UML: Part I

(Based on [Booch *et al.* 2005])

Yih-Kuen Tsay

Dept. of Information Management

National Taiwan University

Outline

- Introduction
- Basics of Modeling
- Overview of the UML
- Structural Modeling
- Behavioral Modeling

Introduction: History of the UML

- The UML---Unified Modeling Language, is a standard graphical language for "drawing a system's blueprints"
- It was initially the result of an effort in unifying the Booch, OOSE, and OMT methods
- Most major software companies eventually got involved, resulting in UML 1.1 (1997)
- Its maintenance was then taken over by OMG
- The previous version was UML 1.5
- Adoption of the current version UML 2.0 was completed in 2005

Intro.: What the UML Is For

- For "drawing a system's blueprints"
- More specifically, for
  - Visualizing
  - Specifying
  - Constructing
  - Documenting

  object-oriented, software-intensive systems.

  (This corresponds to the four aims of modeling.)

Intro.: Whom the UML Is For

- **Analysts and End Users**: specify the (structural and behavioral) requirements
- **Architects**: design systems that meet the requirements
- **Developers**: turn the design into executable code
- Others: quality assurance personnel (e.g., testers), technical writers, librarians, project managers, …

All roles in software development should know something about the UML.

Importance of Modeling

- Mind the scale:
  - dog house
  - family house
  - office building
- The use of modeling is a common thread of successful software projects
- In fact, modeling can be found in every discipline/profession

Basics of Modeling

- What is a model?
  - simplification of reality
  - blueprints of a system: structural or behavioral
- Why do we model?
  - To better understand the system under development
  - To focus on one aspect at a time (it is not possible to comprehend a complex system in its entirety, so divide and conquer …)

Four Aims of Modeling

- To visualize a system
- To specify its structure and/or behavior
- To provide a guiding template for construction
- To document the decisions made

More Tips

- Use a common language
- Do modeling now, before it is too late
    - Things may get more complex than expected

Principles of Modeling

- Models influence the solutions (so, choose your models well)
- Different levels of precision may be expressed
- Good models are connected to reality
- No single model is sufficient; multiple models/views are needed

Five Views of an Architecture

The four aims of modeling demand the system be viewed from different perspectives:

- Use case view: exposing the requirements
- Design view: capturing the vocabulary of the problem/solution space
- Process view: processes and threads
- Implementation view: physical realization
- Deployment view: system engineering issues

Object-Oriented Modeling

- The main building blocks of all software systems are objects and classes
- An object is a thing drawn from the vocabulary of the problem/solution space
- Every object has an identity, a number of states, and behavior
- A class defines a set of common objects

Overview of the UML

- Things
- Relationships
- Diagrams

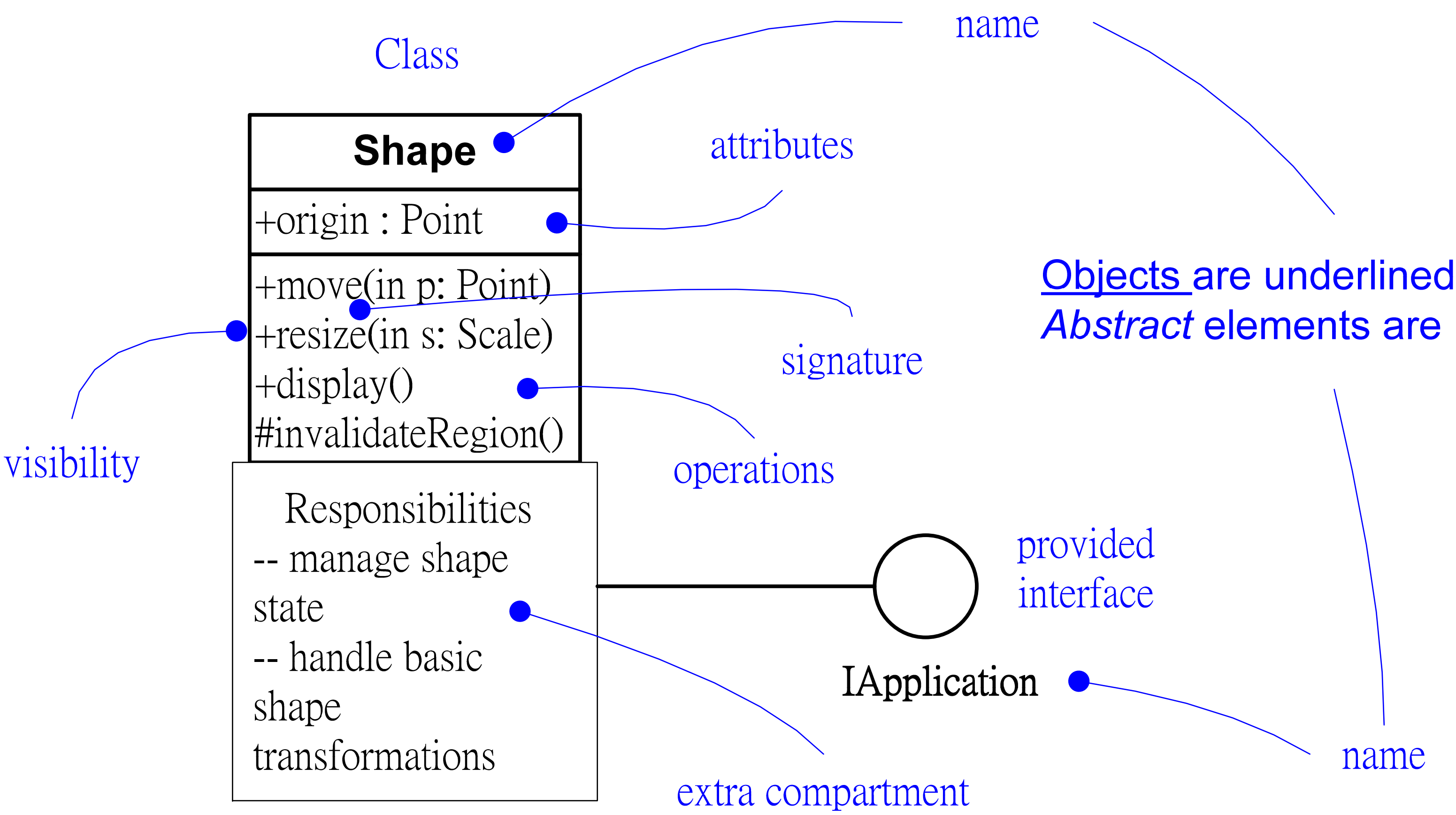
The UML in the Software Development Process

- The UML allows one to express different views of a system and their interactions
- The UML is largely process-independent
- The OMG recommends using the UML with the so-called *Unified Software Development Process*:
  - Characteristics: (1) use case driven; (2) architecture-centric; (3) iterative and incremental
  - Four phases of an iteration: inception, elaboration, construction, transition

Things in the UML

- Structural Things
  - Class, interface, collaboration, use case, active class, component, artifact, node
- Behavioral Things
  - Interaction (messages, action sequences, links)
  - State machine (states, transitions, events)
- Grouping Things: packages
- Annotational Things

Structural Things (I)



Class

Shape

+origin : Point

+move(in p: Point)
+resize(in s: Scale)
+display()
#invalidateRegion()

