Modeling Objects and Classes

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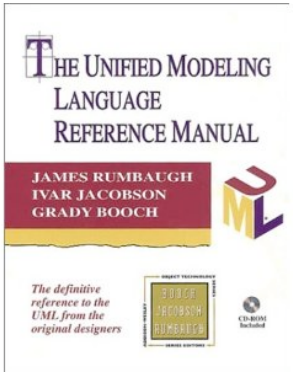
Roadmap

1. UML Overview
2. Classes, attributes and operations
3. UML Lines and Arrows
4. Parameterized Classes, Interfaces and Utilities
5. Objects, Associations
6. Inheritance
7. Patterns, Constraints and Contracts

Sources

The Unified Modeling Language Reference Manual

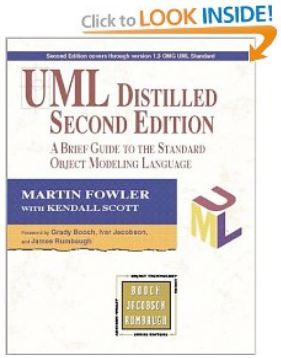
James Rumbaugh, Ivar Jacobson and Grady Booch, Addison Wesley, 1999



UML Distilled

Martin Fowler, Kendall Scott, Addison- Wesley,

Second Edition, 2000



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UML

What is UML?

uniform notation: Booch + OMT + Use Cases (+ state charts)

UML is not a method or process

... The *Unified Development Process* is

Why a Graphical Modeling Language?

Software projects are carried out in team

Team members need to communicate

“One picture conveys a thousand words”

... But which words?

Why UML?

Reduces risks by documenting assumptions

domain models, requirements, architectures, design implementation

Represents industry standard

more tool support, more people understand your diagrams, less education

Is reasonably well-defined

... although there are interpretations and dialects

Why UML?

Is open

- stereotypes, tags and constraints to extend basic constructs
- has a meta-meta-model for advanced extensions

UML history

1994: Grady Booch (Booch method) + James Rumbaugh (OMT) at Rational

1994: Ivar Jacobson (OOSE, use cases) joined Rational

> "The three amigos"

1996: Rational formed a consortium to support UML

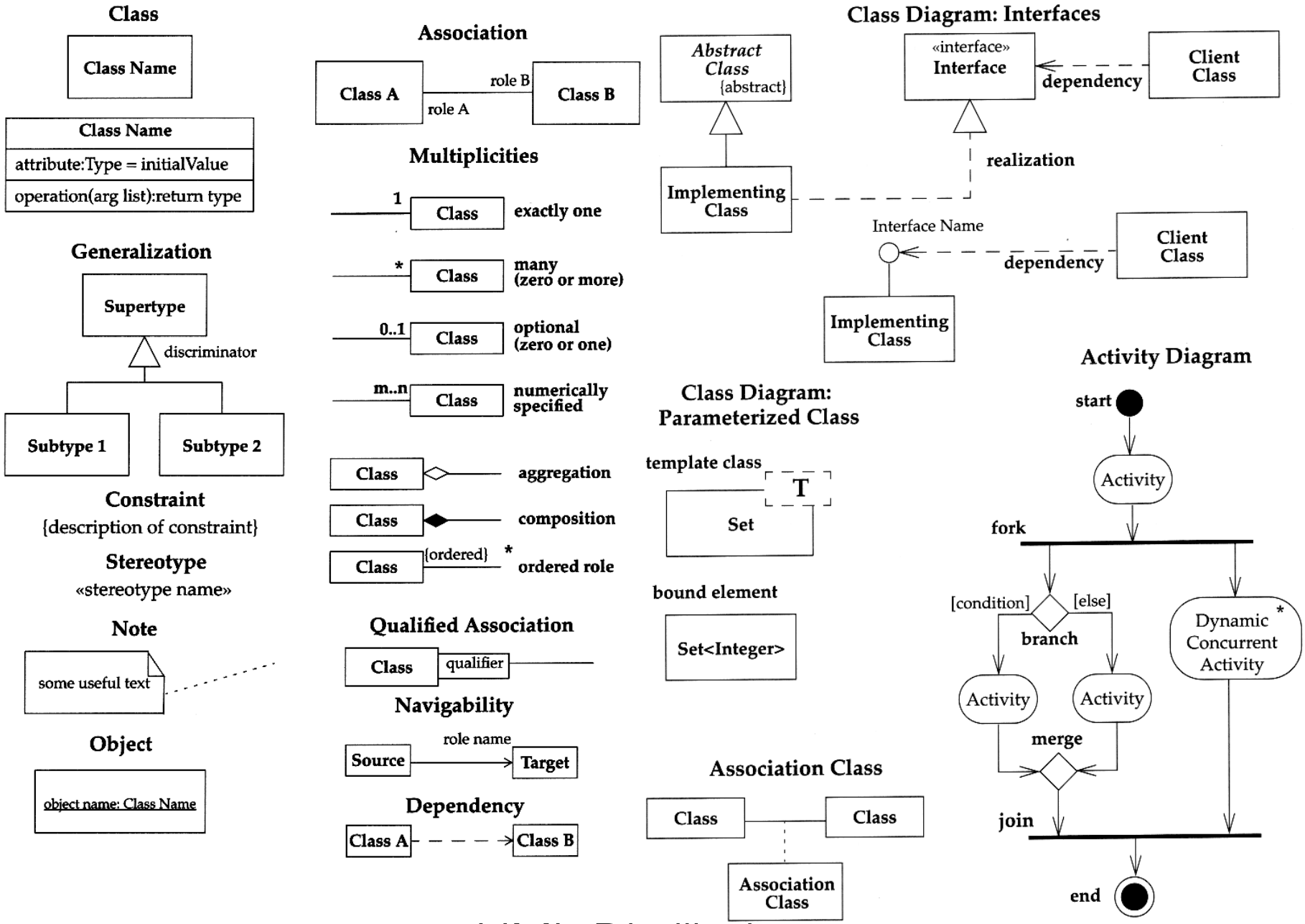
1997: UML 1.0 submitted to OMG by consortium

