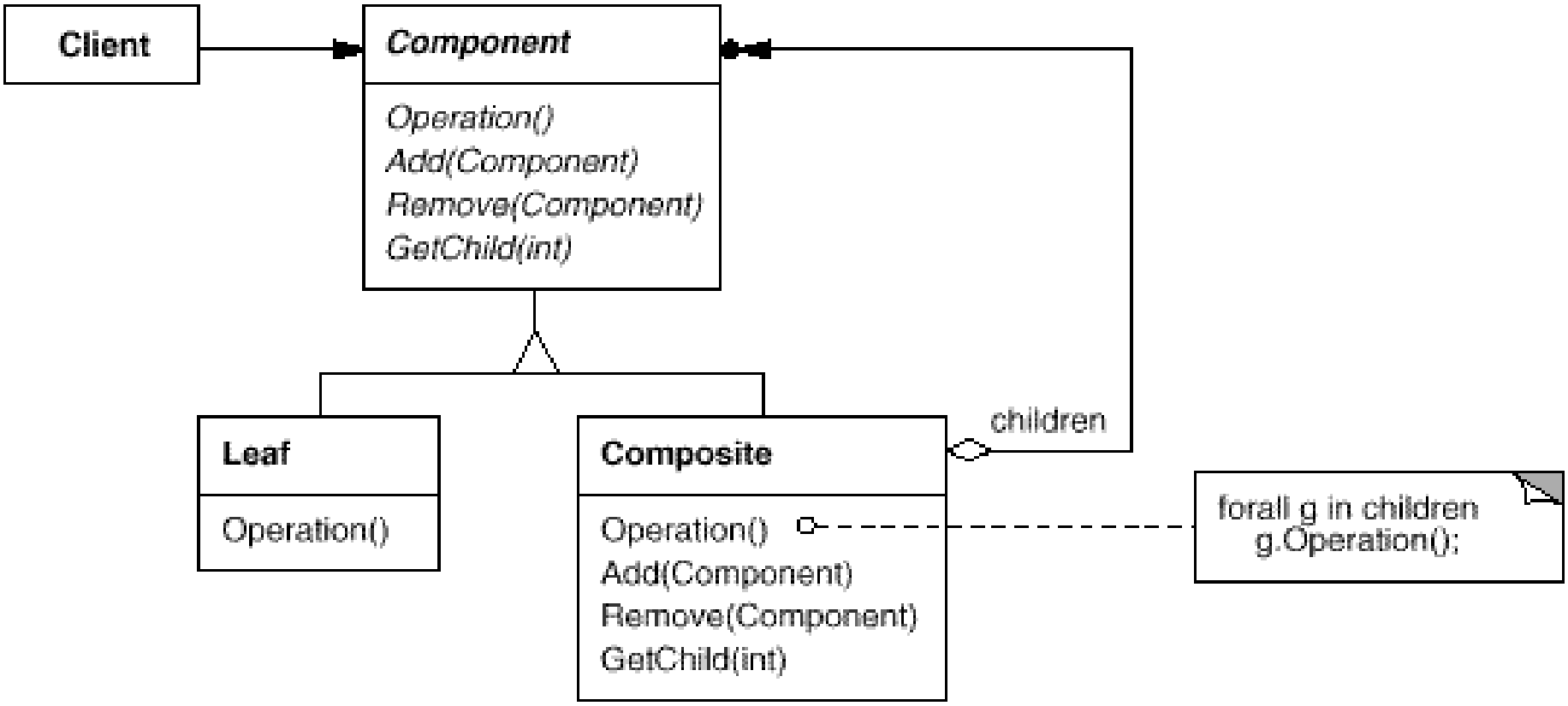
```
public collaboration File {
  public role Client {
    // no methods, but specification of
    // behavioral constraints, e.g.
    // no read or write before open or after close
  }

  public role File {
    public void open();
    public byte[] read(int);
    public void write(byte[]);
    public void close();
    ...
  }
}
```

Similar / Related to Roles

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

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, and implements it if that's appropriate.
- 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.

Composite Pattern as Role Model [R97]

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.