Responsibilities
-- manage shape state
-- handle basic shape transformations

name

attributes

signature

operations

visibility

extra compartment

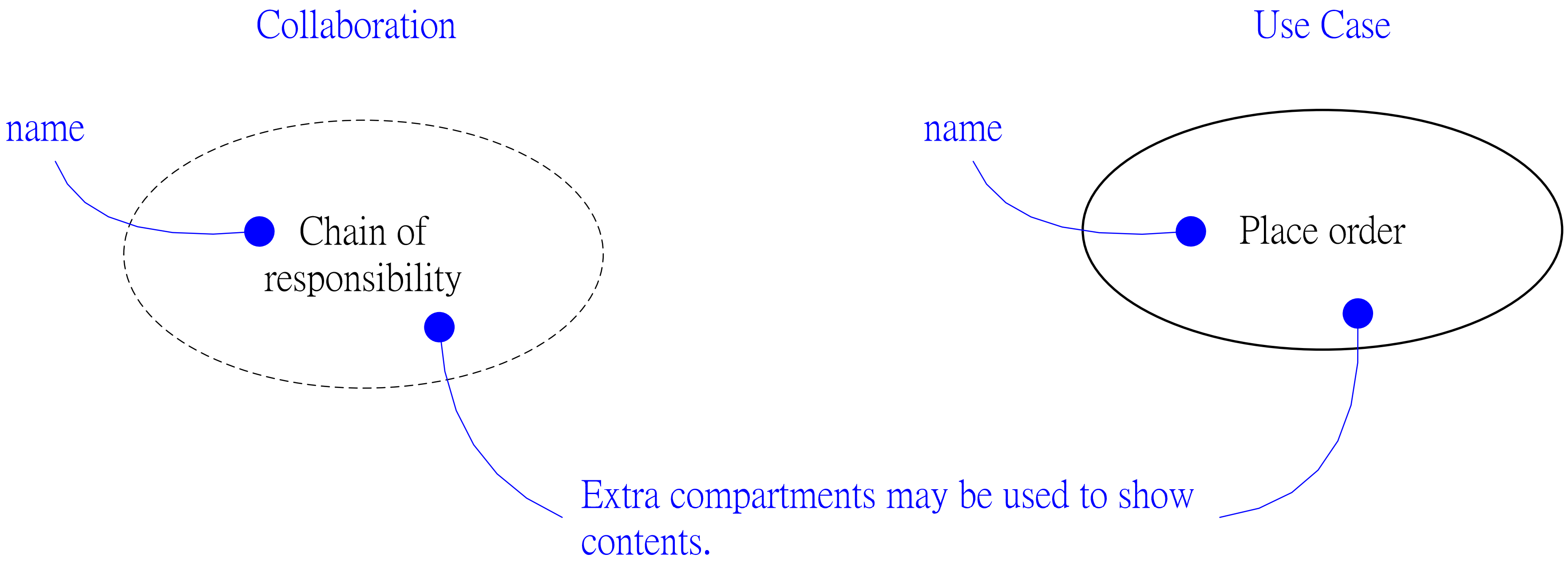
provided interface

IApplication

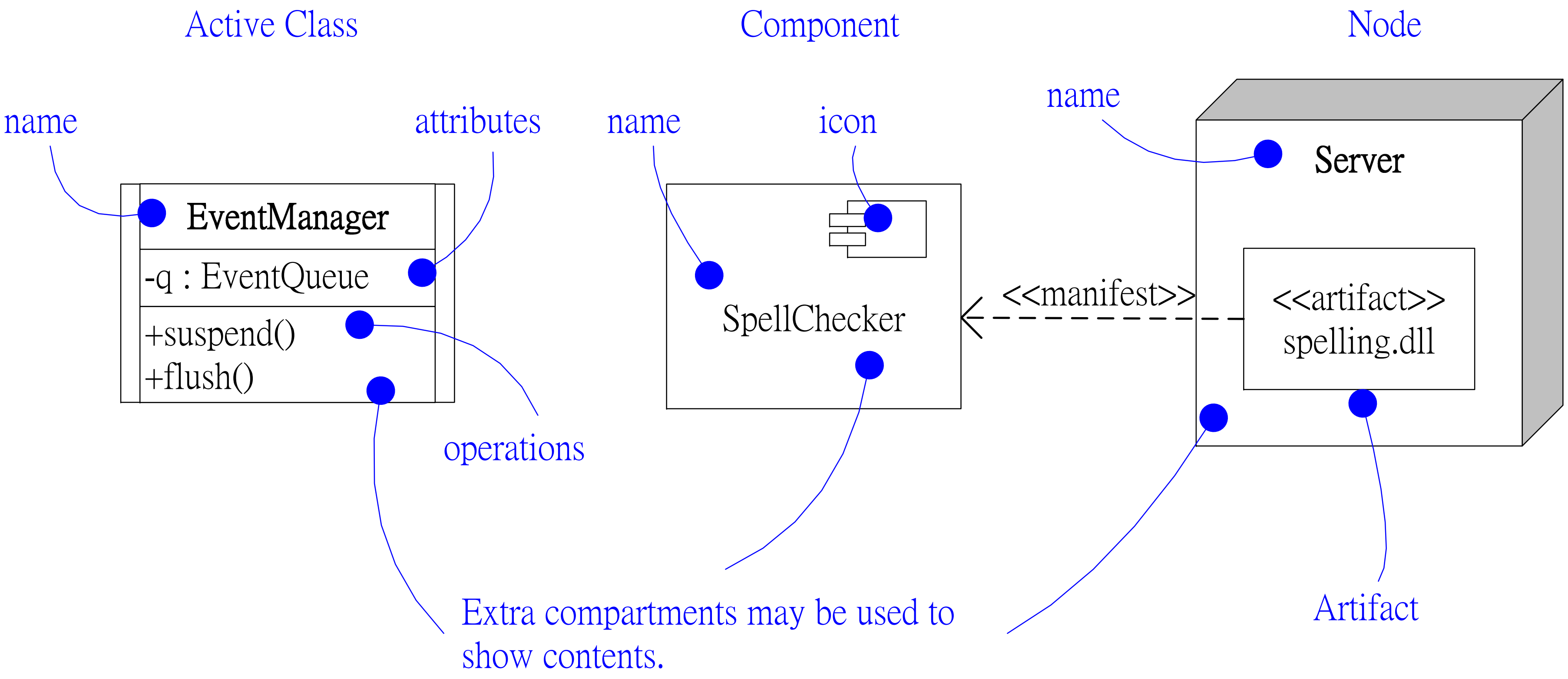
name

Objects are underlined
Abstract elements are in italics

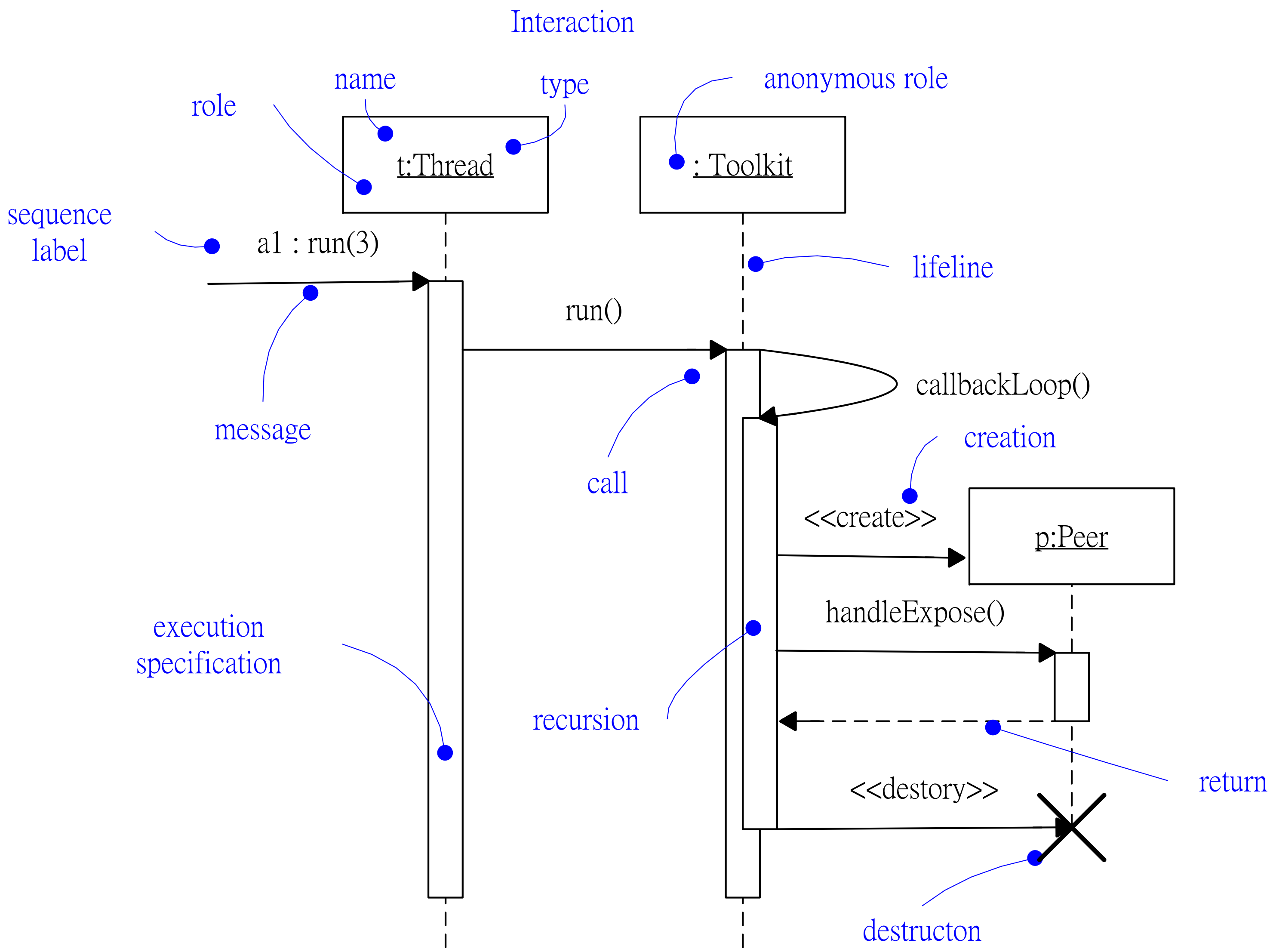
Structural Things (II)



Structural Things (III)

