UML: Part I

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

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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 …)

More Tips

- Use a common language
- Do modeling now, before it is too late

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

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

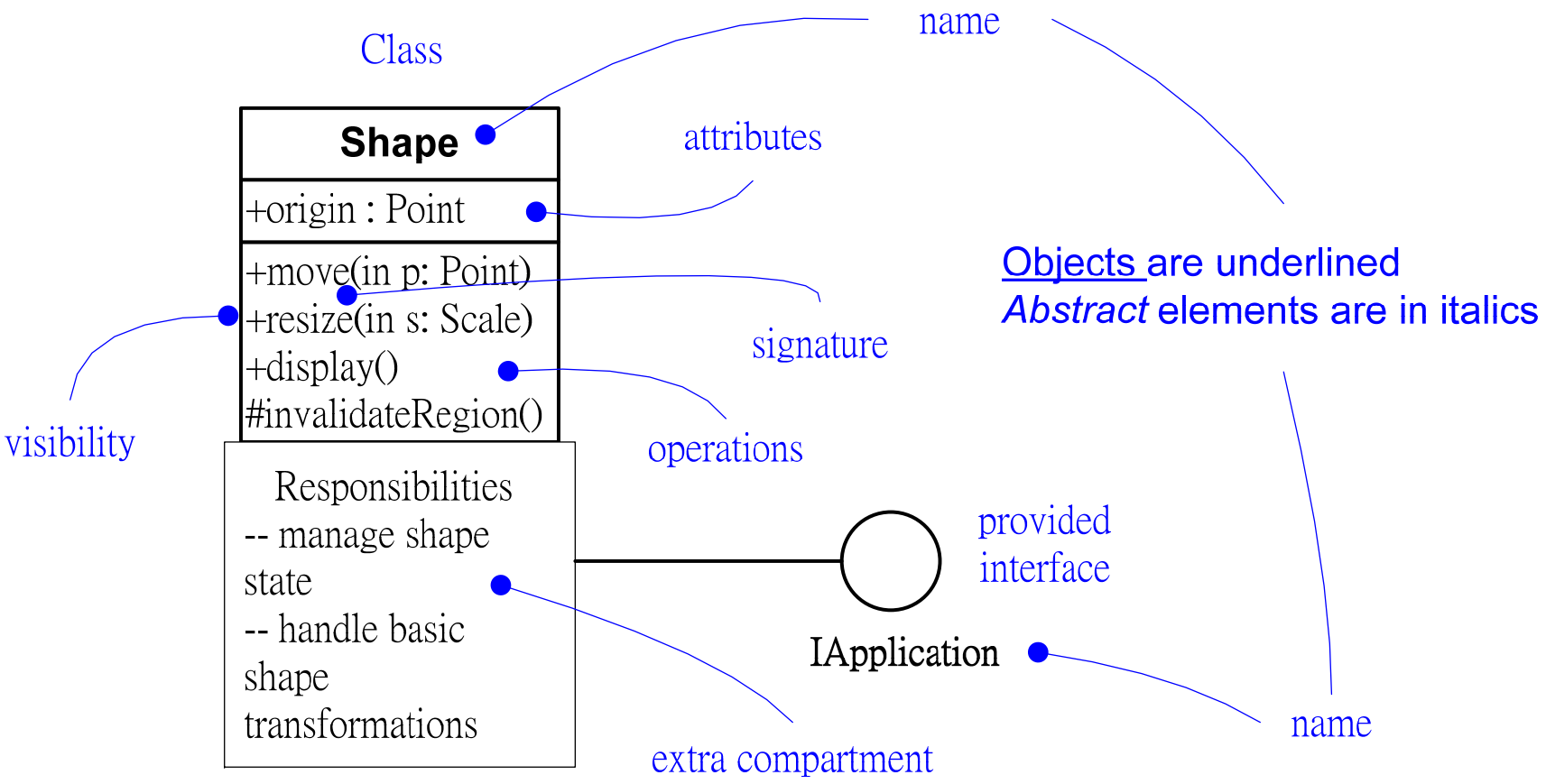
The UML in the Software Development Process