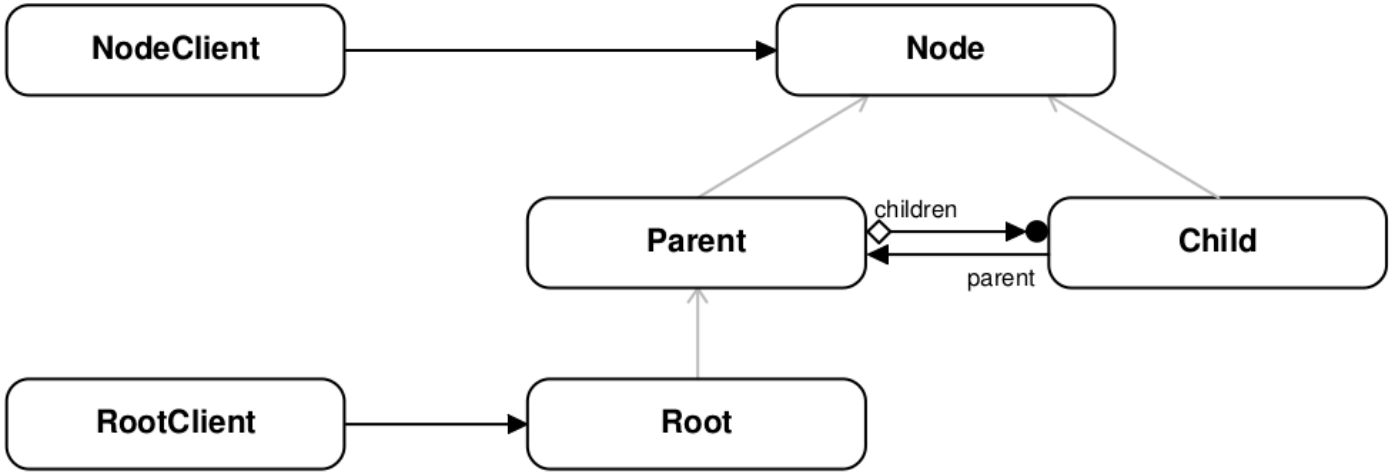
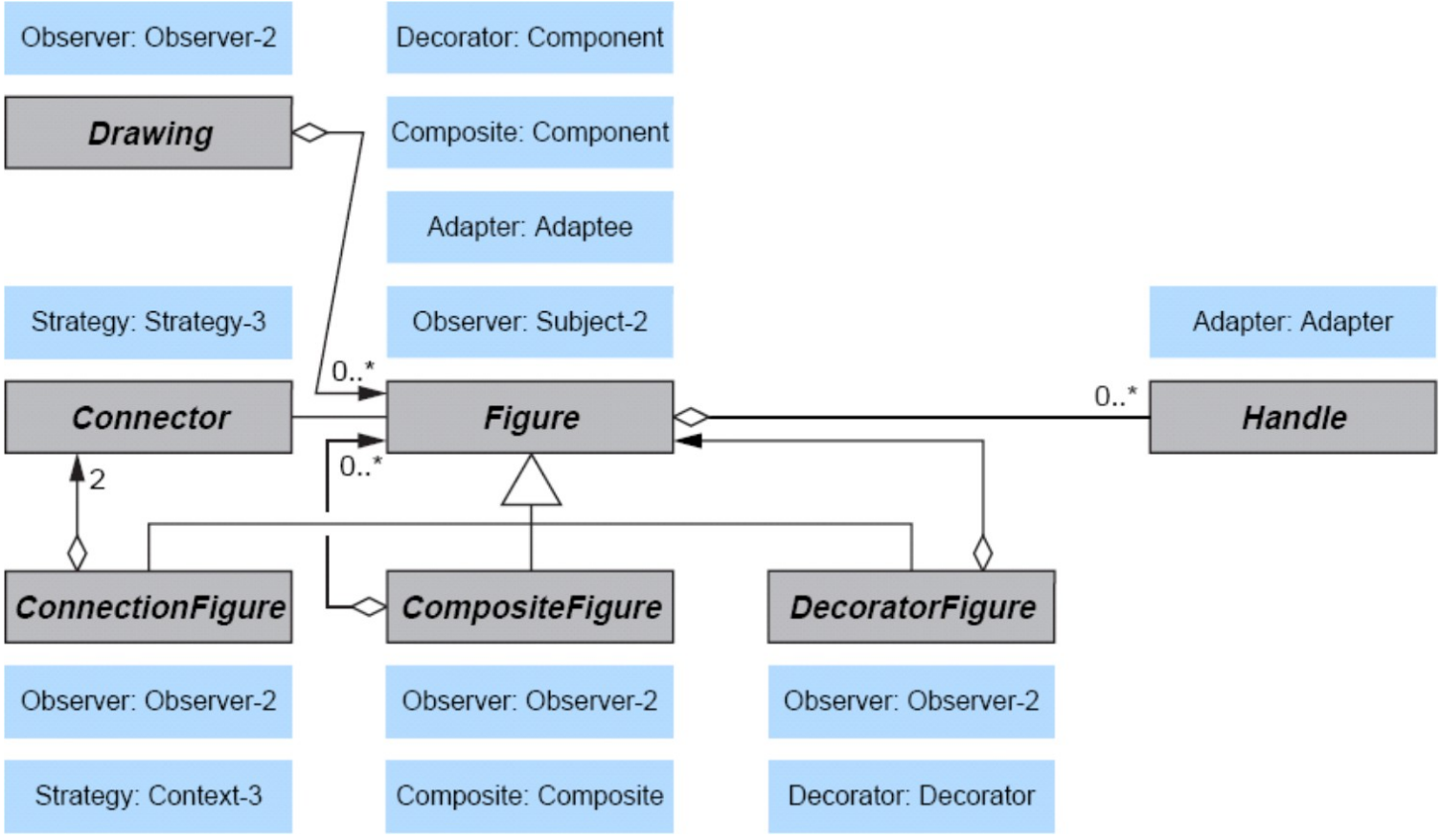