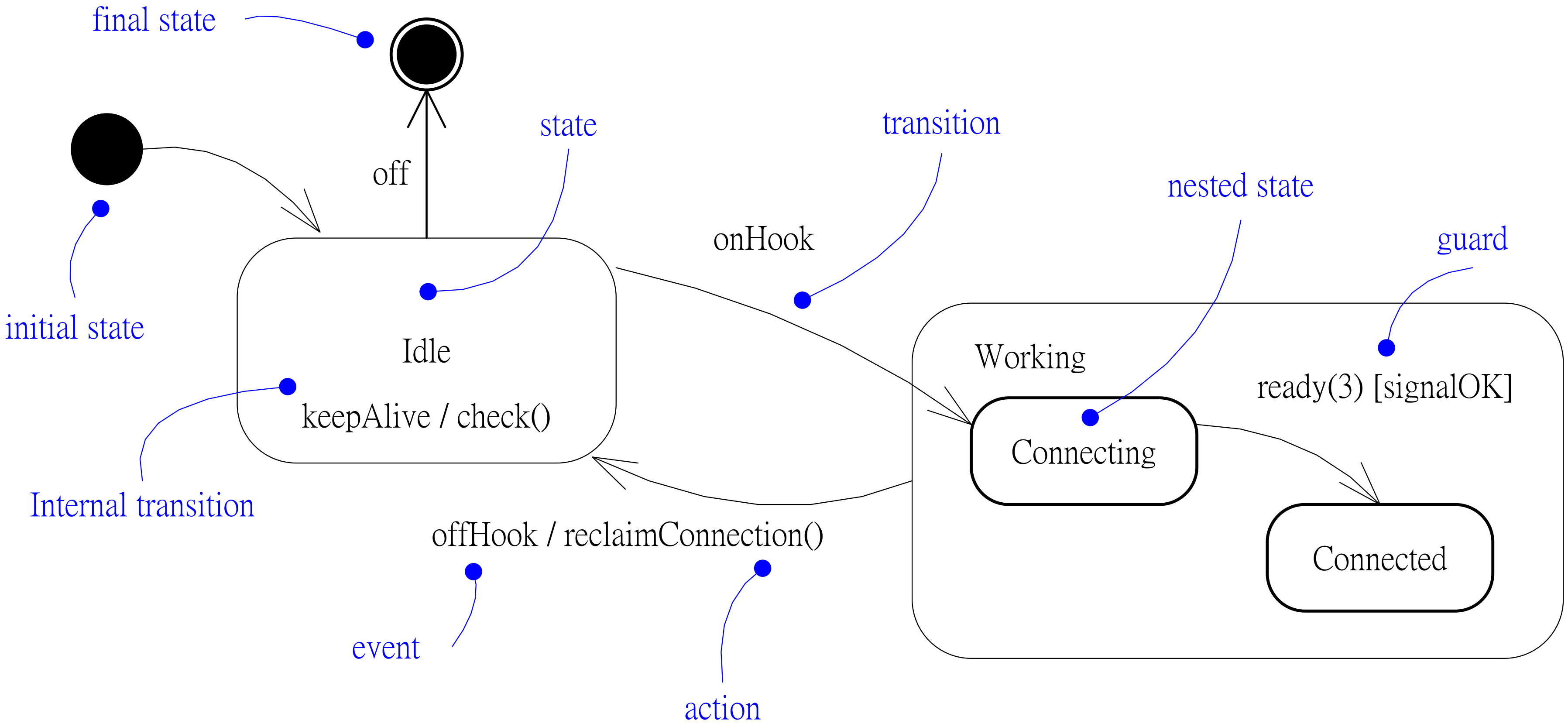


Behavioral Things (I)

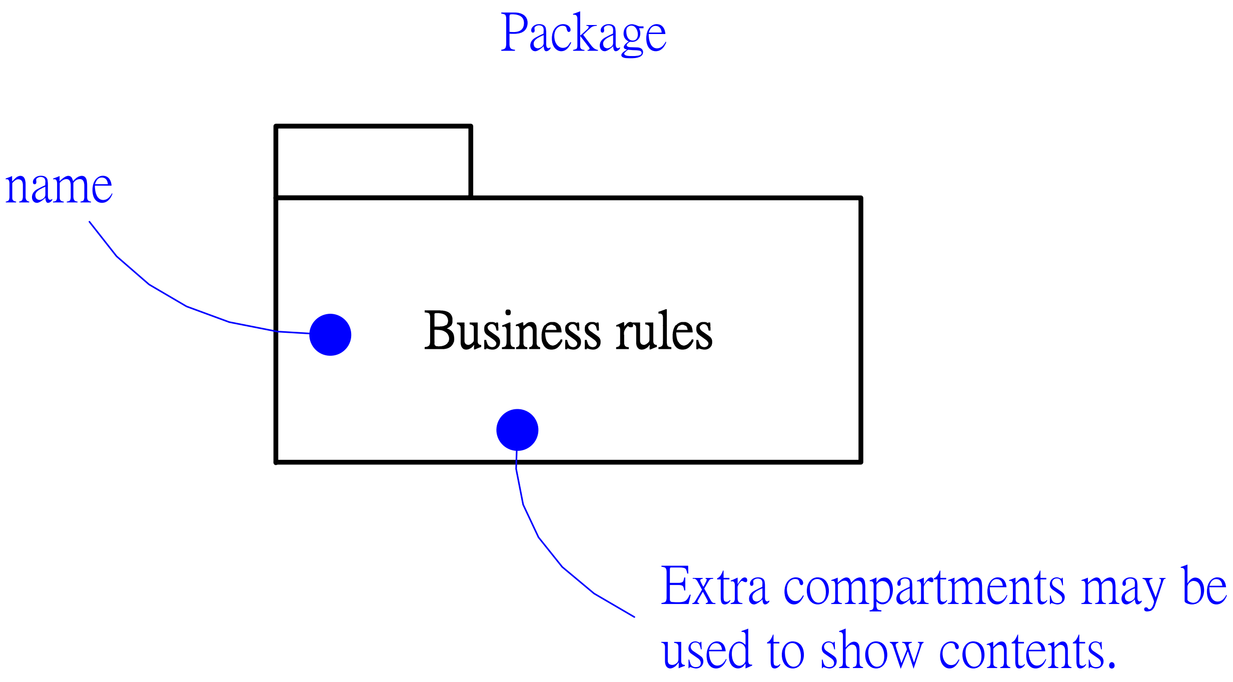


Behavioral Things (II)

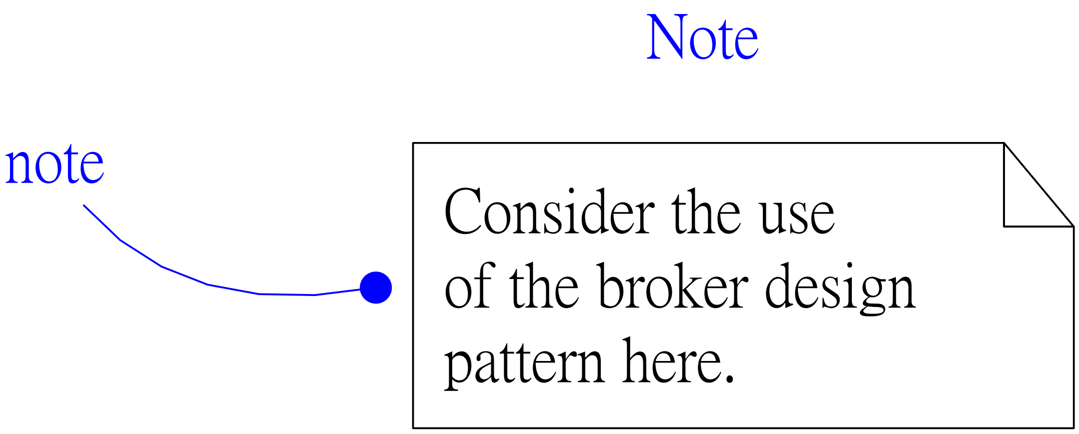
State Machine



Grouping Things



Annotational Things

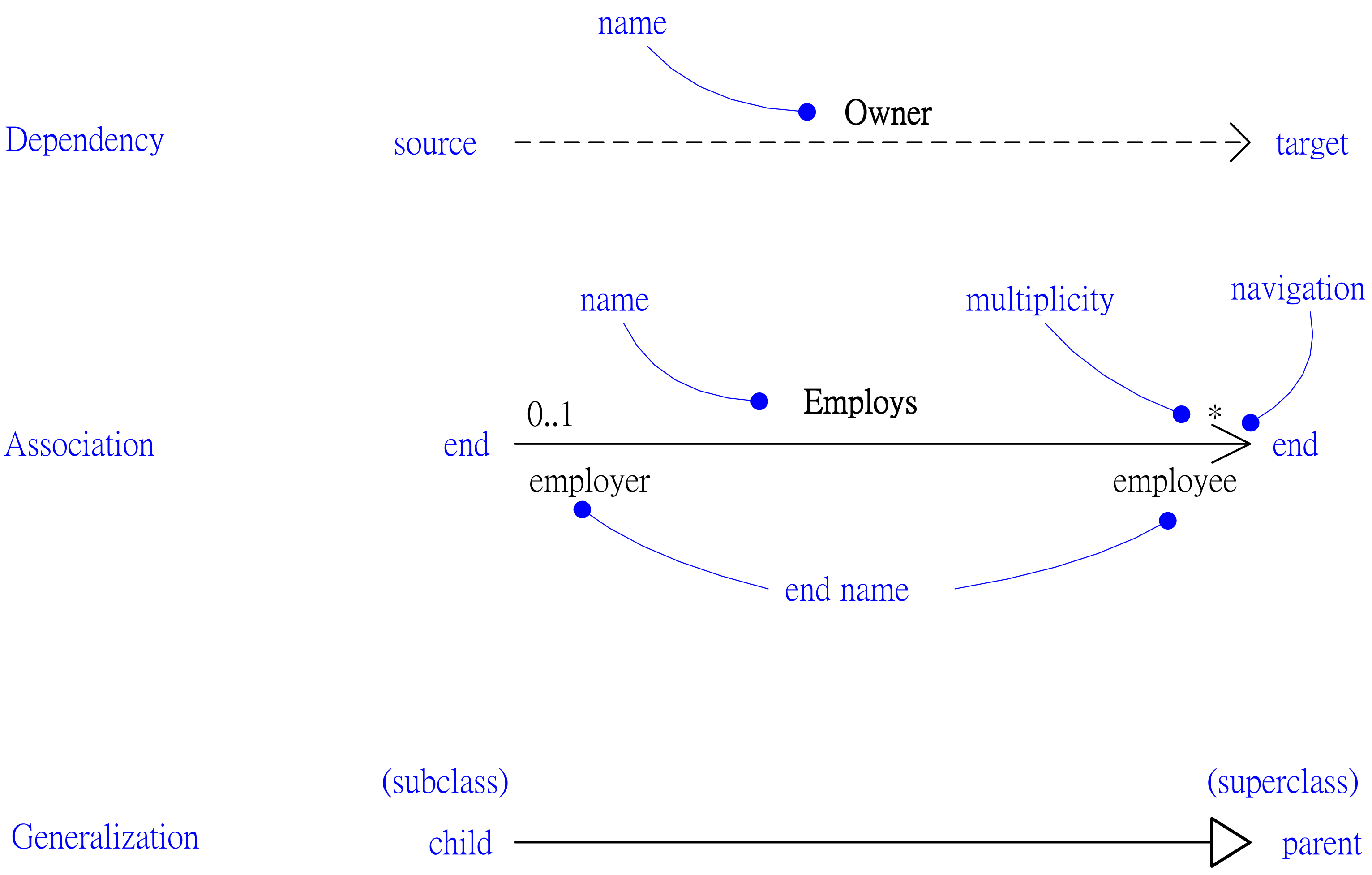


Consider the use of the broker design pattern here.