1997: UML 1.1 accepted as OMG standard

UML history

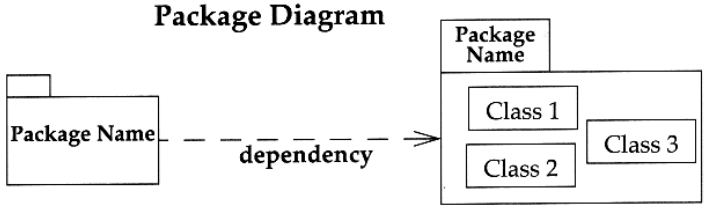
1998- ... : Revisions UML 1.2-1.5

2005: Major revision to UML2.0, includes OCL

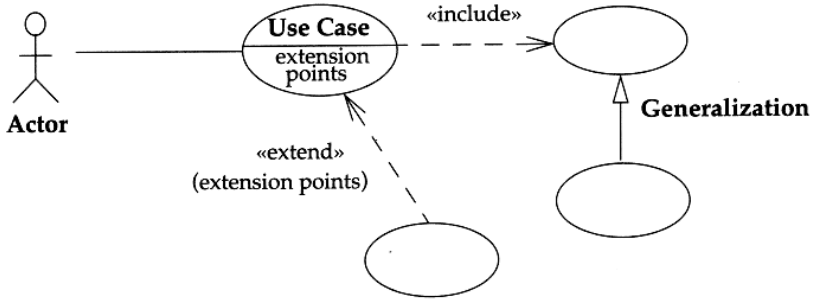


UML Distilled

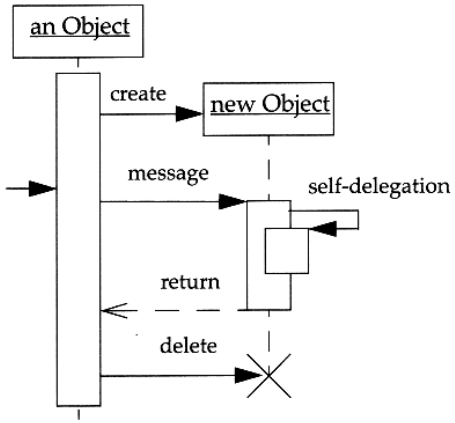
Package Diagram



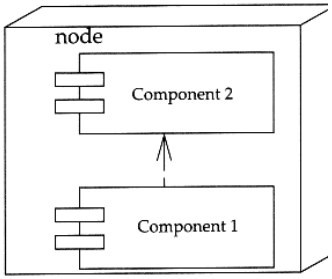
Use Case Diagram



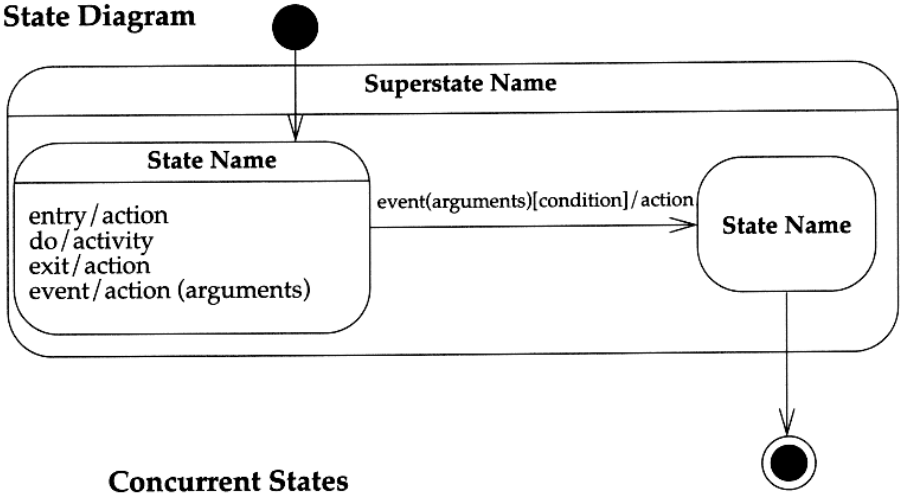
Sequence Diagram



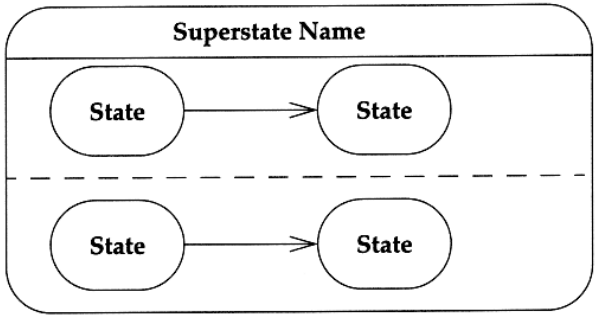
Deployment Diagram



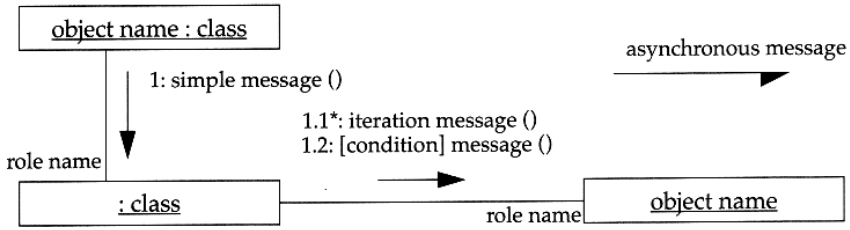
State Diagram



Concurrent States



Collaboration Diagram



Roadmap

1. UML Overview
2. **Classes, attributes and operations**
3. UML Lines and Arrows
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Class Diagrams

"Class diagrams show generic descriptions of possible systems, and object diagrams show particular instantiations of systems and their behaviour."

Attributes and operations are also collectively called *features*.

Danger: *class diagrams risk turning into data models.*
Be sure to focus on behaviour