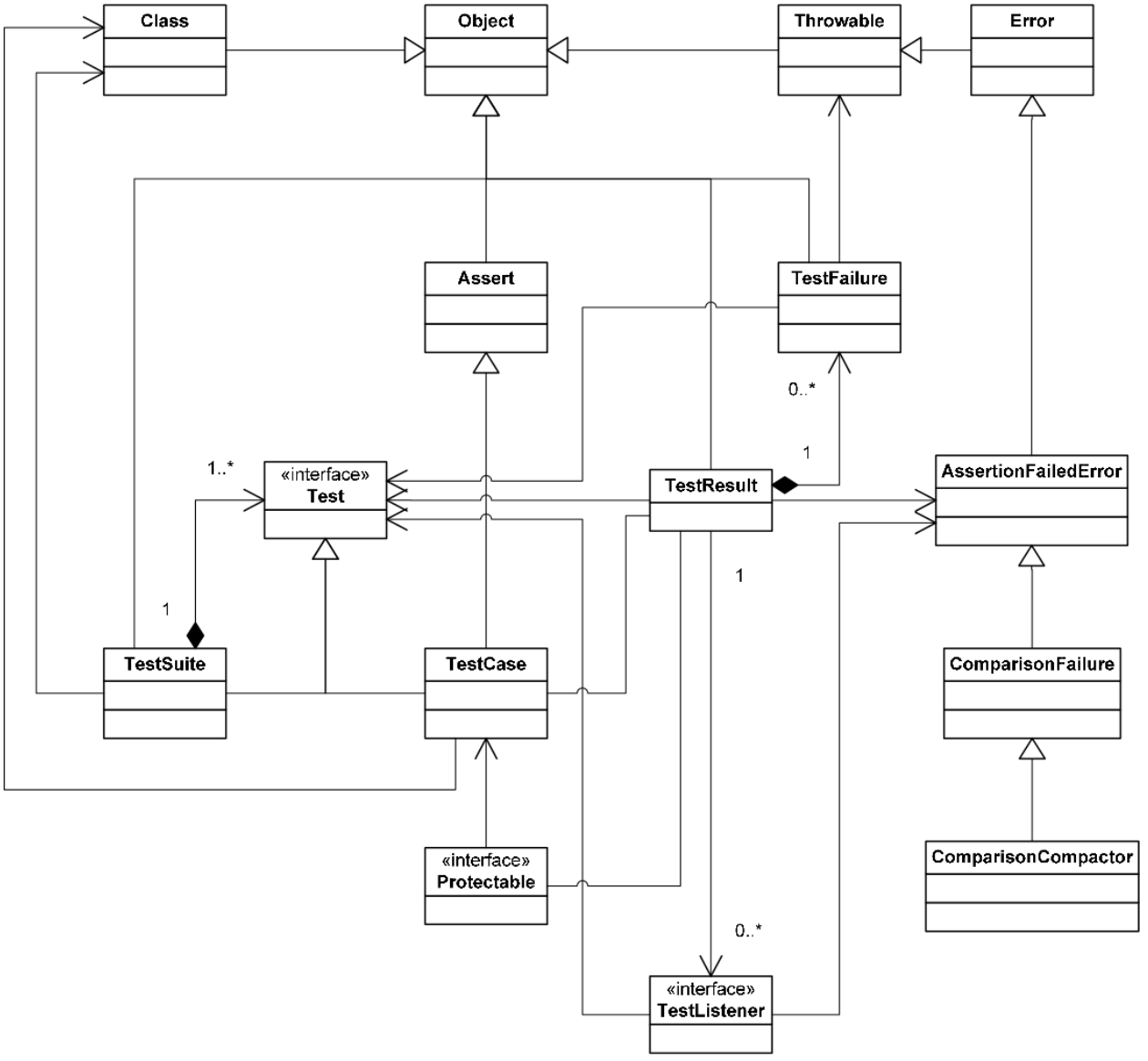