Relationships in the UML

- Dependency
- Association
- Generalization
- Realization

Relationships



Note: direction of an association should now be indicated by a solid triangle ▸ following the association name.

Diagrams in the UML

- Graphical representations of things and relationships
- Structural and Architectural Diagrams:
  - class diagrams, object diagrams, component diagrams, composite structure diagrams, deployment diagrams (including artifact diagrams), package diagrams
- Behavioral Diagrams:
  - use case diagrams, interaction (sequence and communication) diagrams, state diagrams, activity diagrams, timing diagrams, interaction overview diagrams

Rules of the UML

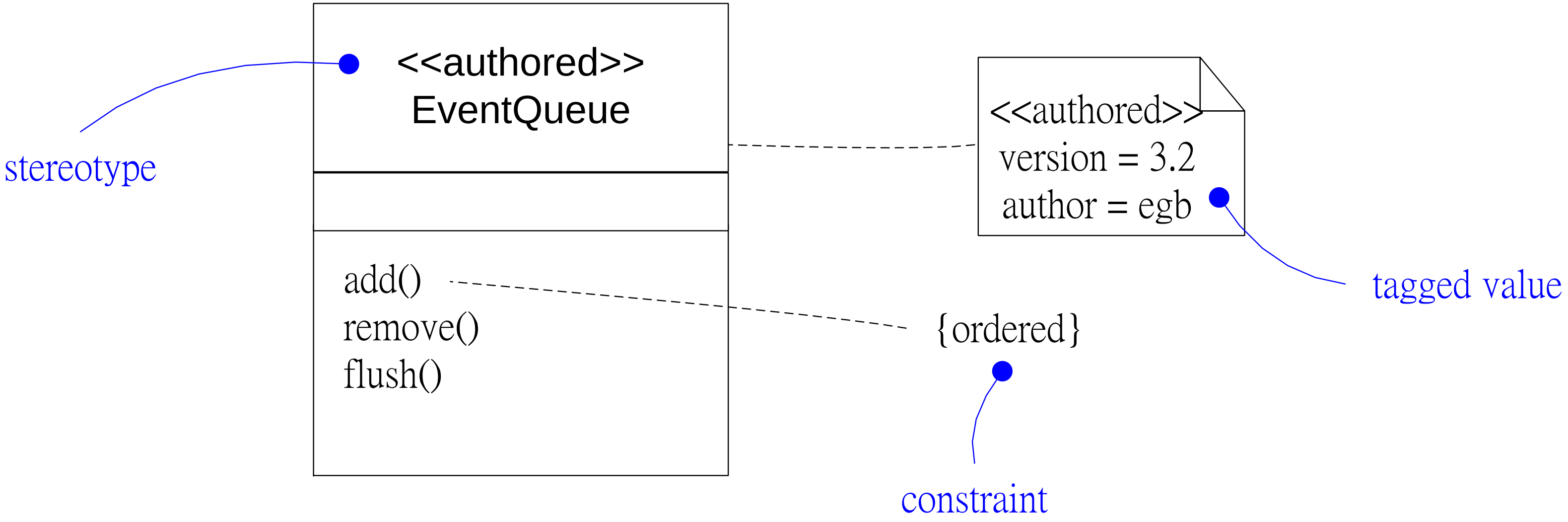
- Well-formed models
  - Self-consistent
  - Following UML rules for

    names, scope, visibility, integrity, execution
- Not well-formed models
  - Elided: some elements hidden
  - Incomplete: some elements missing
  - Inconsistent

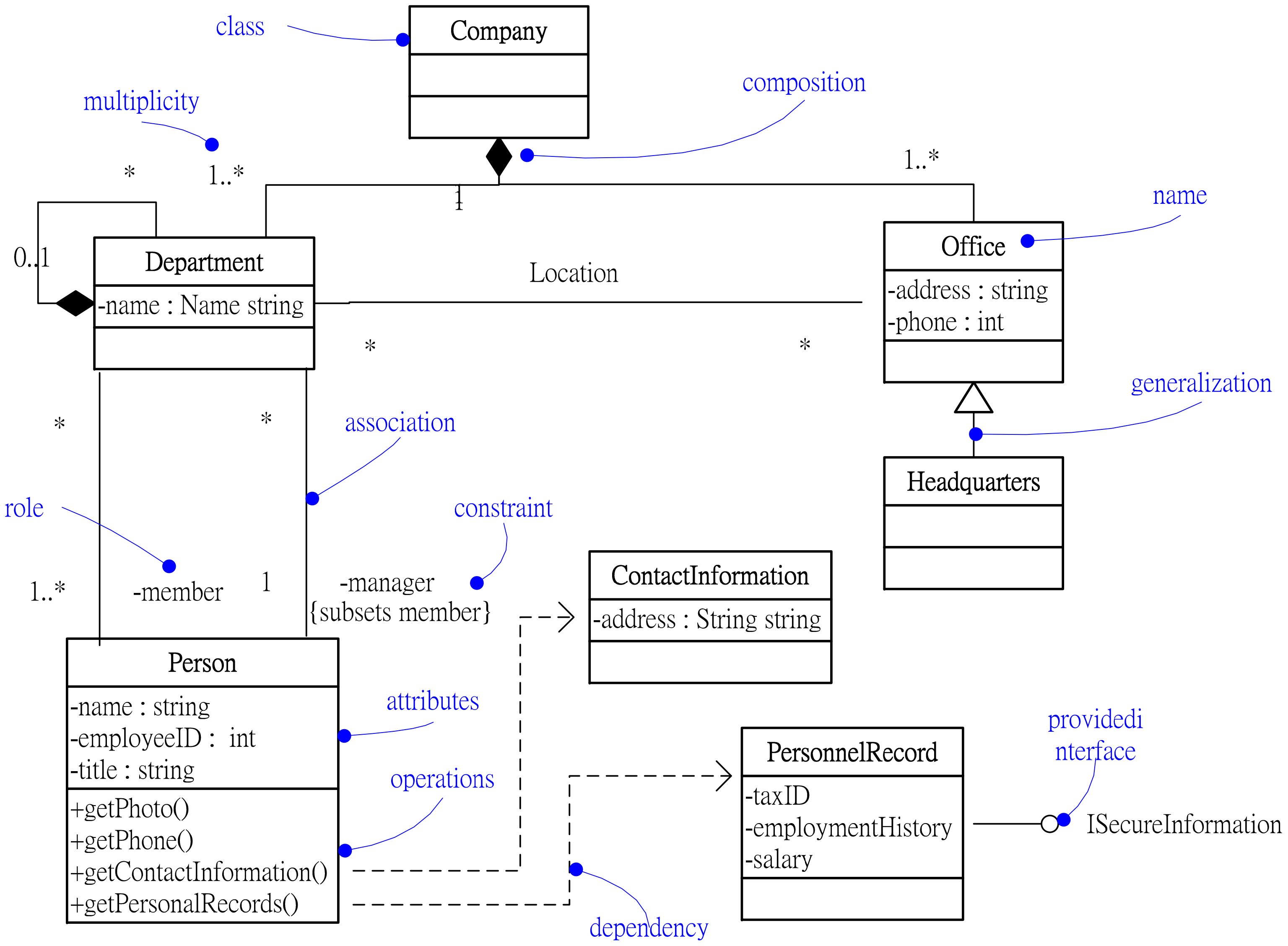
Common Mechanisms in the UML

- Specifications: textual statements behind every graphical element
- Adornments
  - unique notations for different elements/details
- Common divisions
  - class vs. object, interface vs. implementation, role vs. type
- Extensibility mechanisms
  - stereotypes, tagged values, constraints