- 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

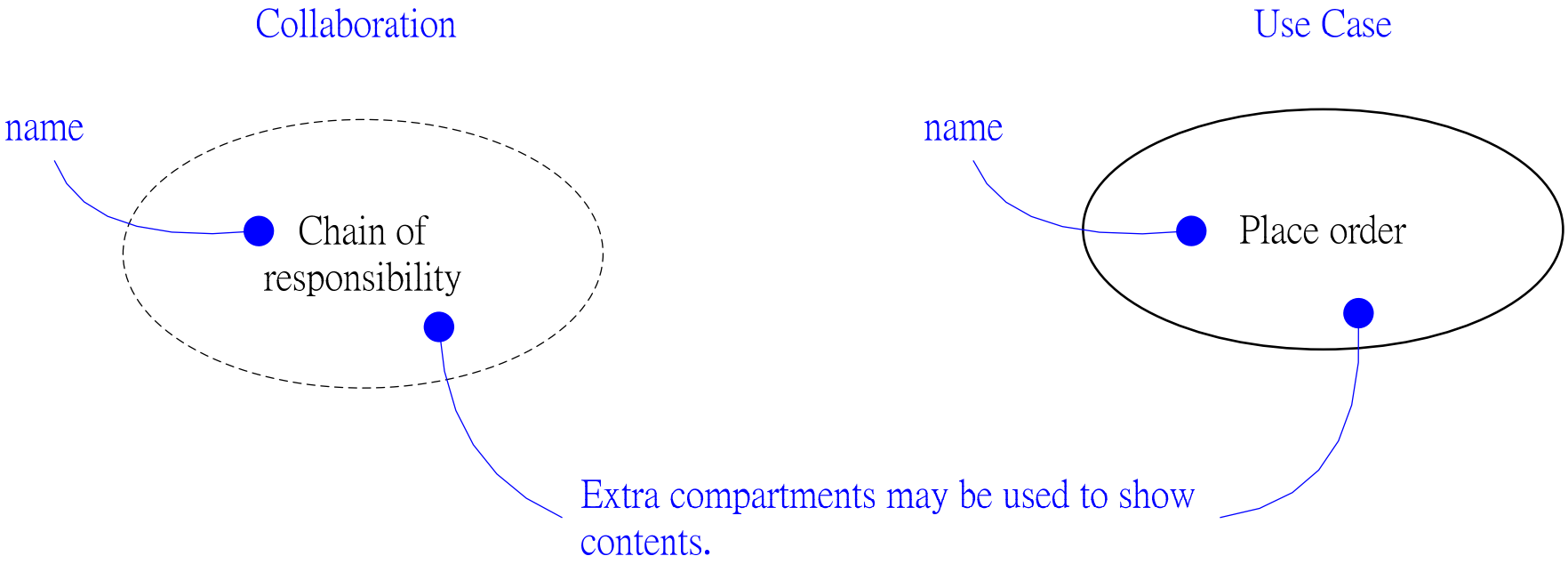
Things in the UML

- 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

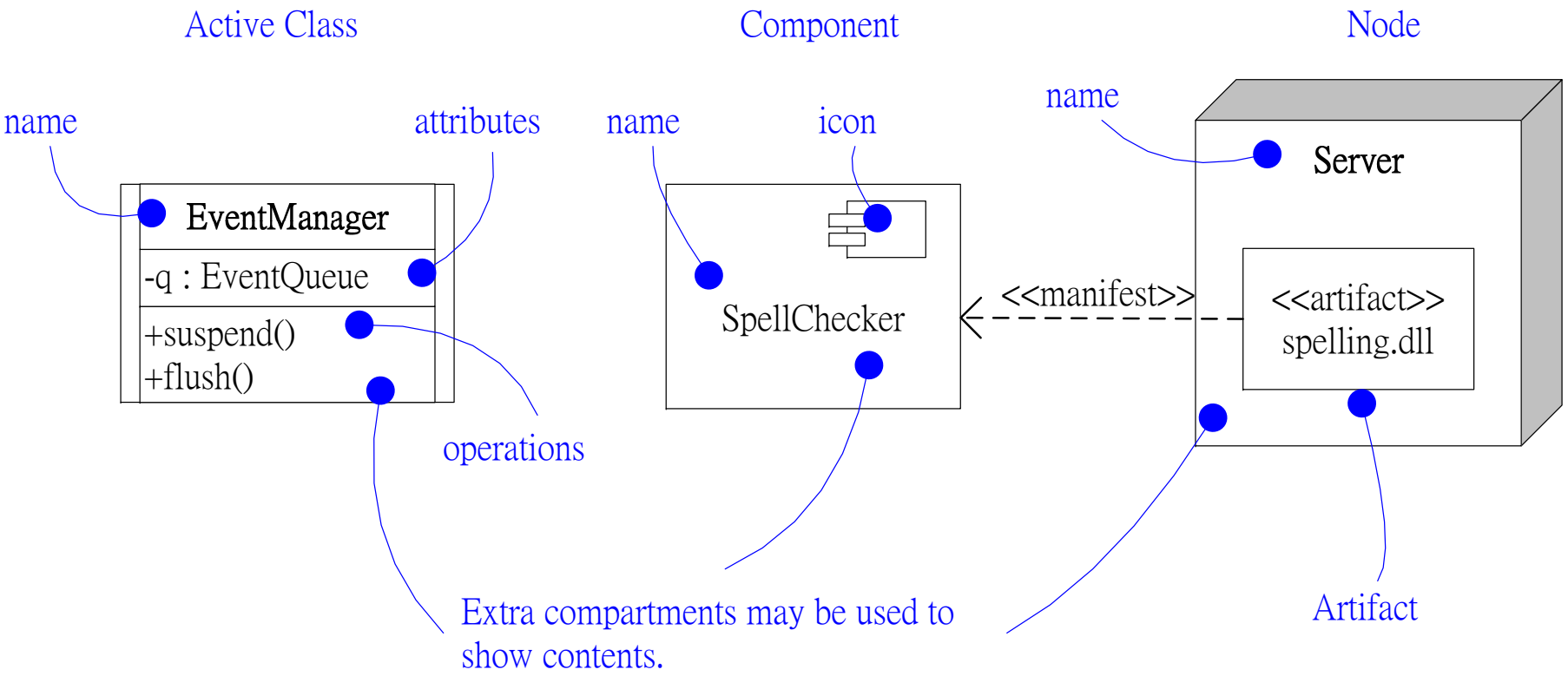
Structural Things (I)