Figure 8-5: Role diagram of the Composite pattern

Design Pattern Composition [R11]




Class
Object
Throwable
Error
Assert
TestFailure
0..*
1..*
«interface»
Test
TestResult
1
AssertionFailedError
1
1
TestSuite
TestCase
ComparisonFailure
«interface»
Protectable
ComparisonCompactor
0..*
«interface»
TestListener

Review / Summary of Session

- Collaboration-based design
  - Definitions, constituents
  - In design and programming
- Design patterns, templates, models
- Composition of models

Thank you! Questions?

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Credits and License

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  - Licensed under Creative Commons Attribution 4.0 International License
- Contributions
  - ...

Collaboration-Based Design

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It is Friedrich-Alexander University Erlangen-Nürnberg – FAU, in short.

Corporate identity wants us to say “Friedrich-Alexander University”.

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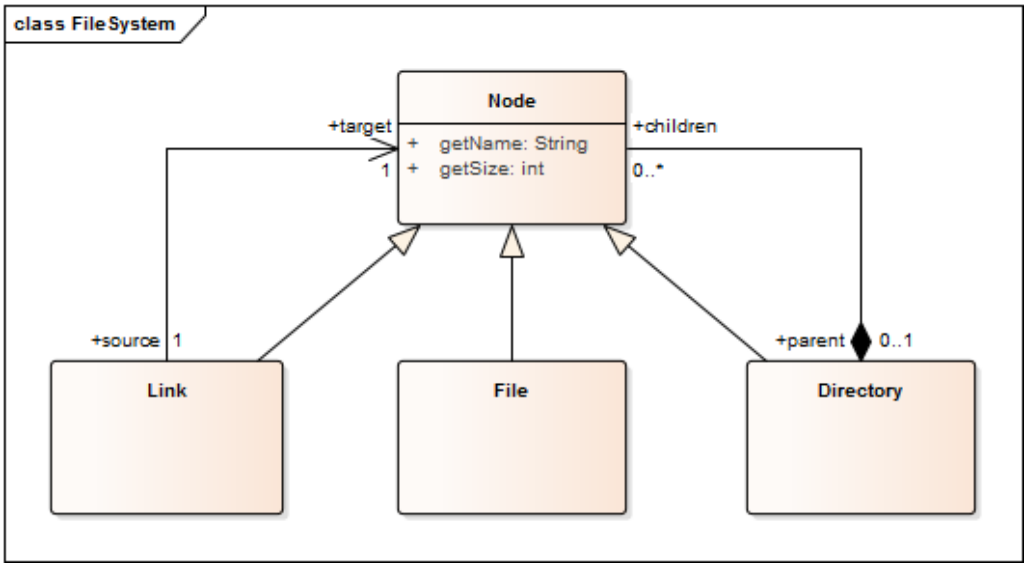
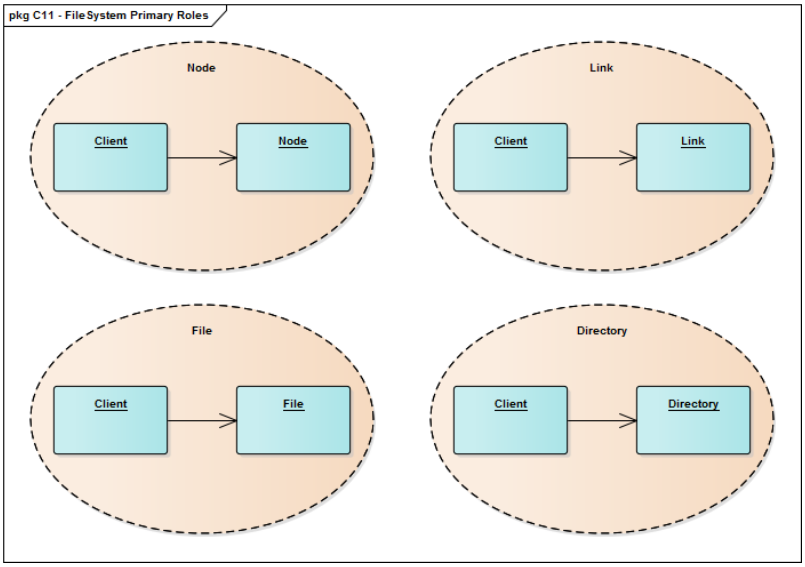


Primary Service Collaborations



Primary Service Roles as Code

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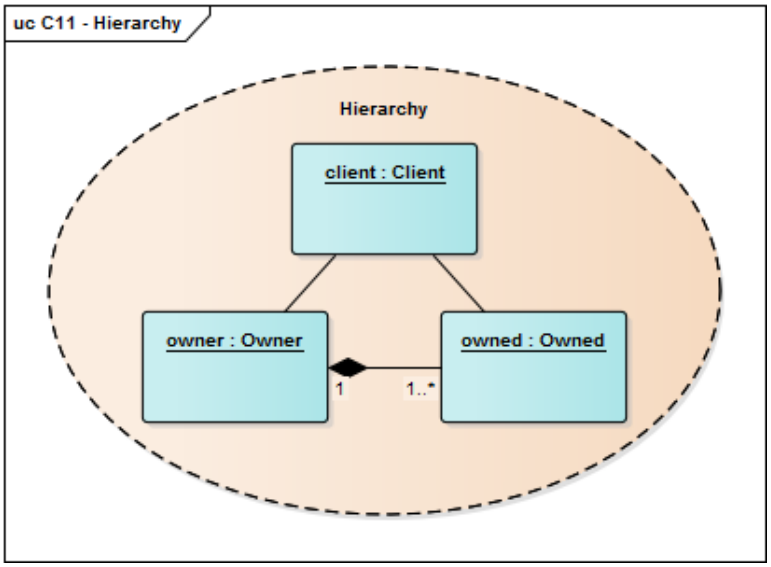
Hierarchy Collaboration



Secondary Service Roles as Code

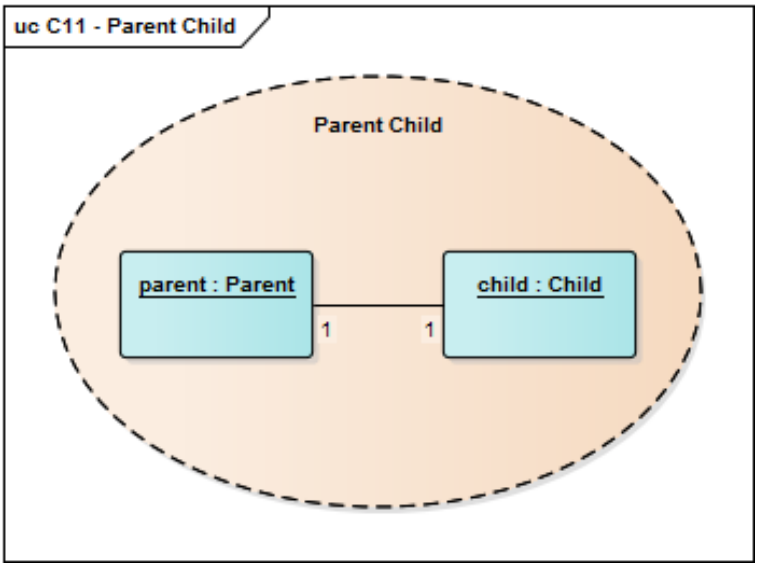
```
public class Node {
  // Hierarchy-Collaboration
  public Node getOwner();
  public void setOwner(Node n);

  // Other collaborations
  ...
}
```

```
public class Directory extends Node {
  // Hierarchy-Collaboration
  public void addOwned(Node n);
  public void removeOwned(Node n);
  public Iterater getIterator();

  // Other collaborations
  ...
}
```