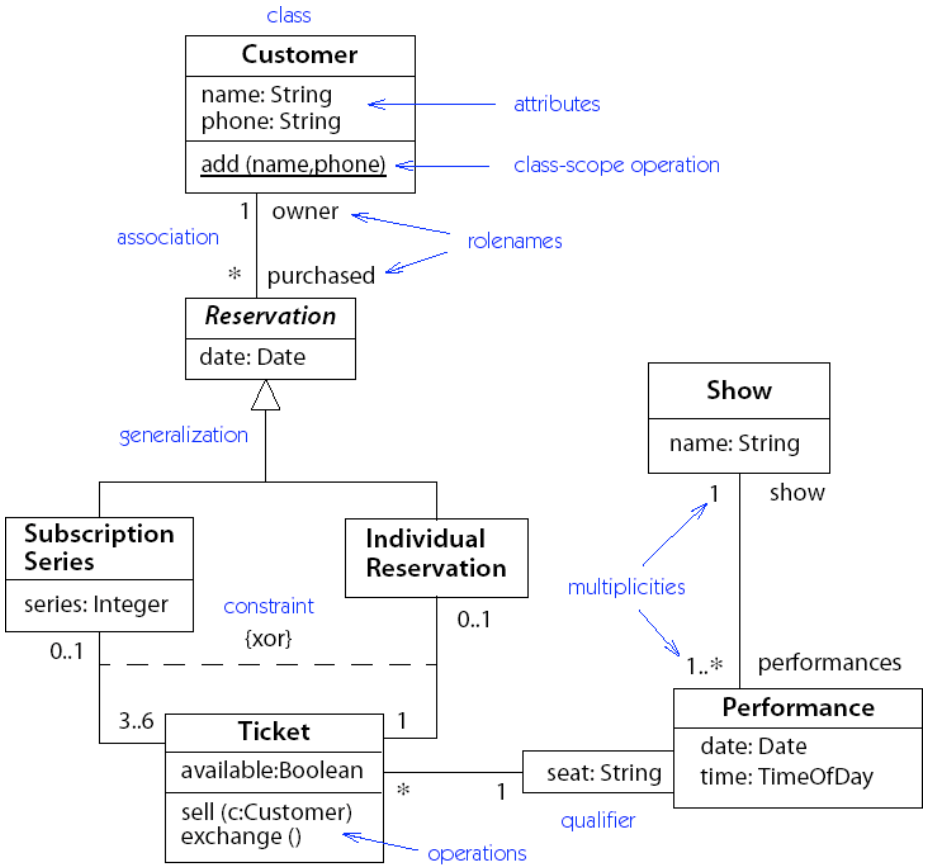
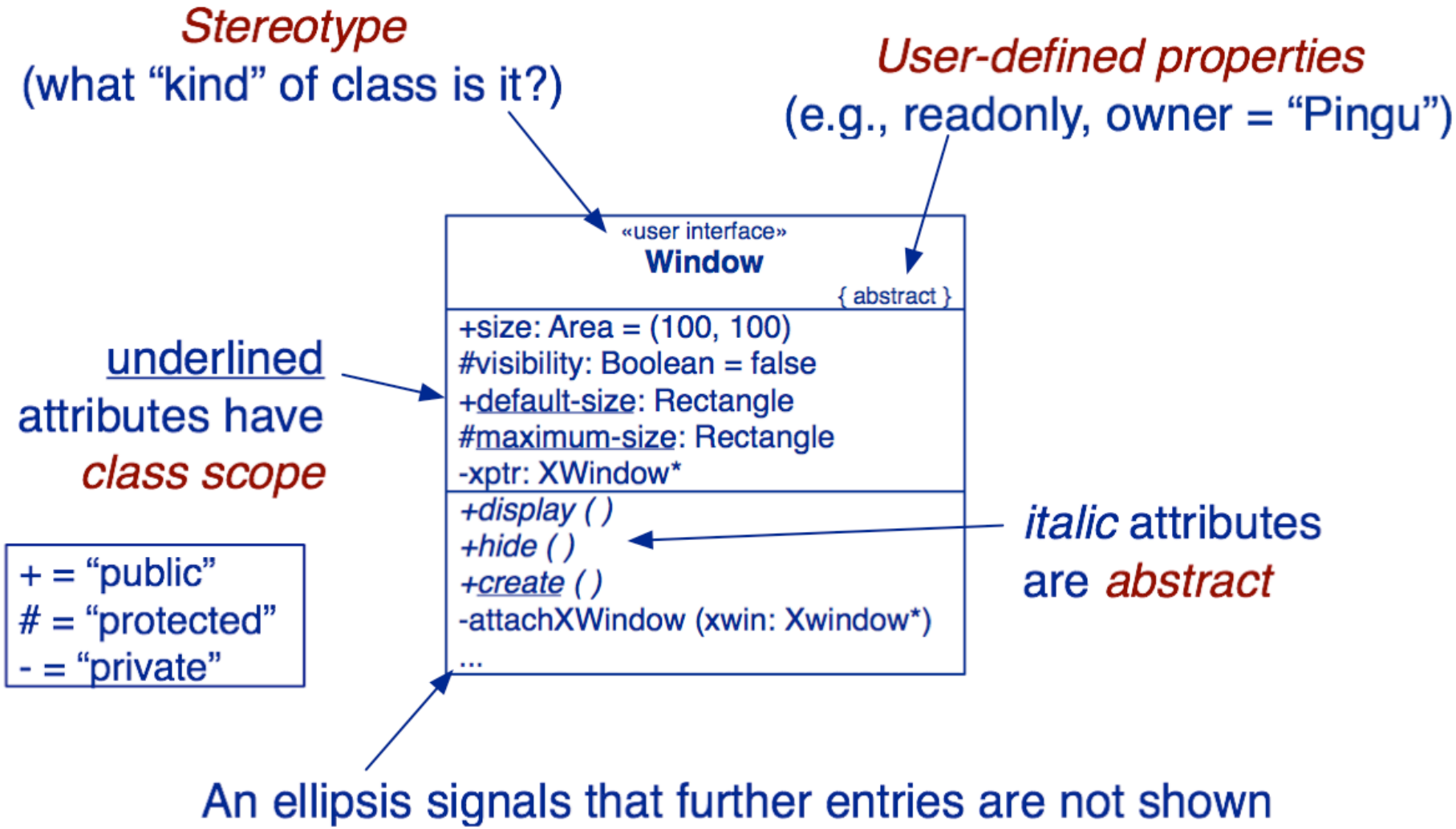


Figure 3-1. *Class diagram*

Visibility and Scope of Features



Attributes and Operations

Attributes are specified as:

name: type = initialValue { property string }

Operations are specified as:

name (param: type = defaultValue, ...) : resultType

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UML Lines and Arrows

Constraint
(usually annotated)

Association
e.g., «uses»

Dependency
e.g., «requires»,
«imports» ...

Navigable
association
e.g., part-of

Realization
e.g., class/template,
class/interface

"Generalization"
i.e., specialization (!)
e.g., class/superclass,
concrete/abstract class

Aggregation
i.e., "consists of"

"Composition"
i.e., containment

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Parameterized Classes

Parameterized (aka “template” or “generic”) classes are depicted with their parameters shown in a *dashed box*.