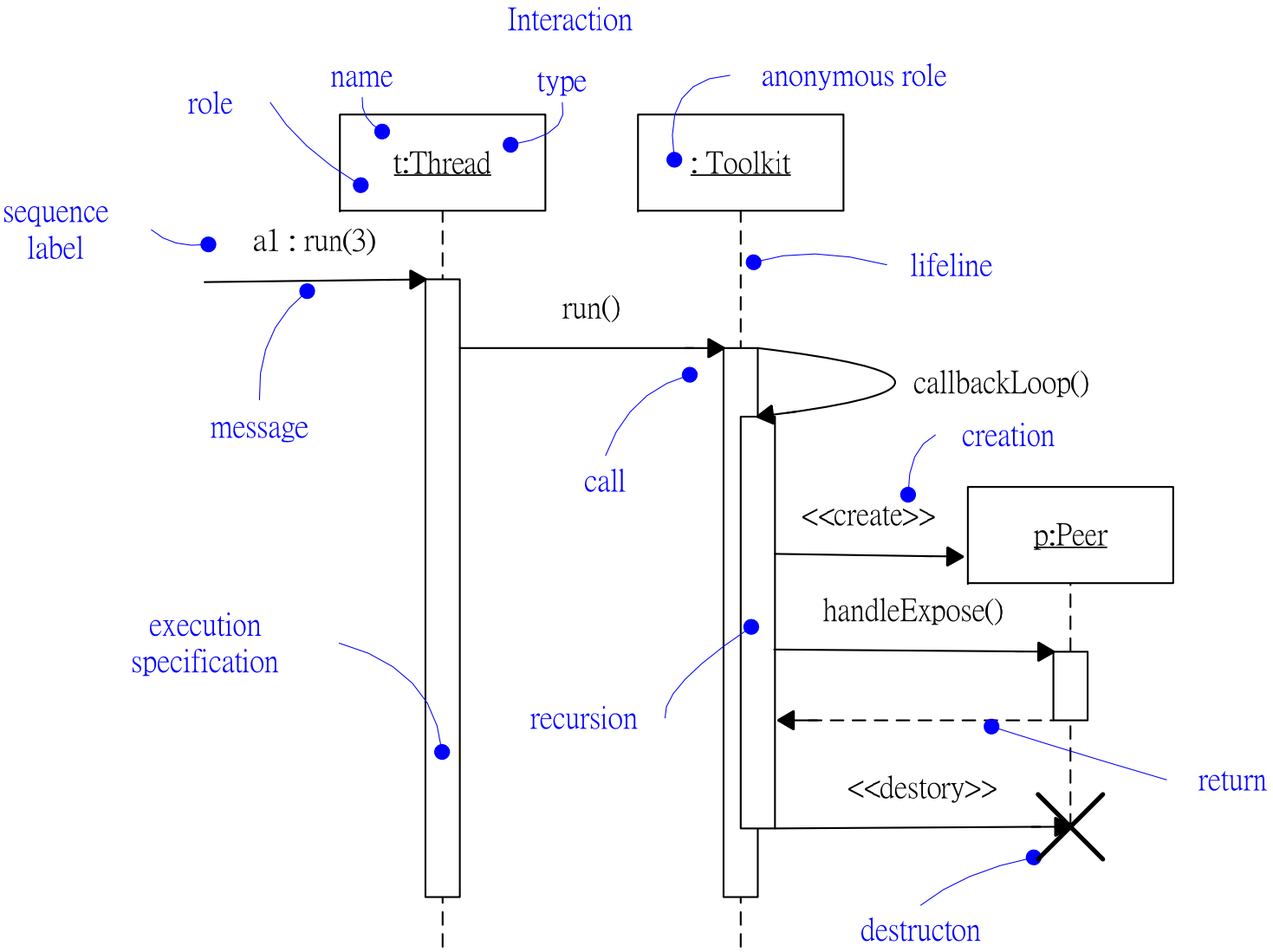
Structural Things (II)