Parent Child Collaboration



Maintenance Roles as Code

```
public class Node {
  // Parent-Child-Collaboration
  protected Node getParent();
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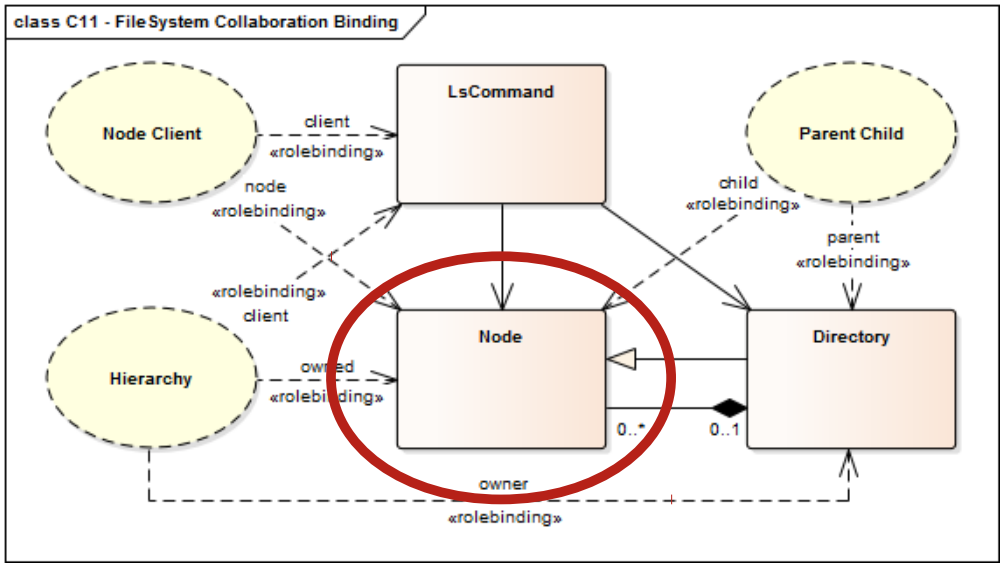

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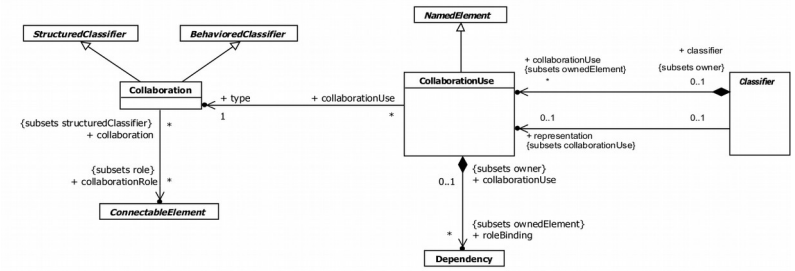

Figure 11.49 Collaborations

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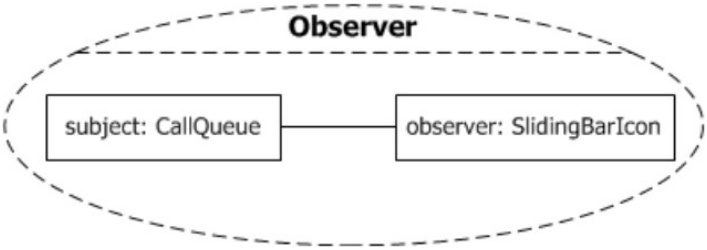
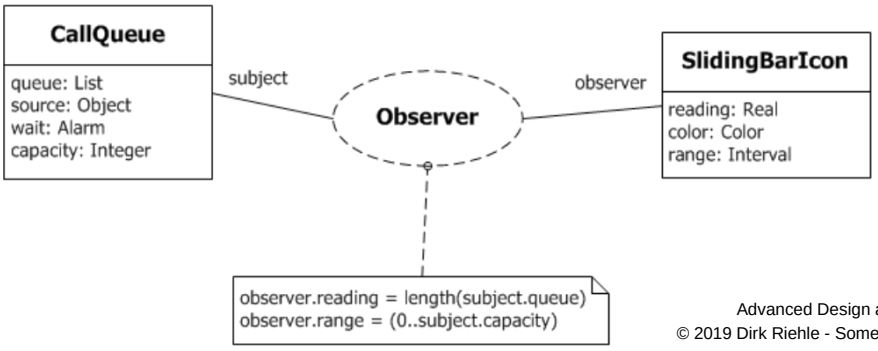
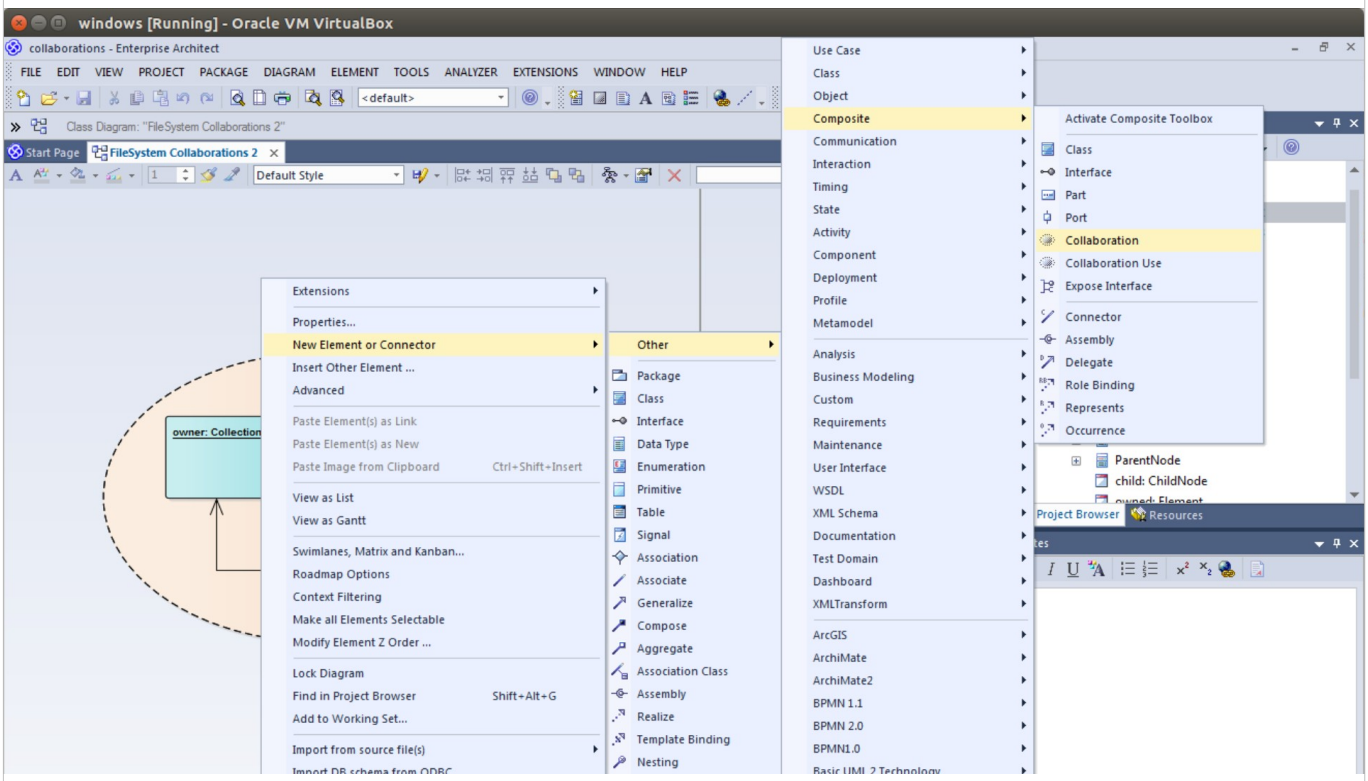
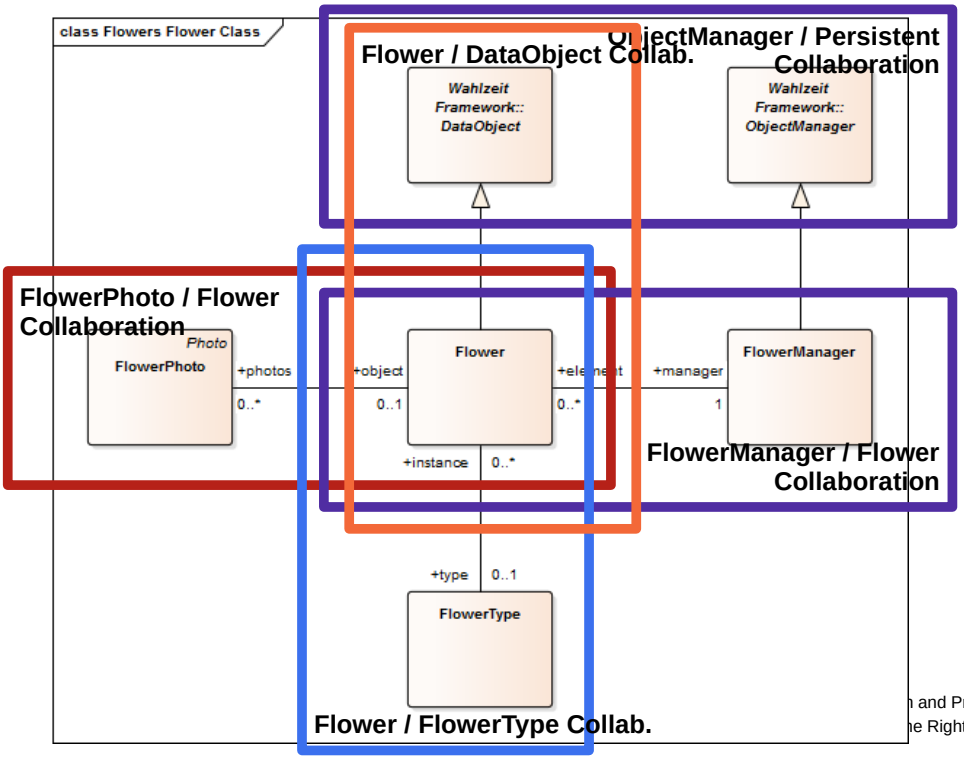





windows [Running] - Oracle VM VirtualBox
collaborations - Enterprise Architect
FILE EDIT VIEW PROJECT PACKAGE DIAGRAM ELEMENT TOOLS ANALYZER EXTENSIONS WINDOW HELP
Class Diagram: "FileSystem Collaborations 2"
Start Page
FileSystem Collaborations 2