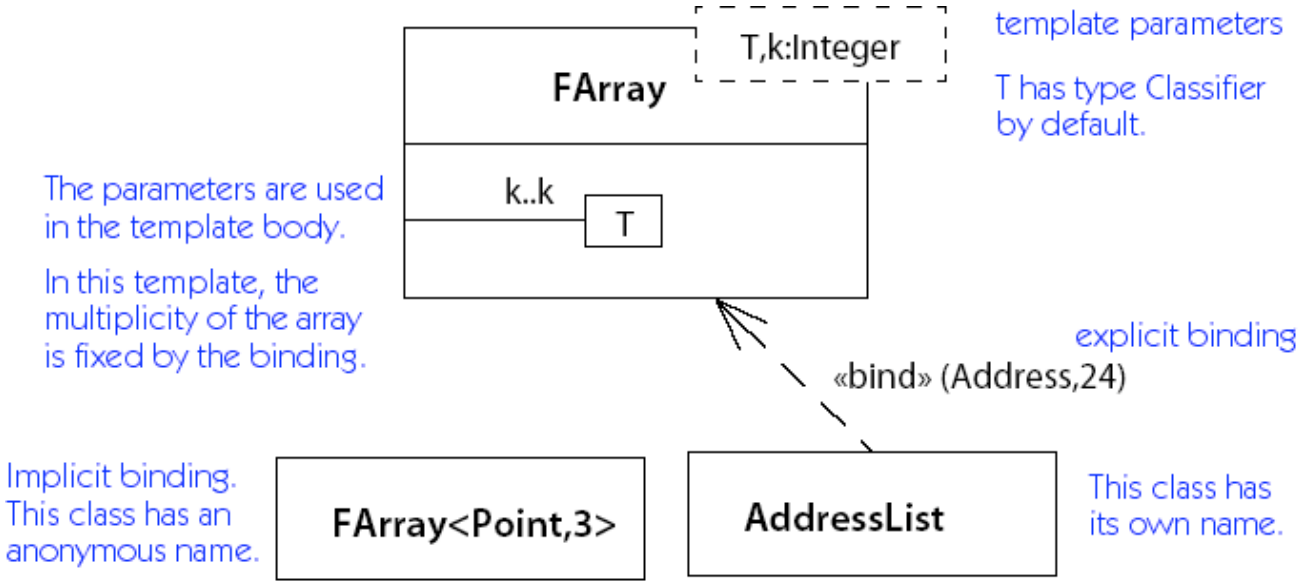


Figure 13-180. *Template notation with use of parameter as a reference*

Interfaces

Interfaces, equivalent to abstract classes with no attributes, are represented as classes with the stereotype «interface» or, alternatively, with the "Lollipop-Notation":

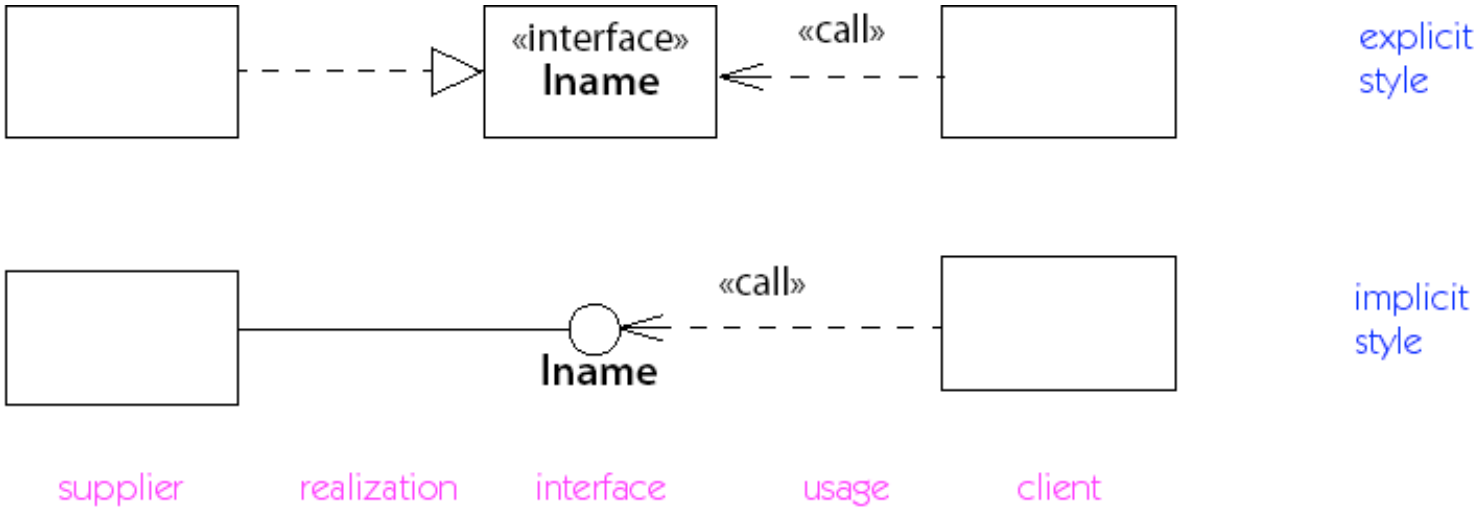
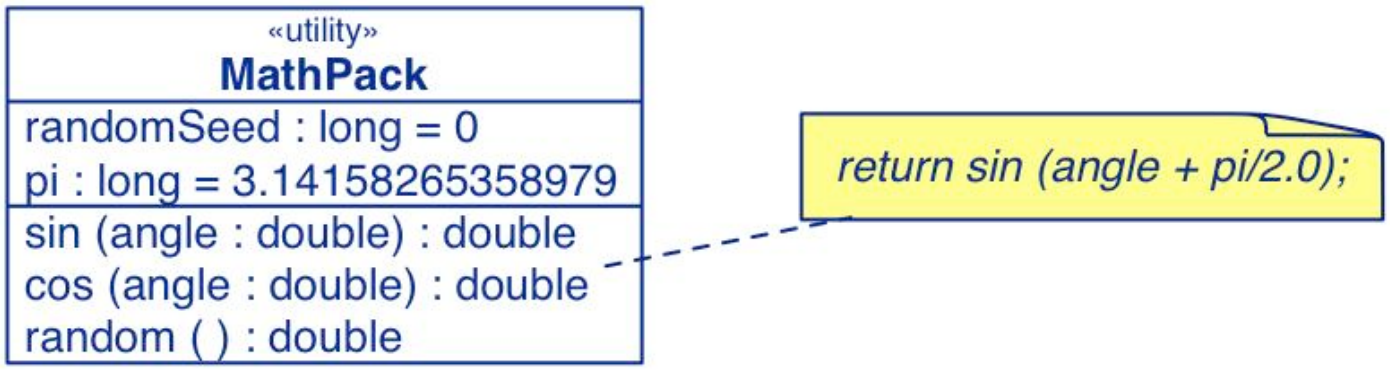


Figure B-5. *Realization of an interface*

Utilities

A utility is a grouping of global attributes and operations. It is represented as a class with the stereotype «utility». Utilities may be parameterized.



Utilities

NB: A utility's attributes are already interpreted as being in class scope, so it is redundant to underline them.

A "note" is a text comment associated with a view, and represented as box with the top right corner folded over.

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Objects

Objects are shown as rectangles with their name and type underlined in one compartment, and attribute values, optionally, in a second compartment.