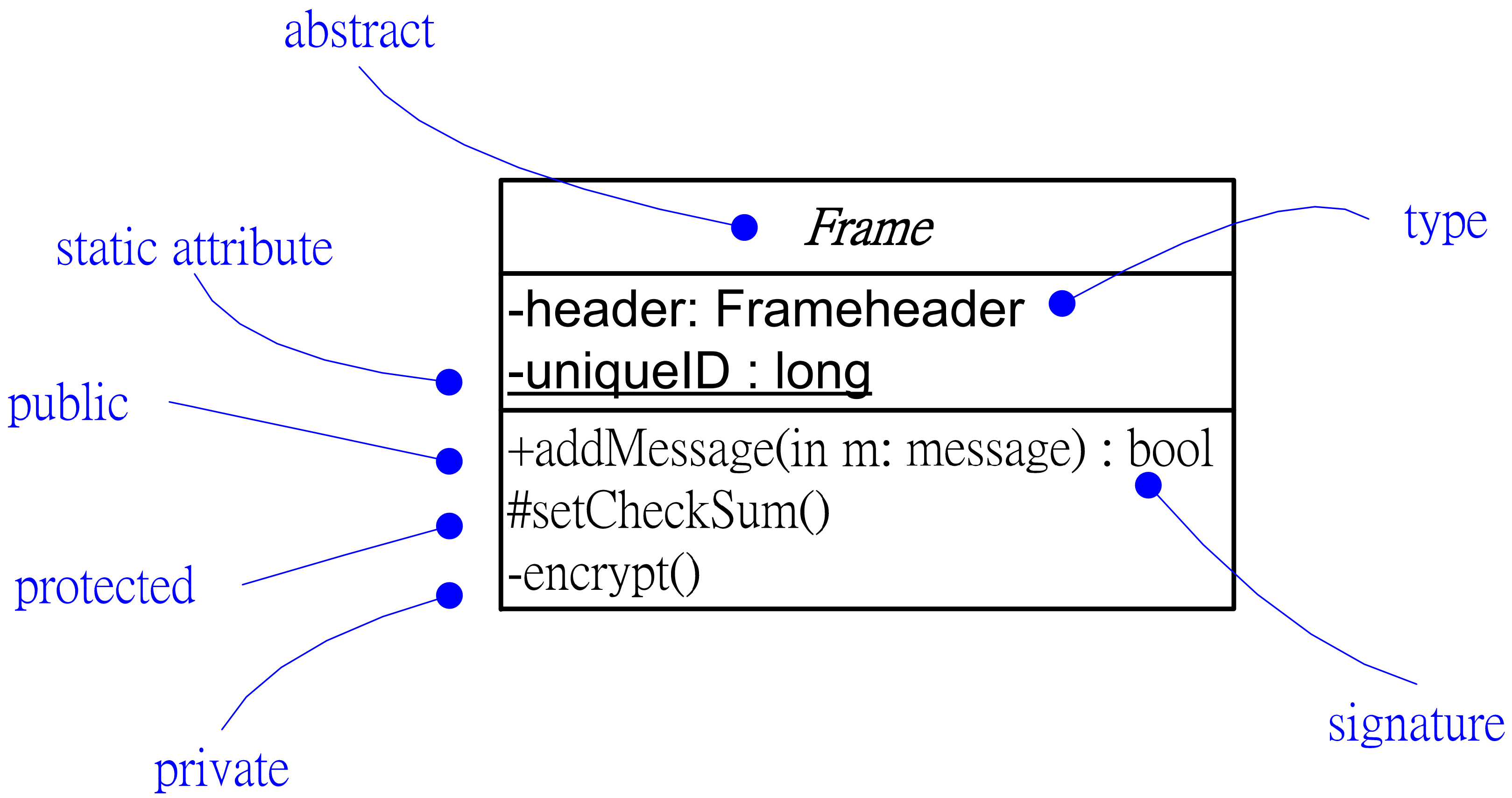
Extensibility



Class Diagram



Advanced Classes



abstract

static attribute

public

protected

private

Frame

-header: Frameheader

<u>-uniqueID : long</u>

+addMessage(in m: message) : bool

#setCheckSum()

-encrypt()

type

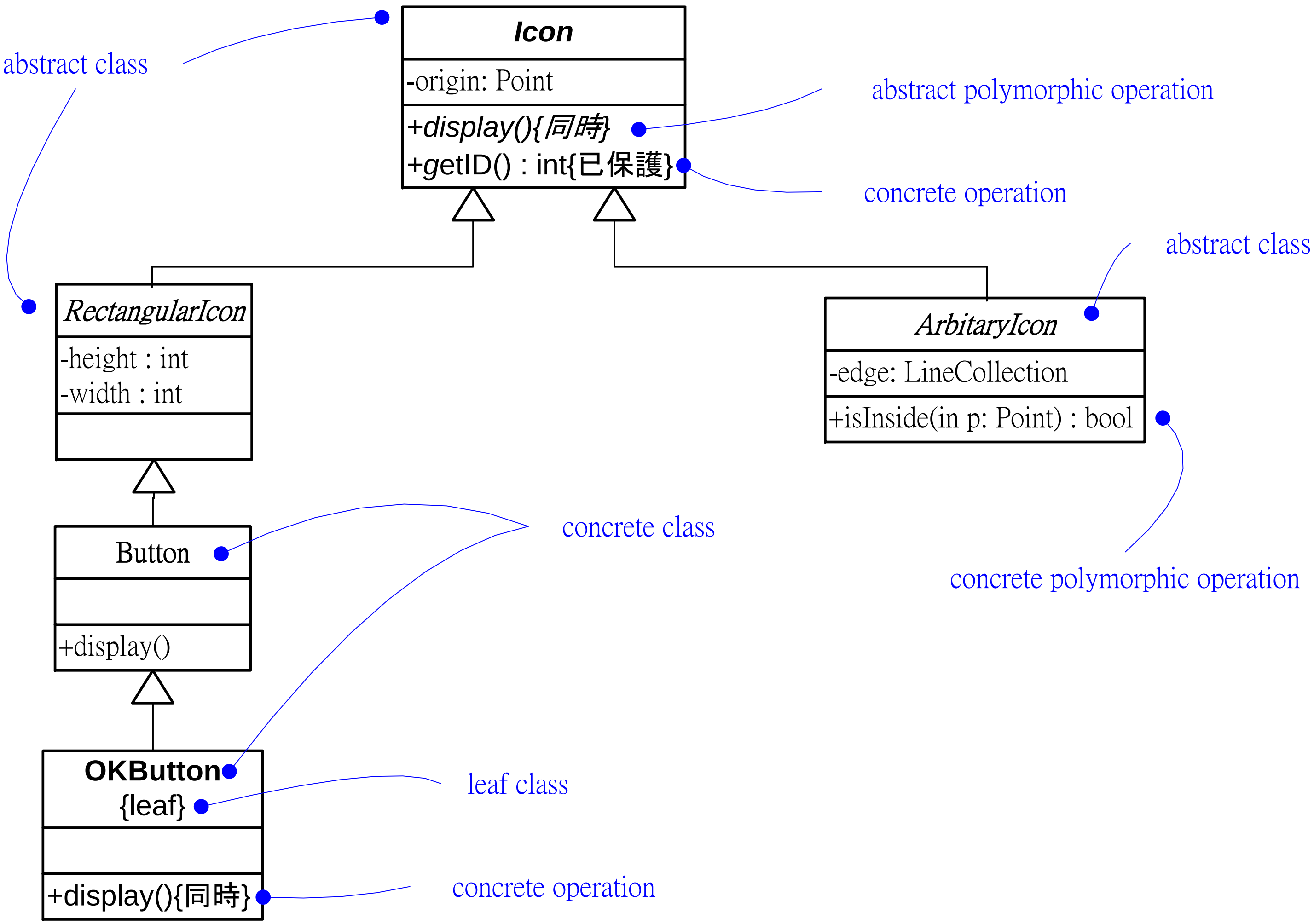
signature

Classifiers

In general, those modeling elements that can have instances are called classifiers.