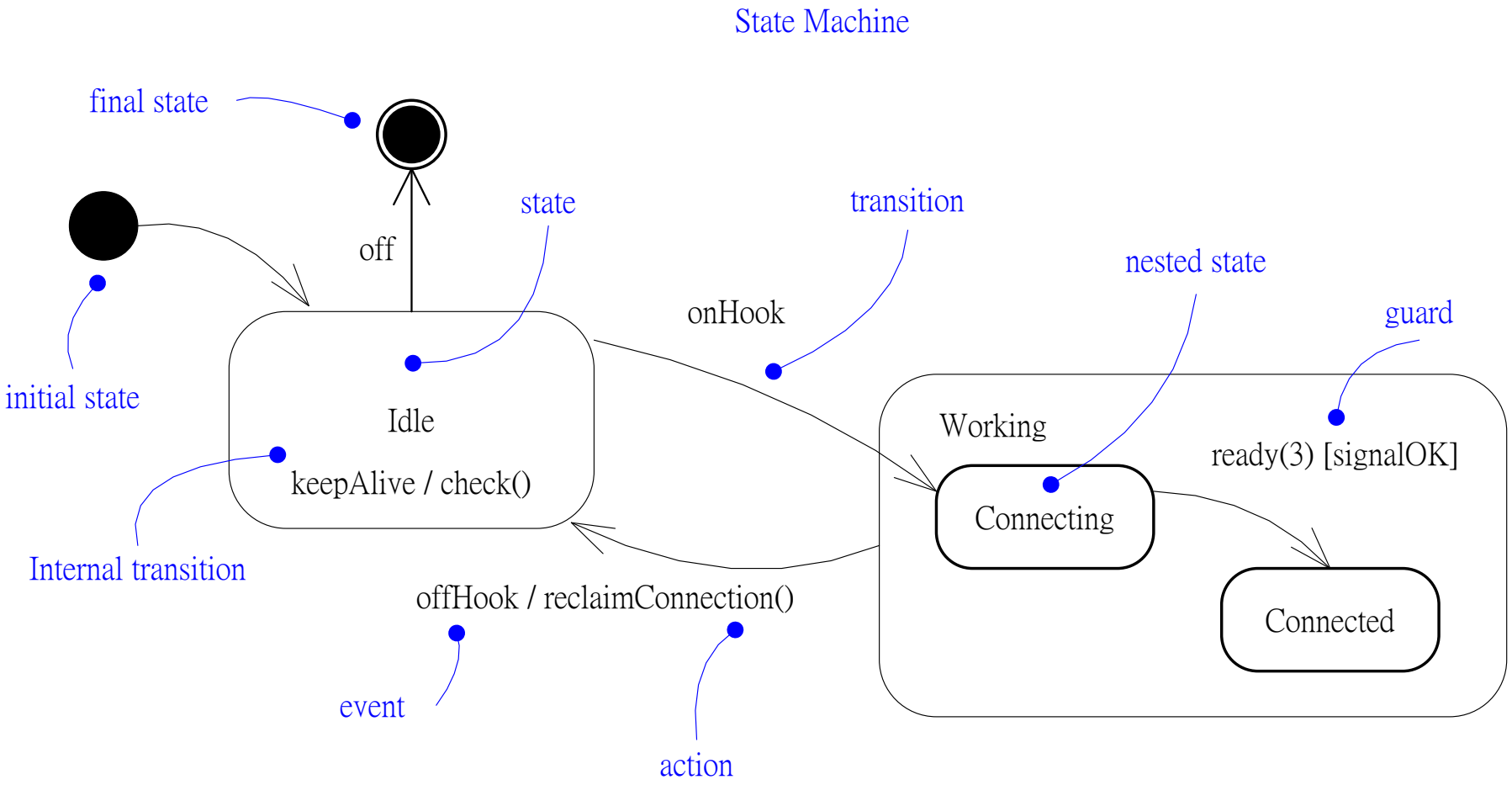
Structural Things (III)



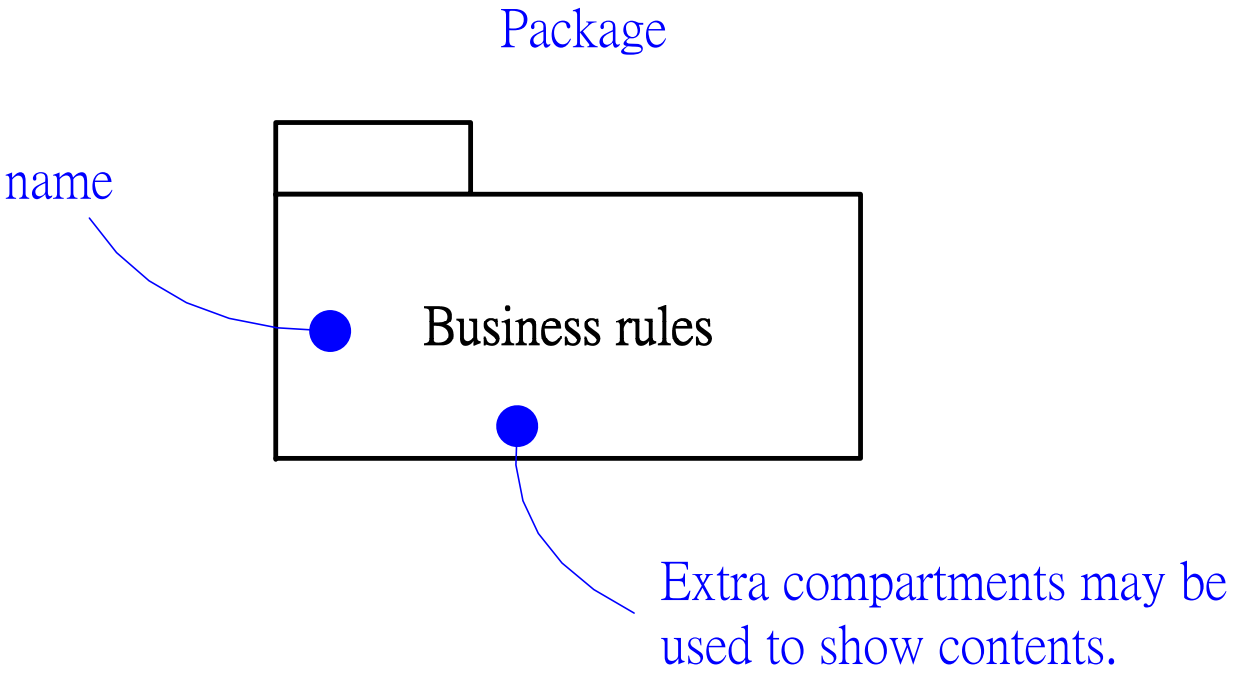
Behavioral Things (I)