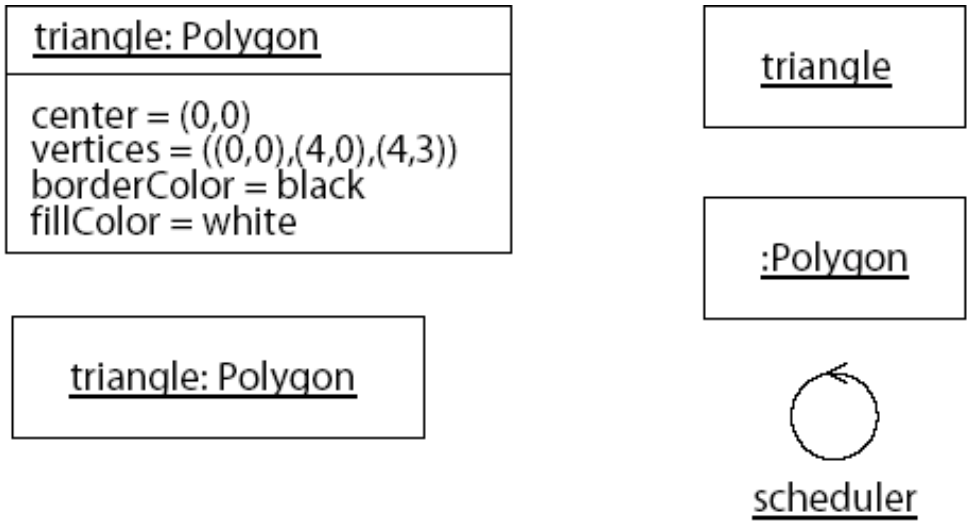


Figure 13-134. *Object notation*

At least one of the name or the type must be present.

Associations

Associations represent *structural relationships* between objects

- usually binary (but may be ternary etc.)
- optional name and direction
- (unique) role names and multiplicities at end-points

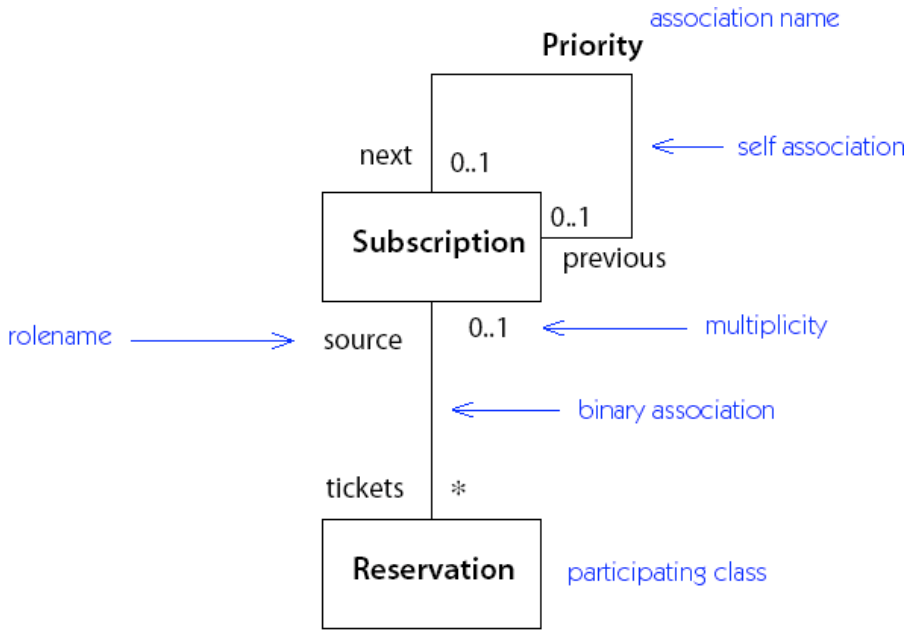


Figure 4-2. *Association notation*

Multiplicity

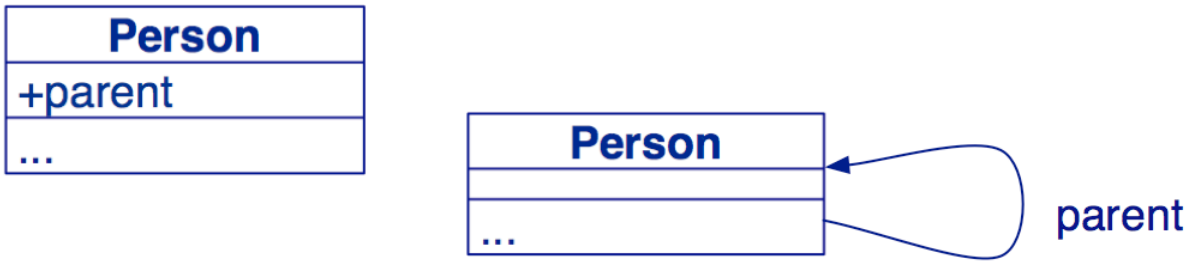
The multiplicity of an association constrains how many entities one may be associated with

0..1	Zero or one entity
1	Exactly one entity
*	Any number of entities
1..*	One or more entities
1..n	One to n entities
	And so on …

Associations and Attributes

Associations may be implemented as attributes

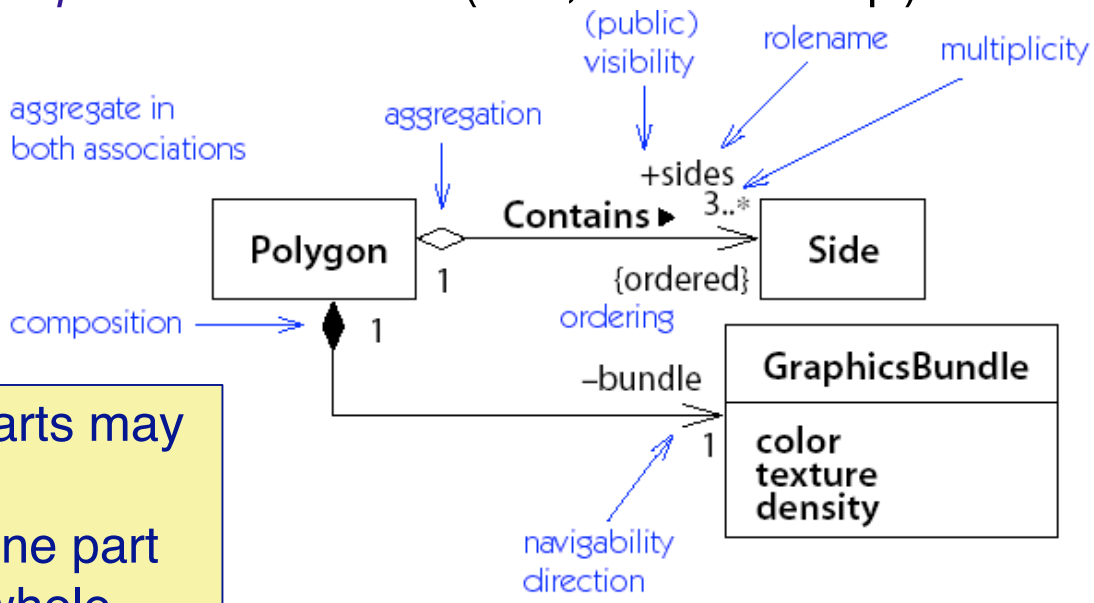
But need not be …



Aggregation and Composition

Aggregation is denoted by a *diamond* and indicates a *part-whole dependency*:

A *hollow diamond* indicates a *reference*; a *solid diamond* an *implementation* (i.e., ownership).