Default Style
owner: Collection
Extensions
Properties...
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)
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
Activate Composite Toolbox
Class
Interface
Part
Port
Collaboration
Collaboration Use
Expose Interface
Connector
Assembly
Delegate
Role Binding
Represents
Occurrence
ParentNode
child: ChildNode
Project Browser
Resources



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 should be inheritance between collaborations
  - Many collaborations are design pattern applications

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 Specifcations

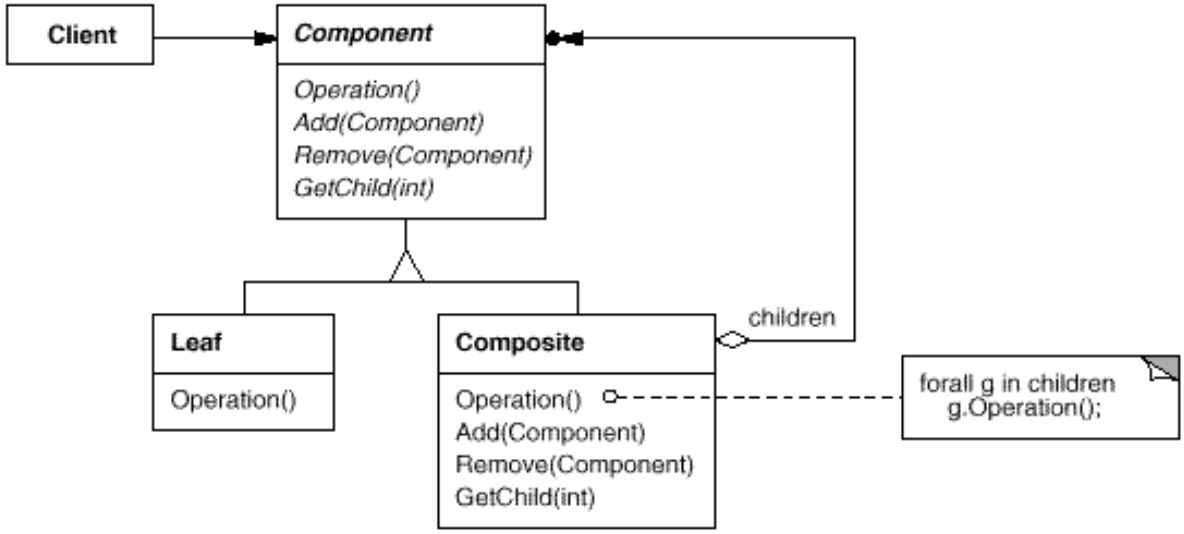
```
public collaboration File {
  public role Client {
    // no methods, but specification of
    // behavioral constraints, e.g.
    // no read or write before open or after close
  }