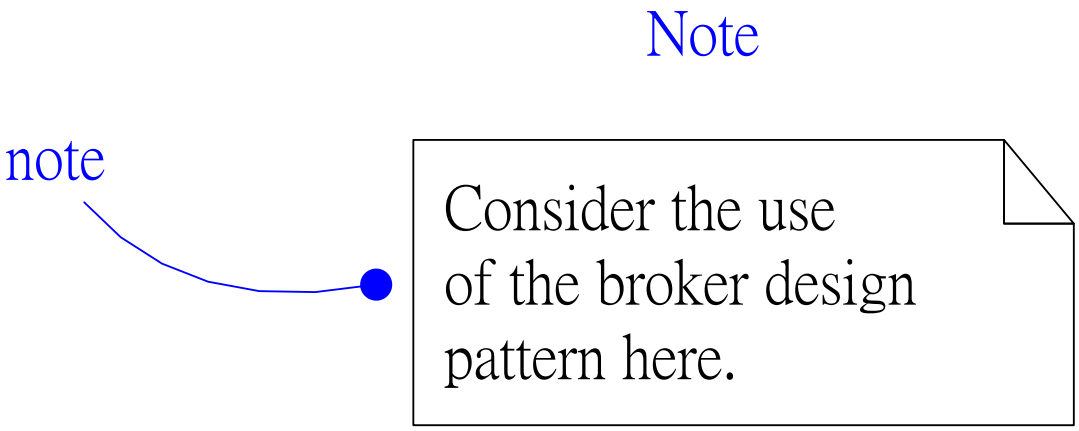
Behavioral Things (II)