Aggregation: parts may be shared.
Composition: one part belongs to one whole.

Figure 13-29. *Various adornments on association ends*

Association Classes

An association may be an instance of an association class:

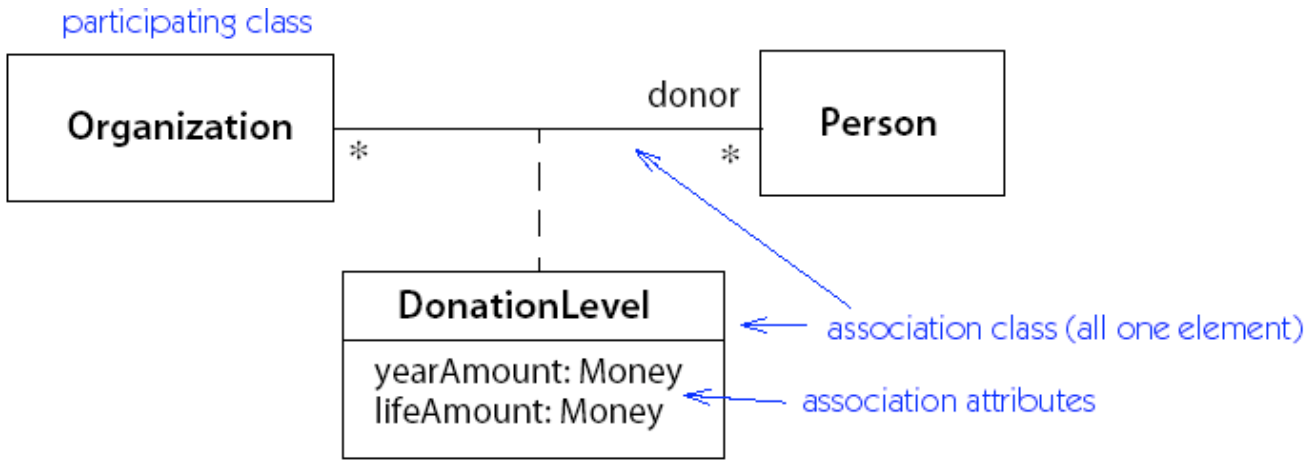


Figure 4-3. *Association class*

In many cases the association class only stores attributes, and its name can be left out.

Qualified Associations

A qualified association uses a special *qualifier value* to identify the object at the other end of the association.

NB: Qualifiers are part of the association, not the class

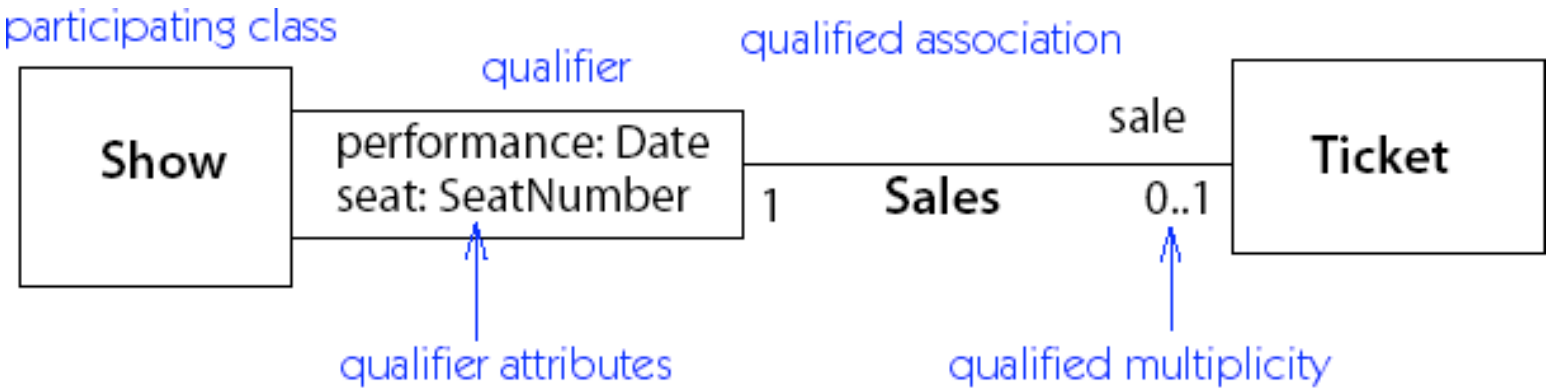


Figure 4-4. *Qualified association*

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Generalization

A subclass specializes its superclass:

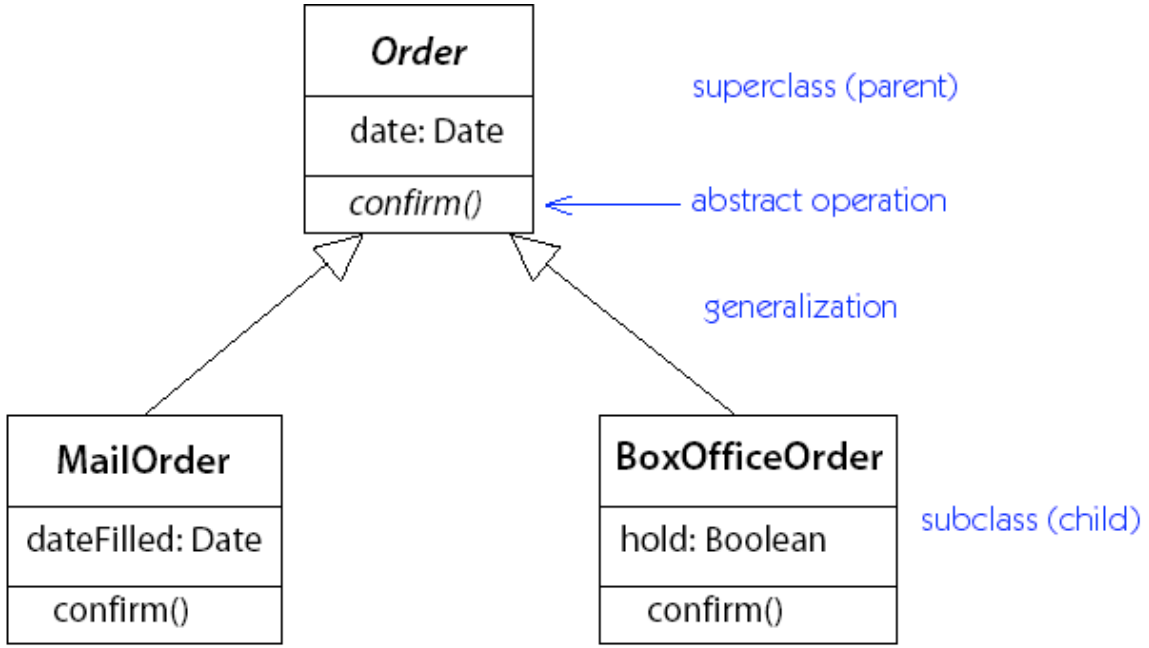


Figure 4-7. *Generalization notation*

What is Inheritance For?