  public role File {
    public void open();
    public byte[] read(int);
    public void write(byte[]);
    public void close();
    ...
  }
}
```

Similar / Related to Roles

- Interfaces
- Protocols
- Mix-ins
- Traits

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, and implements it if that's appropriate.
- 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.

Composite Pattern as Role Model [R97]

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.

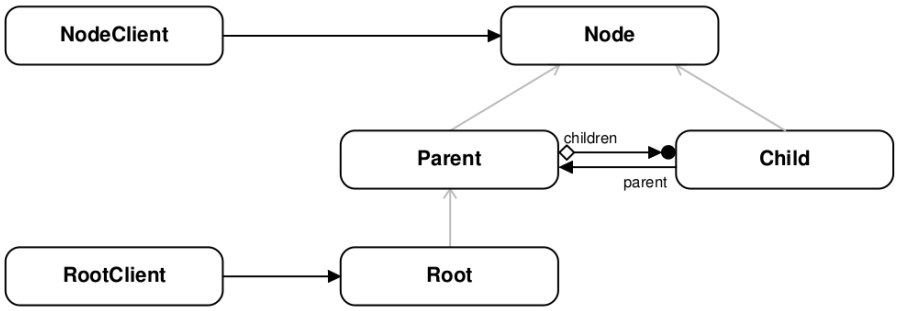
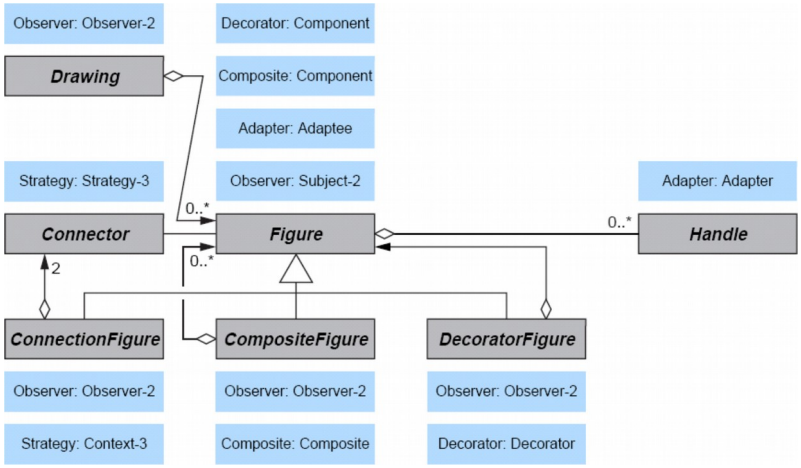
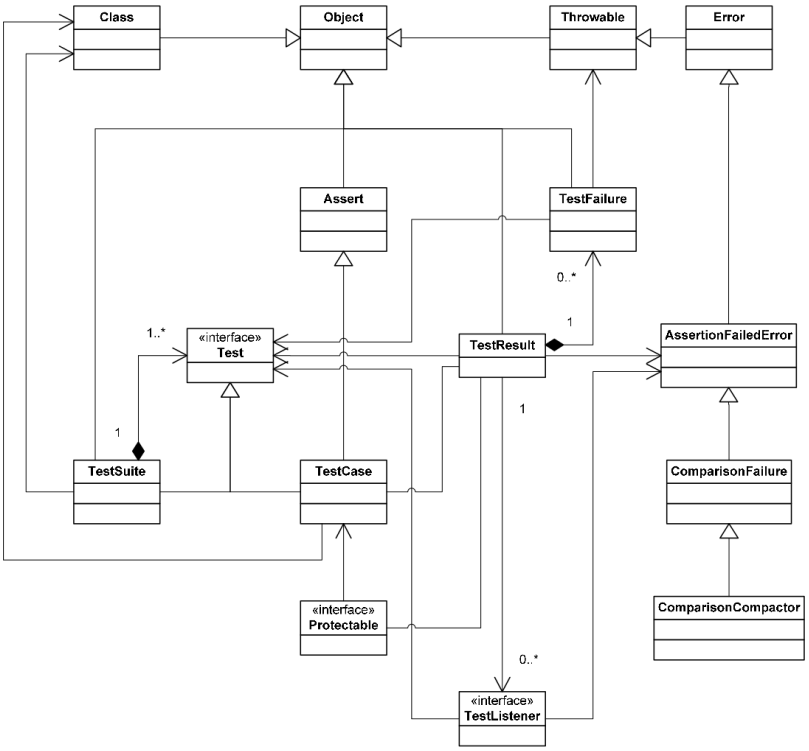


Figure 8-5: Role diagram of the Composite pattern