- Interface
- Datatype
- Signal
- Component
- Node
- Use case
- Subsystem

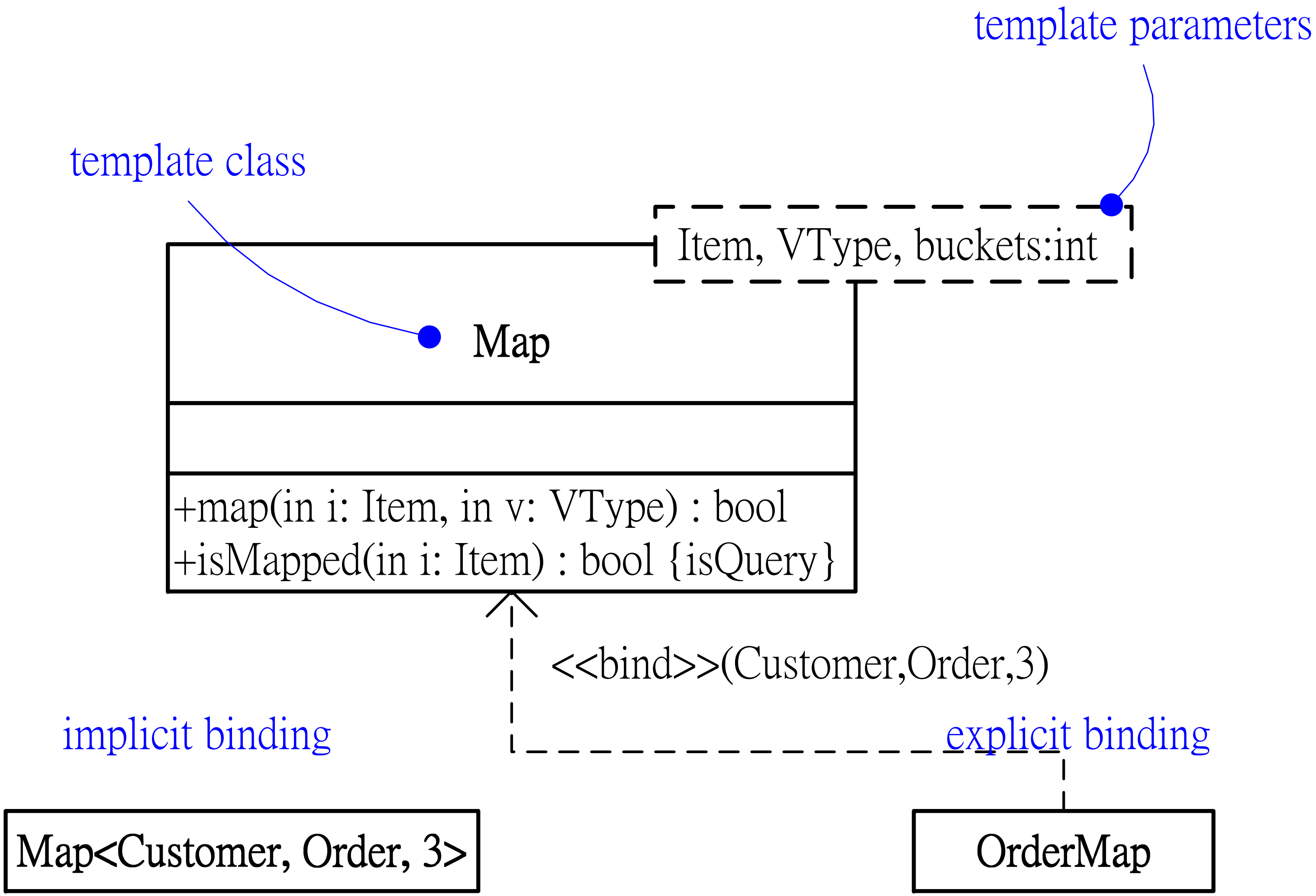
Abstract and Concrete Classes



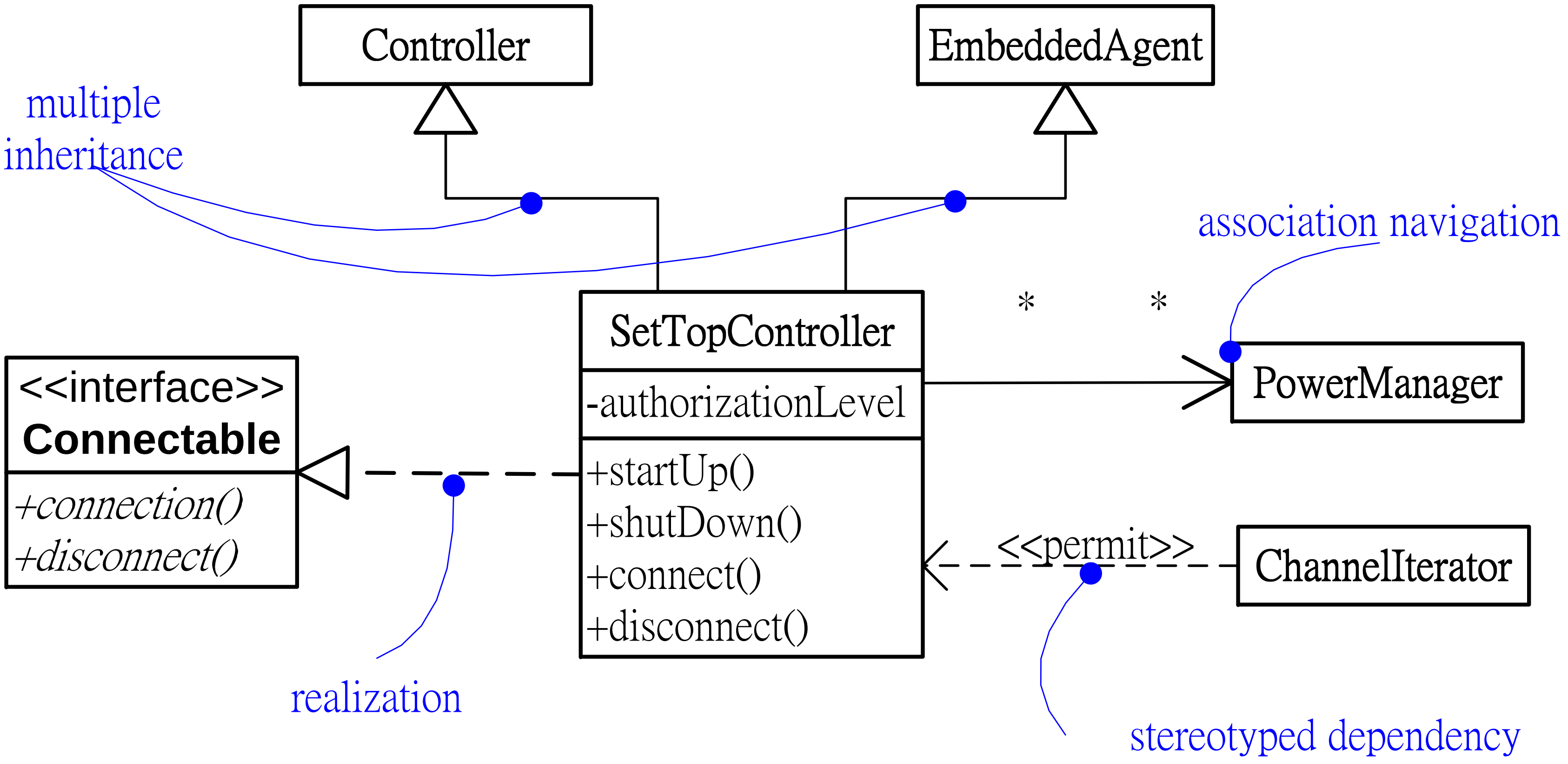
Properties on Operations

- **query**: no side effects
- **sequential**: relying on the callers to do the coordination
- **guarded**: all calls sequentialized (by the object)
- **concurrent**: concurrency control enforced
- **static**: like a global procedure

Template Classes



Advanced Relationships



Advanced Relationships (cont.)

- Stereotypes for dependency
  - Among classes and objects (in class diagrams): **bind, derive, permit (friend), instanceOf, instantiate, powertype, refine, use**
  - Among packages: **import, access**
  - Among use cases: **extend, include**
  - In state machines: **send**
  - In subsystems and models: **trace**

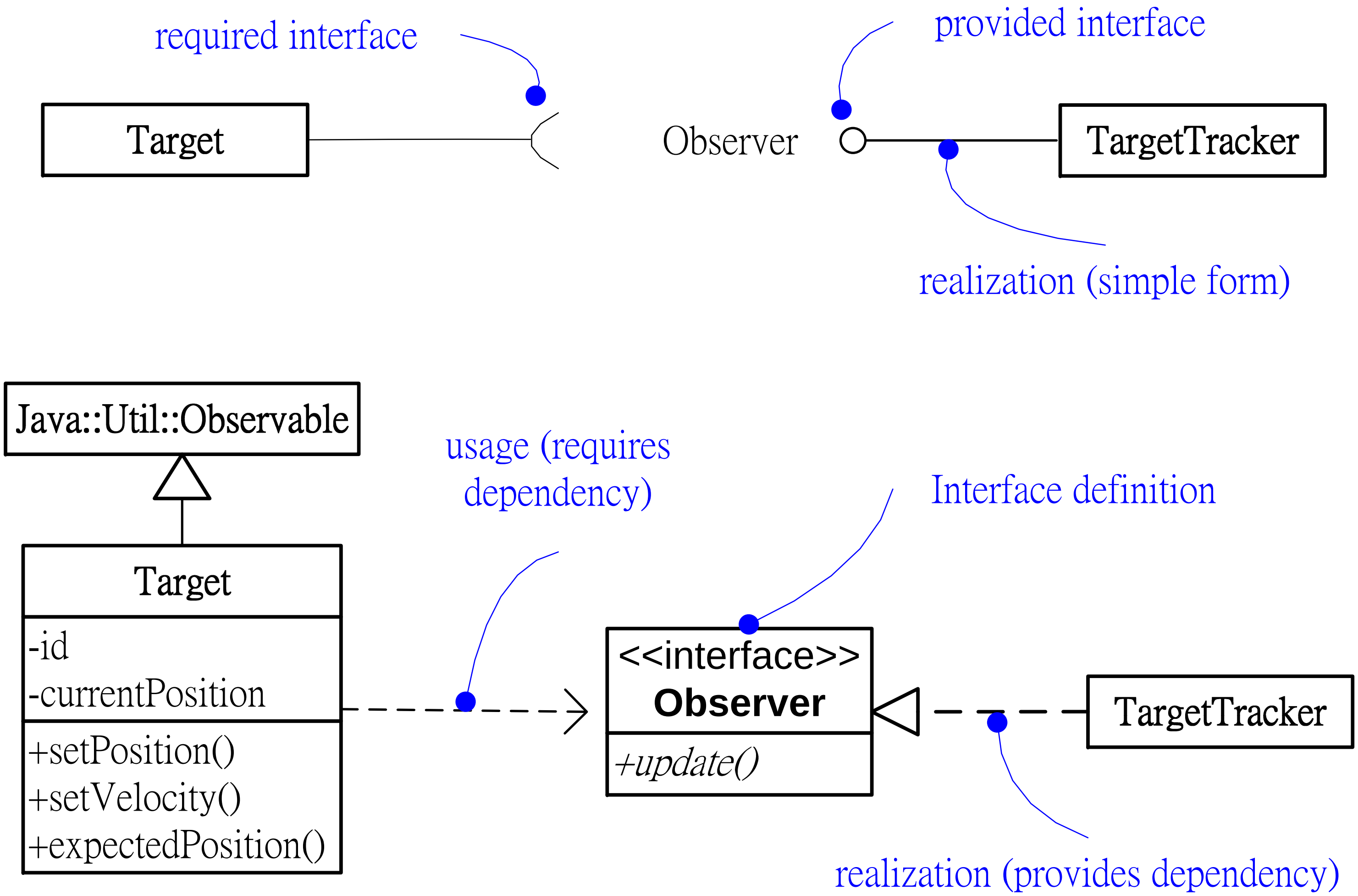
Advanced Relationships (cont.)