New software often builds on old software by *imitation*, *refinement* or *combination*

Similarly, classes may be *extensions*, *specializations* or *combinations* of existing classes

Generalization expresses ...

Conceptual hierarchy

conceptually related classes can be organized into a specialization hierarchy

people, employees, managers

geometric objects ...

Polymorphism

objects of distinct, but related classes may be uniformly treated by clients

array of geometric objects

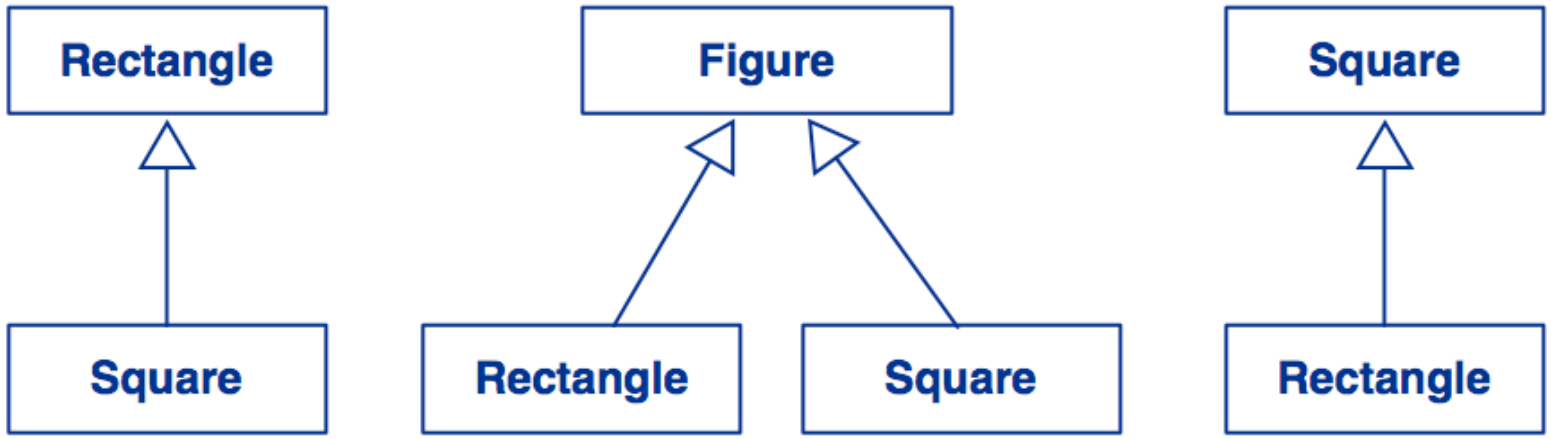
Generalization expresses ...

Software reuse

related classes may share interfaces, data structures or behaviour

geometric objects ...

The different faces of inheritance



Is-a ***Polymorphism*** ***Reuse***

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Design Patterns as Collaborations