Grouping Things



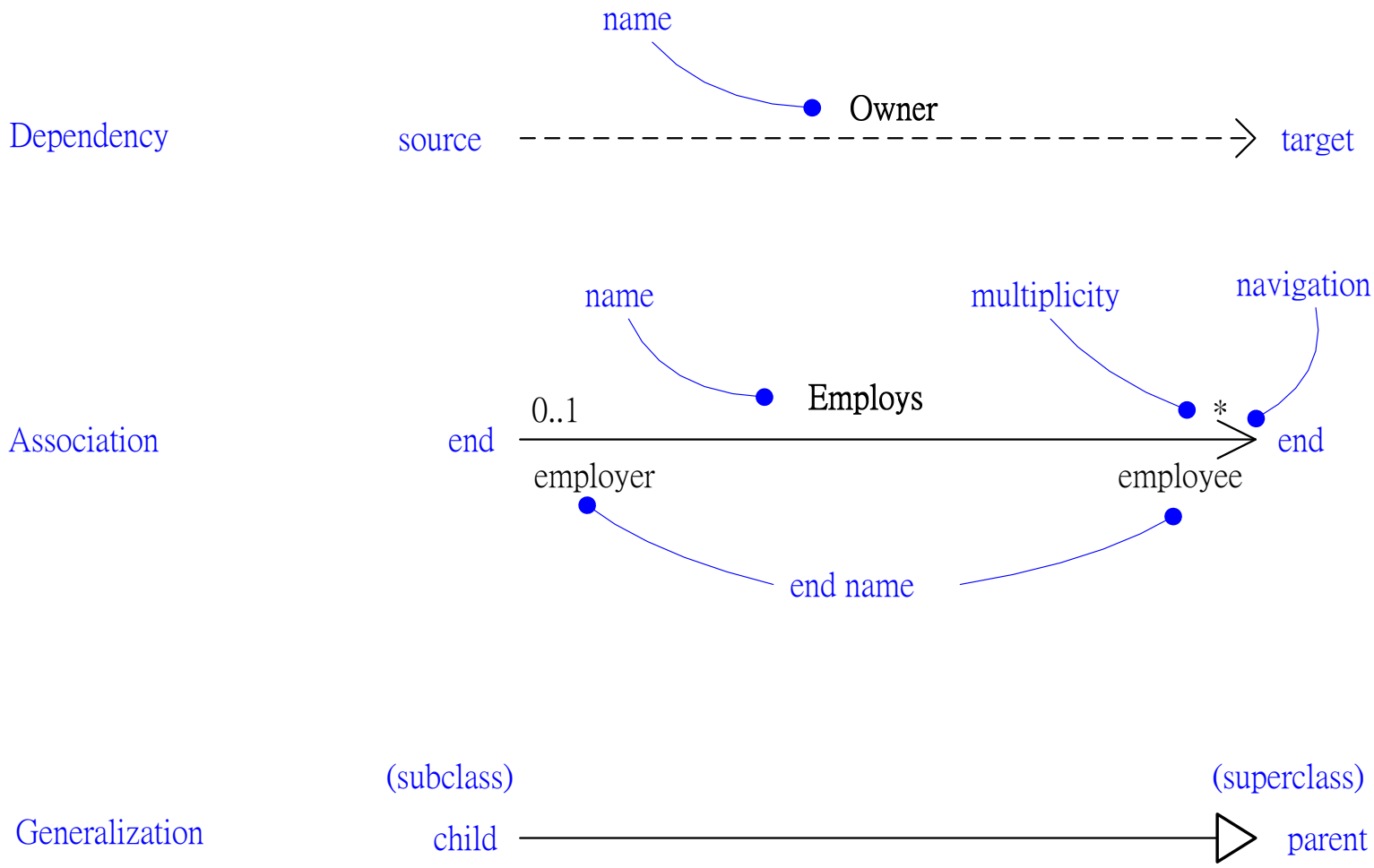
Annotational Things



Relationships in the UML

- Dependency
- Association
- Generalization
- Realization

Relationships



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

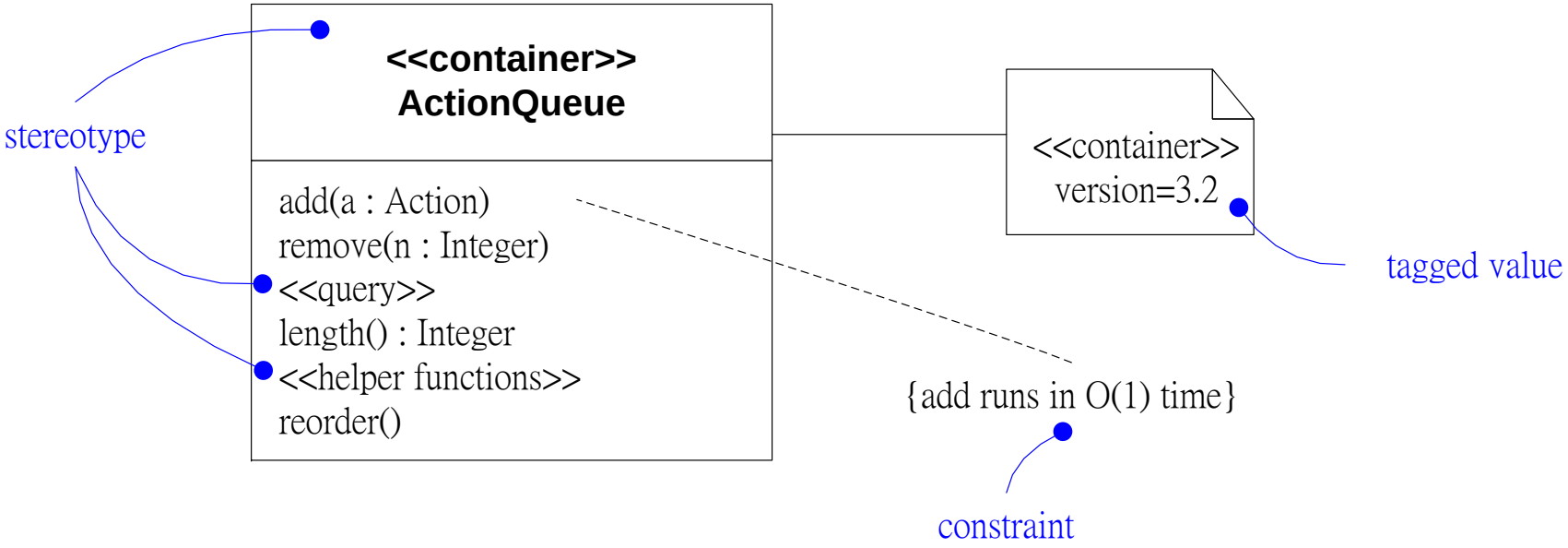
Rules of the UML

- Well-formed models
  - Consistency
  - Semantic rules: names, scope, visibility, integrity, execution
- Not well-formed models
  - Elided
  - Incomplete
  - Inconsistent