- A stereotype for generalization:
  - **implementation**
- Constraints for generalization:
  - **complete, incomplete, disjoint, overlapping**

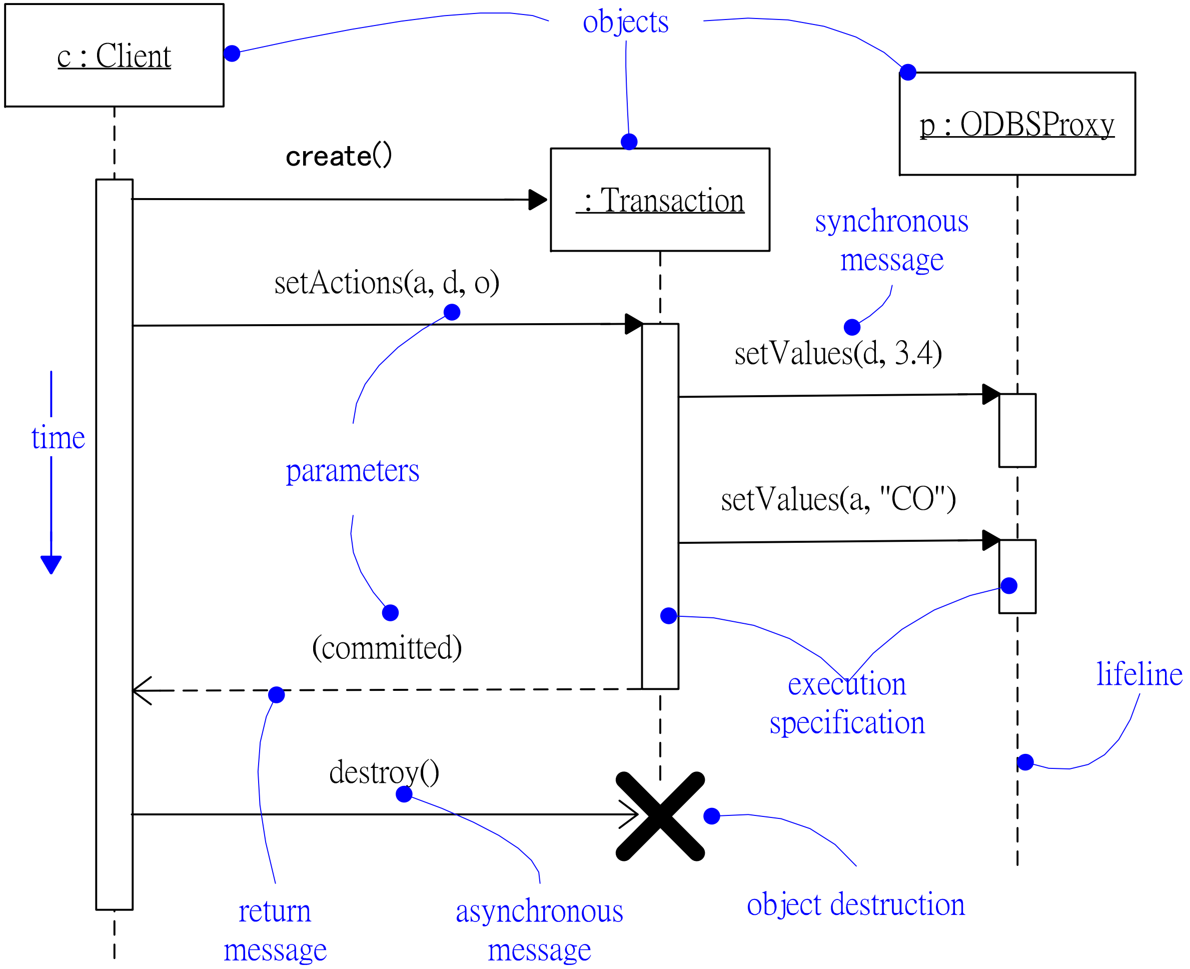
Advanced Relationships (cont.)

- Properties of association
  - Navigation
  - Visibility
  - Qualification
  - Interface specifier
  - Composition
  - Association classes
  - Constraints: **ordered, set, bag, ordered set, list** or **sequence, readonly**