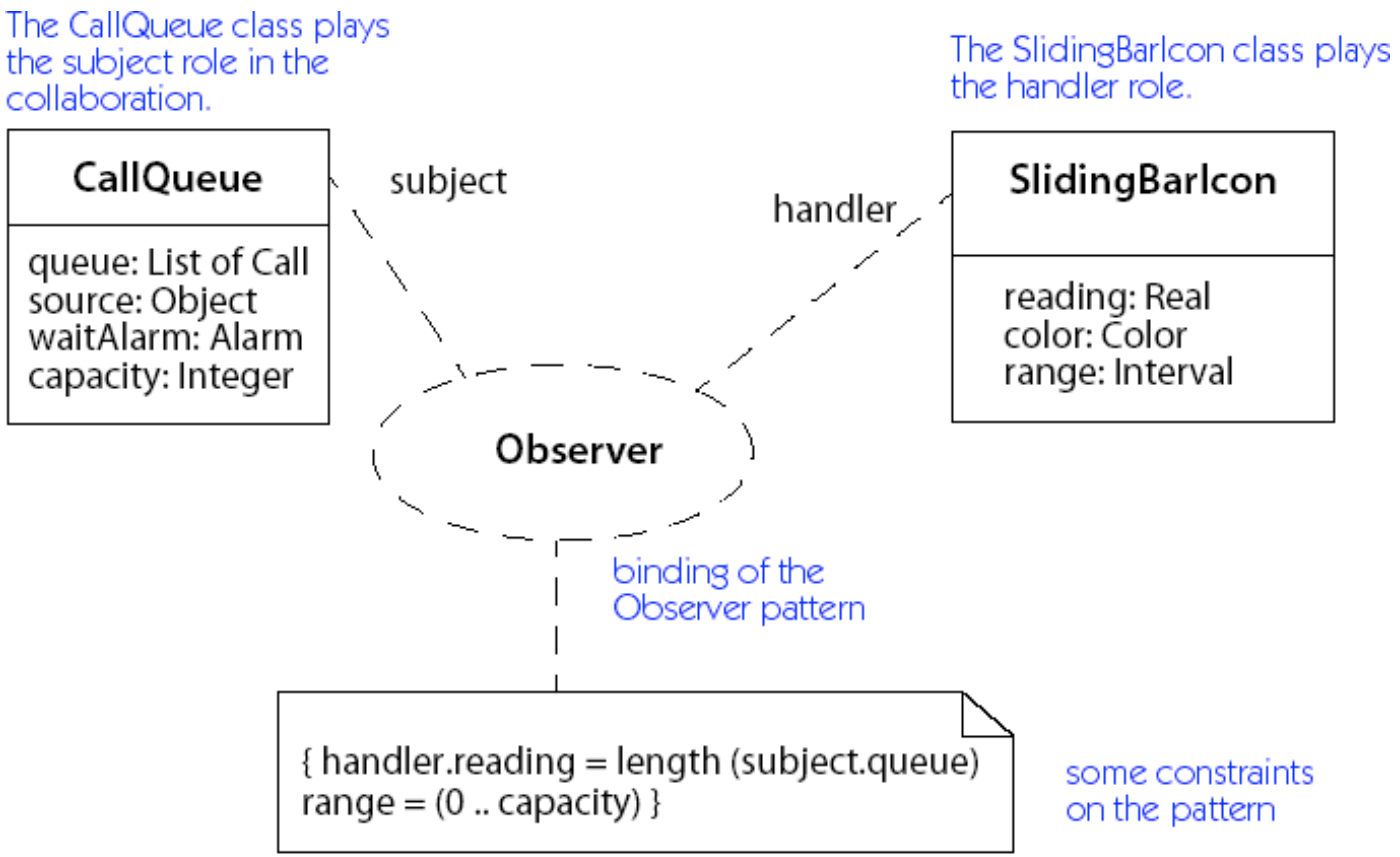

Figure 13-144. *Binding of a pattern to make a collaboration*

Constraints

Constraints are *restrictions* on values attached to classes or associations

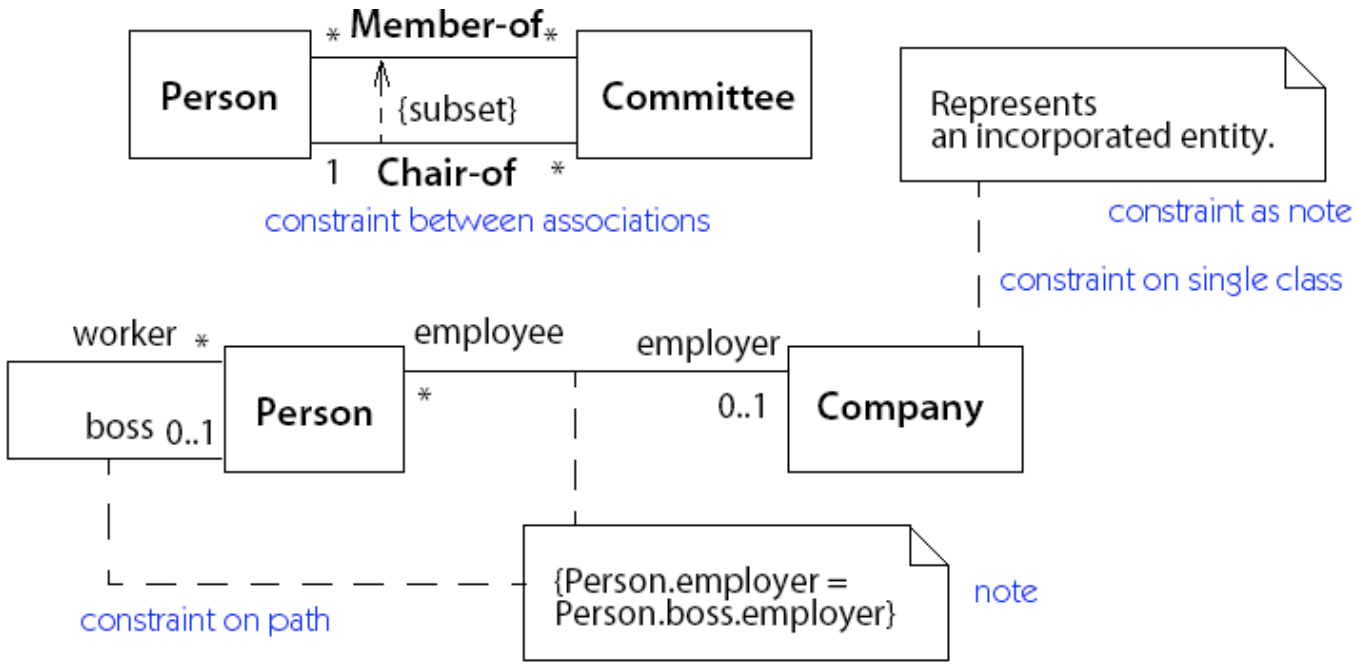

Figure 4-12. *Constraints*

OCL - Object Constraint Language

Used to express queries and constraints over UML diagrams

Navigate associations:

Person.boss.employer

Select subsets:

Company.employee->select(title="Manager")

Boolean and arithmetic operators:

Person.salary < Person.boss.salary

Design by Contract in UML

Combine constraints with stereotypes:

NB: «invariant», «precondition», and «postcondition» are predefined in UML.

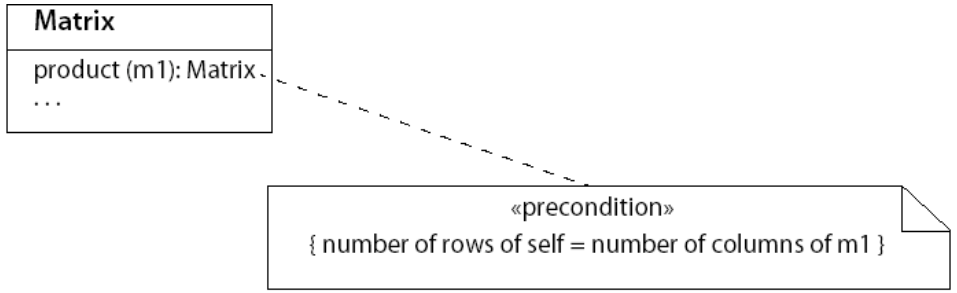

Figure 13-147. *Precondition*

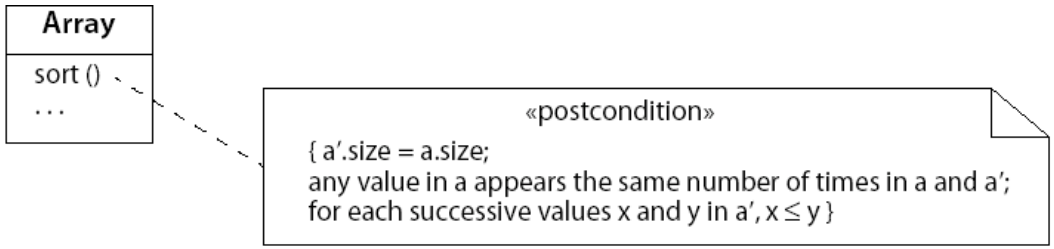

Figure 13-145. *Postcondition*

Using the Notation

During Analysis

- Capture classes visible to *users*
- Document *attributes and responsibilities*
- Identify *associations and collaborations*
- Identify *conceptual hierarchies*
- Capture all *visible features*

The graphical notation is only one part of the analysis or design document. For example, a data dictionary cataloguing and describing all names of classes, roles, associations, etc. must be maintained throughout the project.

During Design

- Specify *contracts and operations*
- *Decompose* complex objects
- Factor out *common interfaces* and functionalities

What you should know!

How do you represent classes, objects and associations?

How do you specify the visibility of attributes and operations to clients?

How is a utility different from a class? How is it similar?

Why do we need both named associations and roles?

Why is inheritance useful in analysis? In design?

How are constraints specified?

Can you answer the following questions?

Why would you want a feature to have class scope?

Why don't you need to show operations when depicting an object?

Why aren't associations drawn with arrowheads?

How is aggregation different from any other kind of association?

How are associations realized in an implementation language?

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