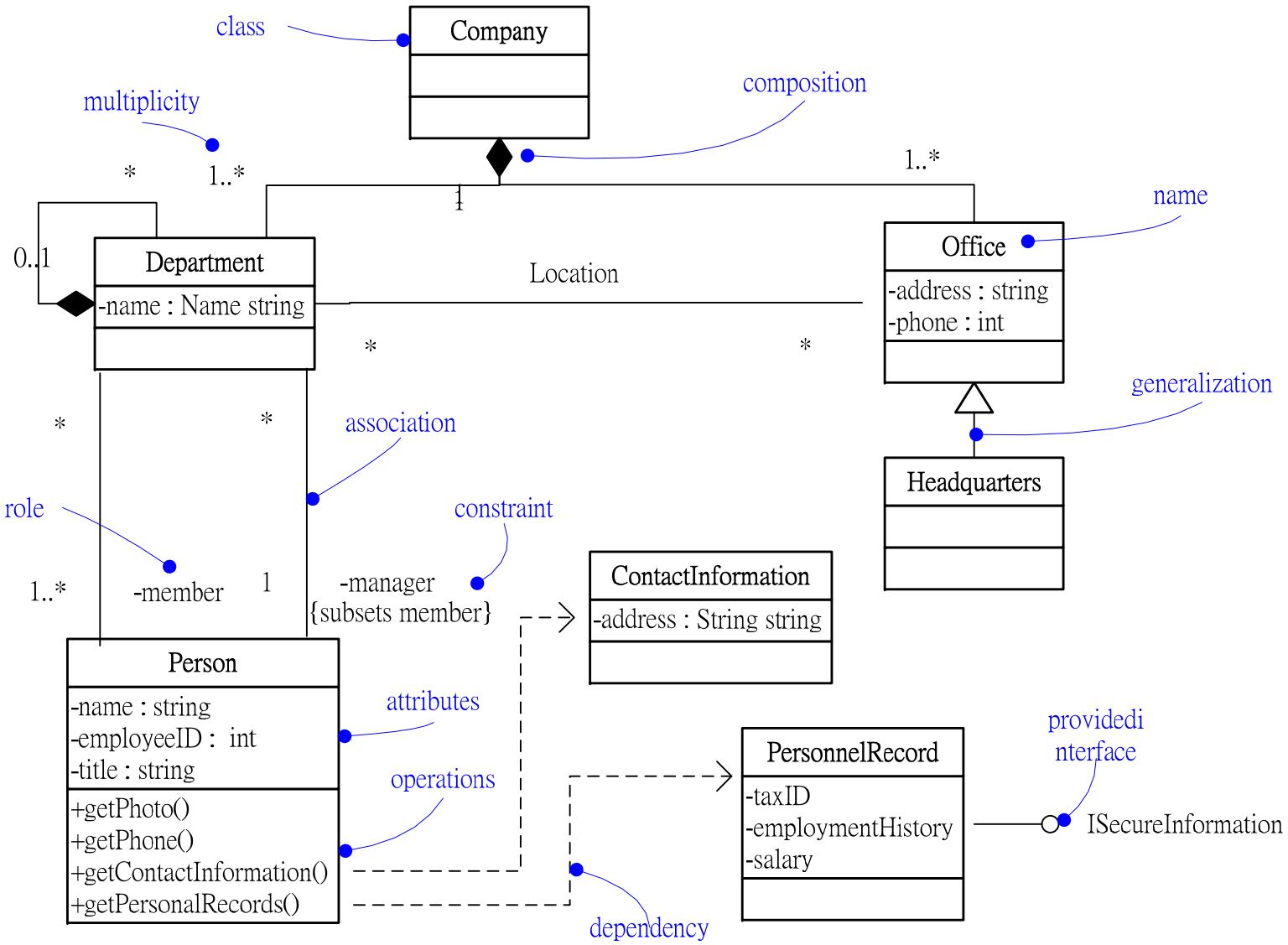
Common Mechanisms in the UML

- Specifications: textual statements behind every graphical element
- Adornments
- Common divisions
  - class vs. object, interface vs. implementation, role vs. type
- Extensibility mechanisms
  - stereotypes, tagged values, constraints