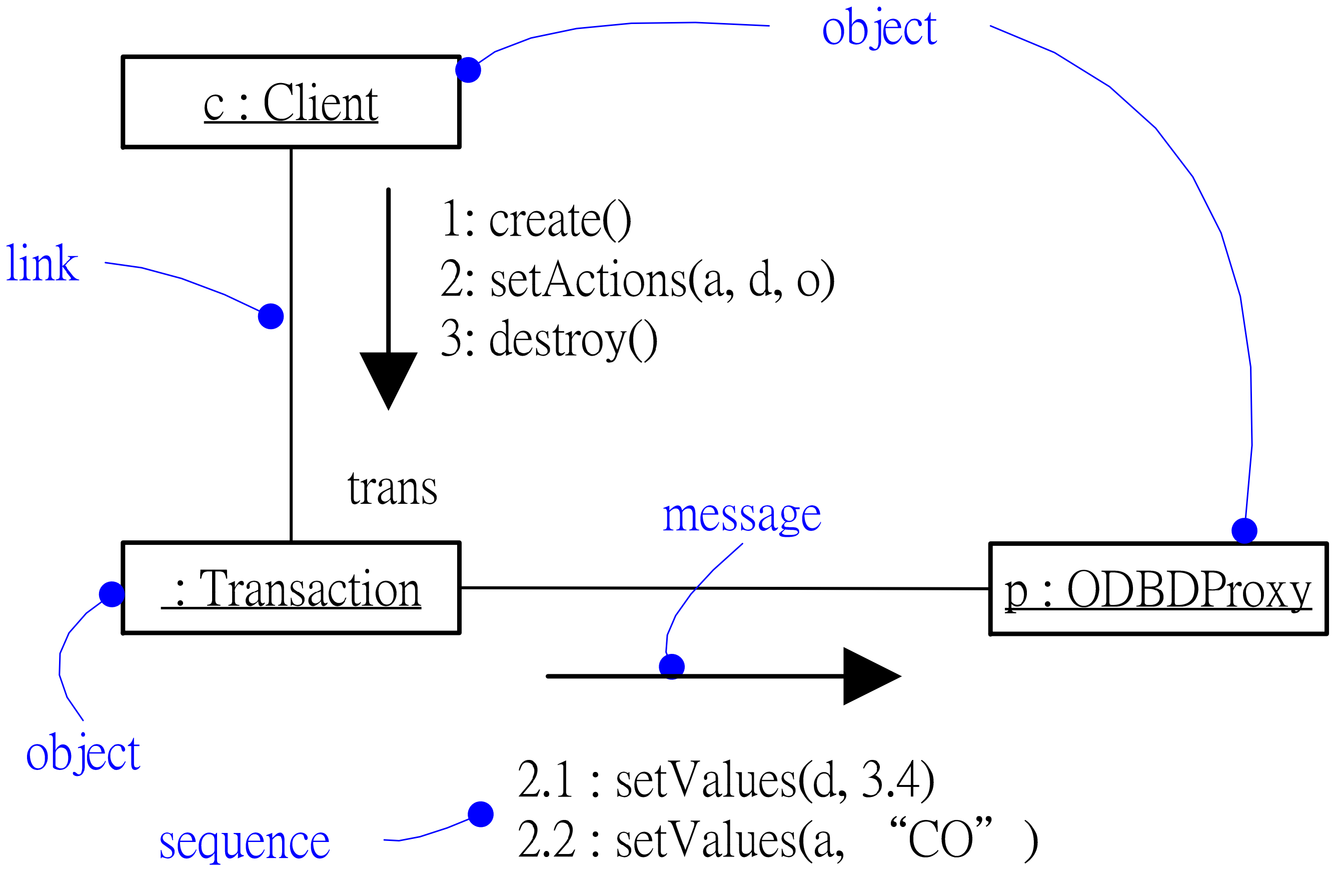
Realizations



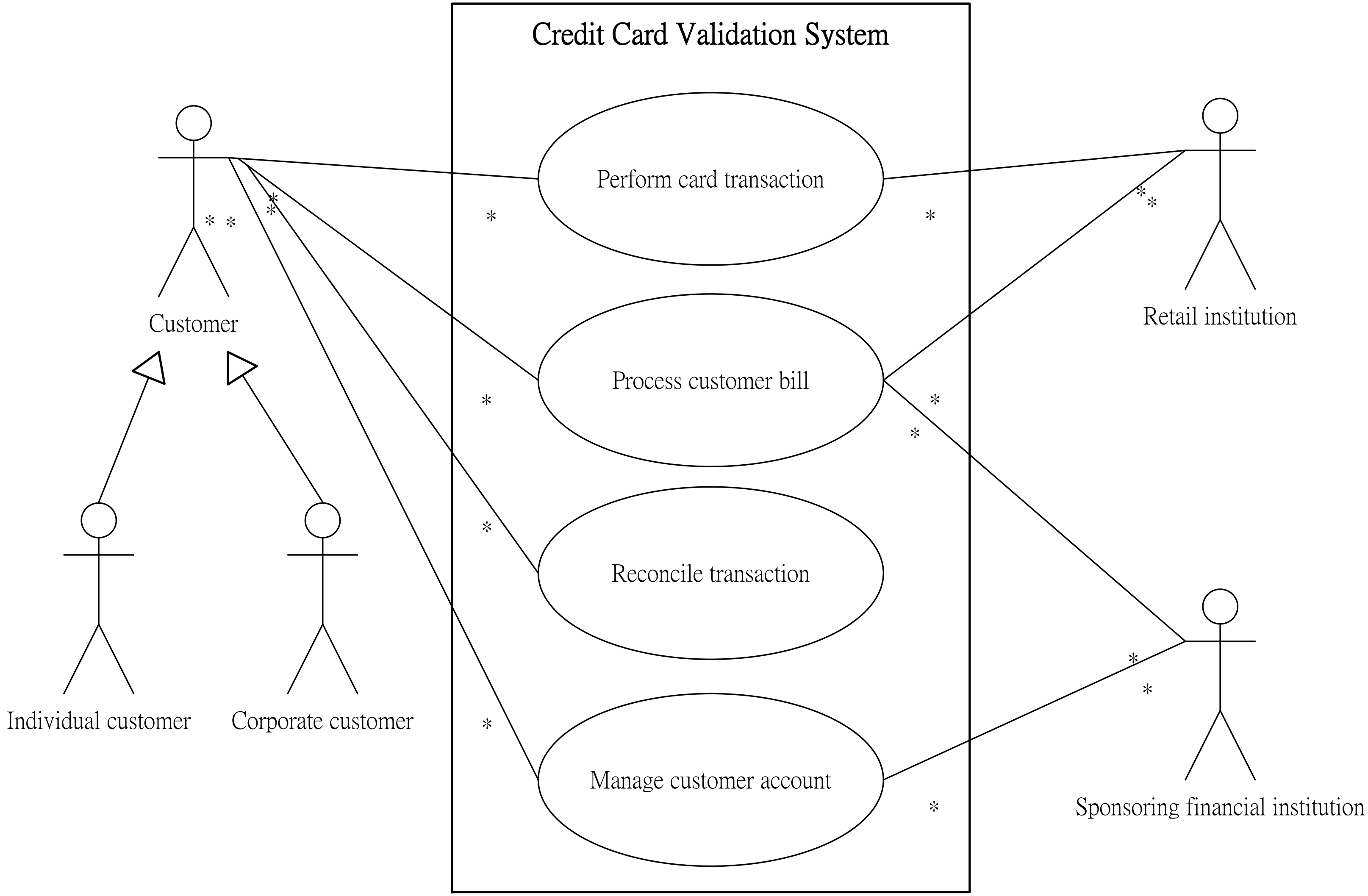
Sequence Diagram



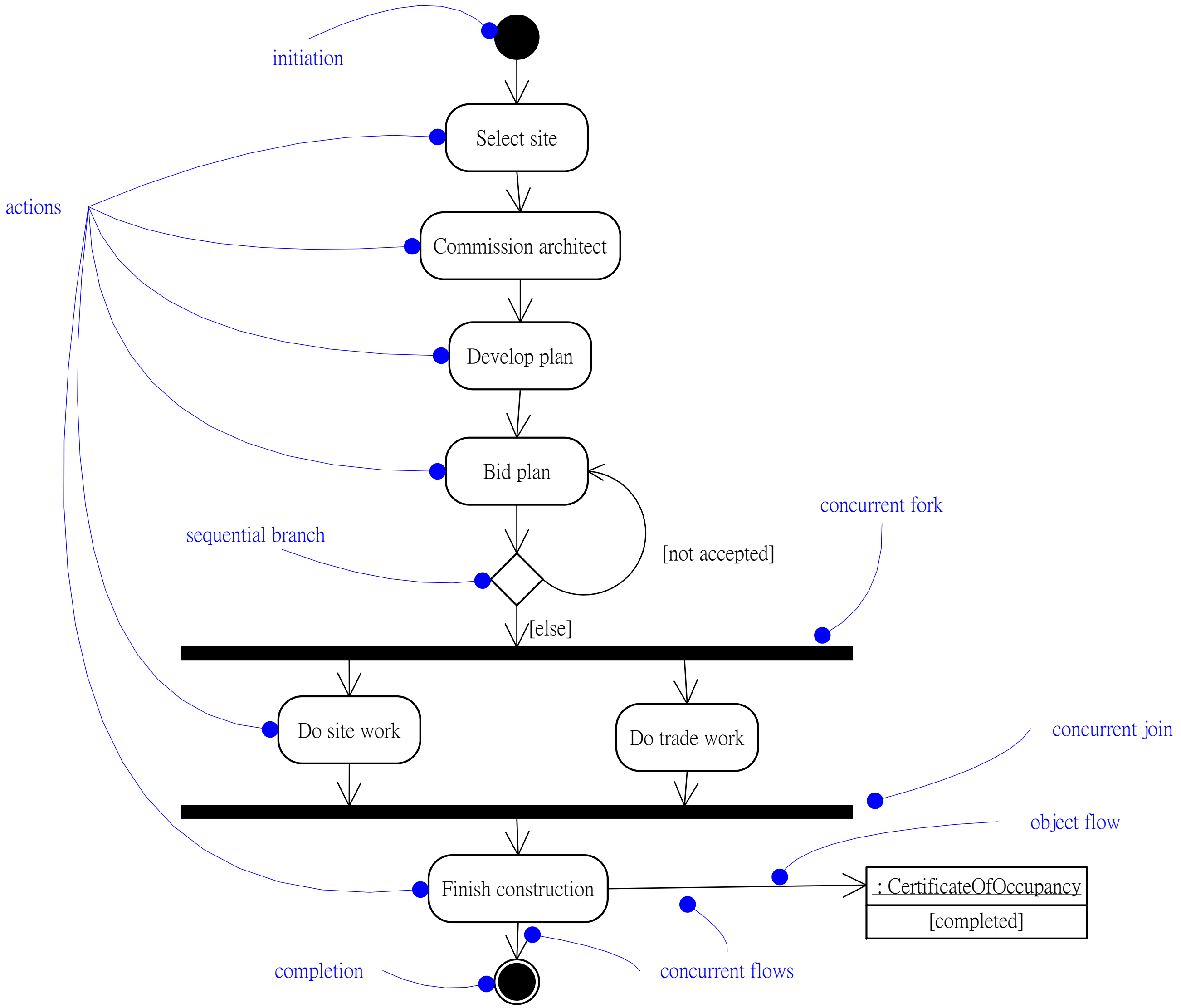
Communication Diagram



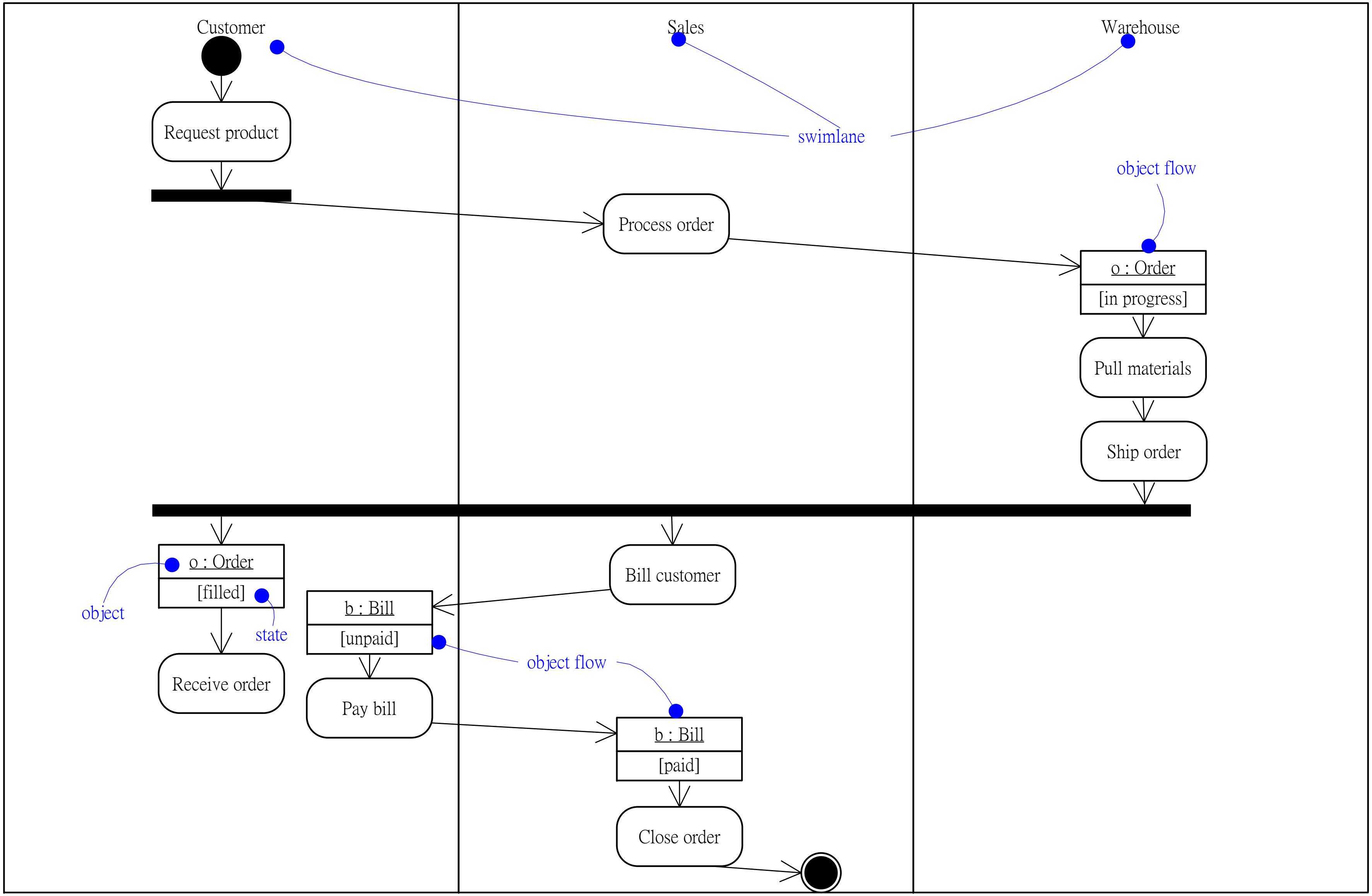
Use Case Diagram



Activity Diagram



Swimlanes and Object Flow



Remarks

- The best way to learn the UML is by actually using it:
  - Design patterns
  - Term project
- In follow-up lectures, we will cover
  - Some more advanced UML features
  - The Object Constraint Language
- Things not covered in class are left for you to explore.