Design Pattern Composition [R11]




Class
Object
Throwable
Error
Assert
TestFailure
0..*
1..*
«interface»
Test
TestResult
1
AssertionFailedError
1
1
TestSuite
TestCase
ComparisonFailure
«interface»
Protectable
ComparisonCompactor
0..*
«interface»
TestListener

Review / Summary of Session

- Collaboration-based design
  - Definitions, constituents
  - In design and programming
- Design patterns, templates, models
- Composition of models

Thank you! Questions?

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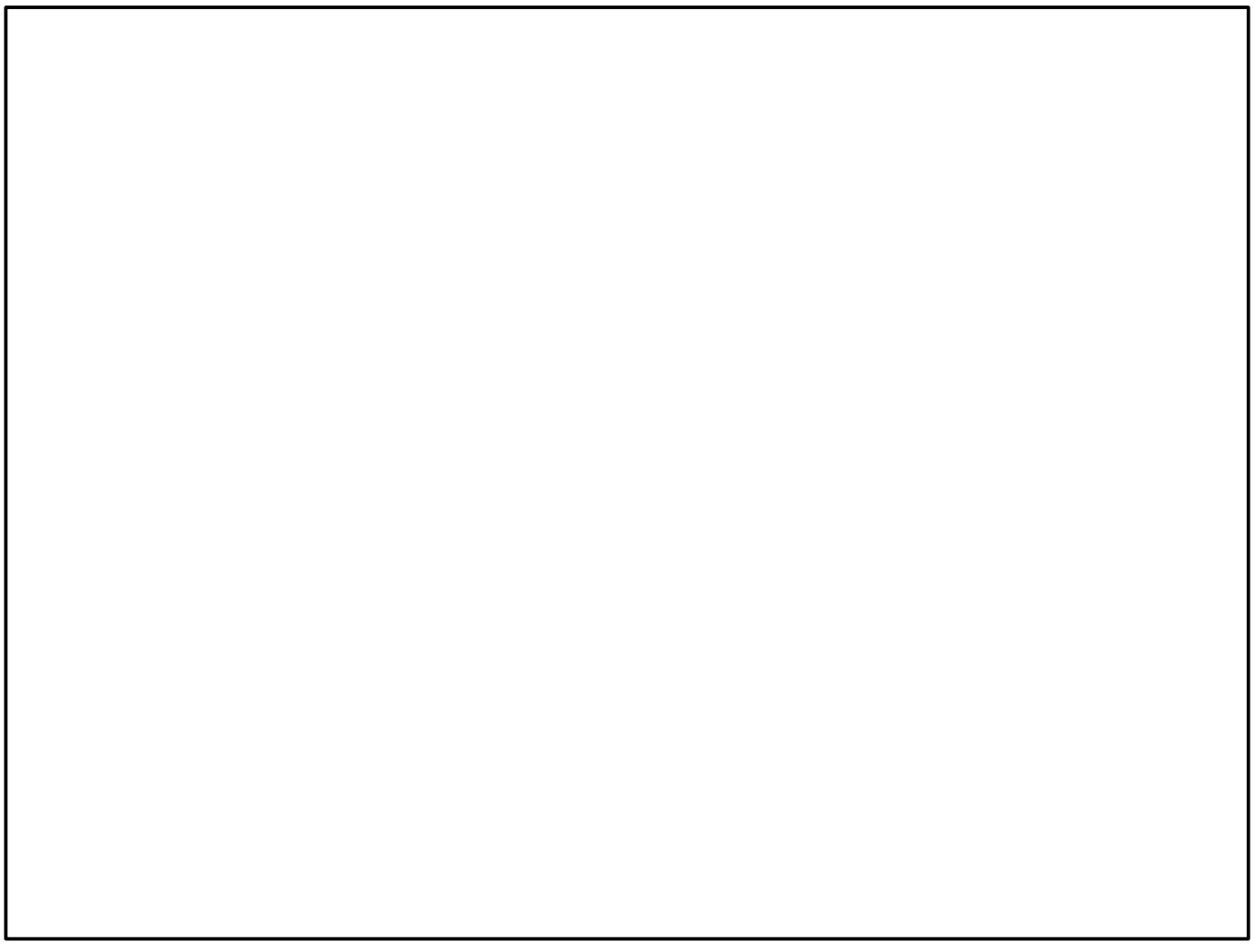
DR



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