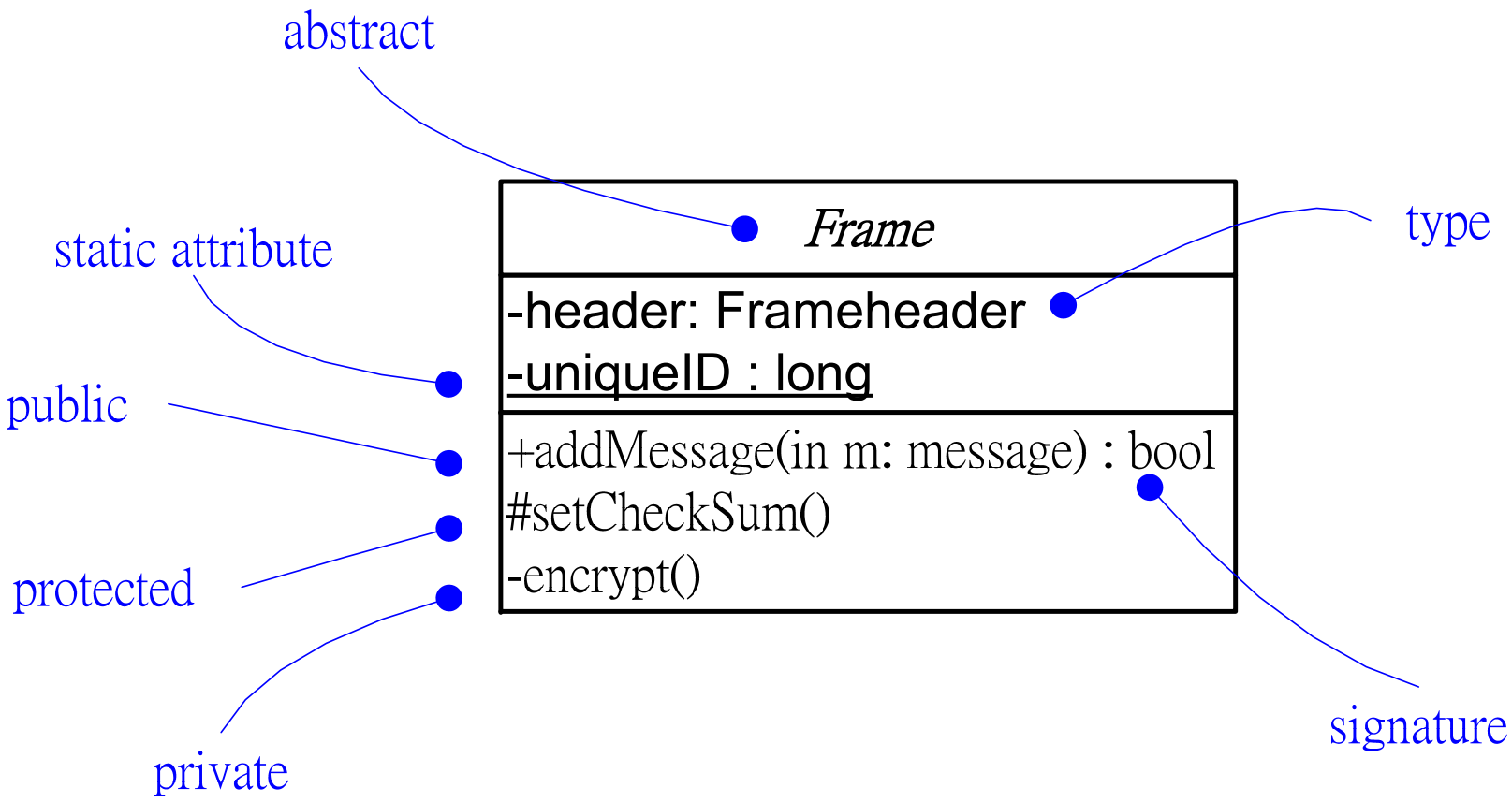
Extensibility



Class Diagram



Advanced Classes

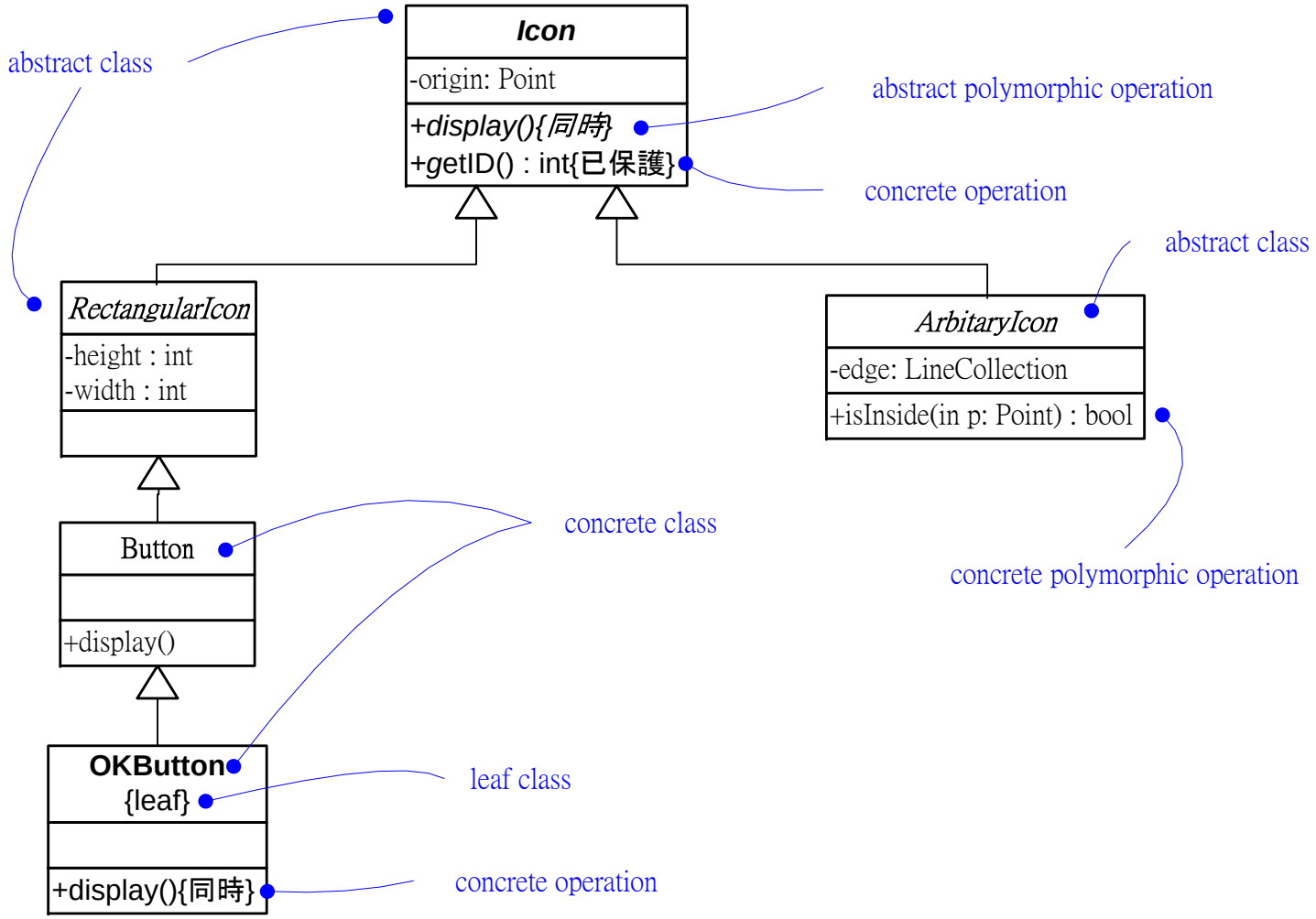


Classifiers

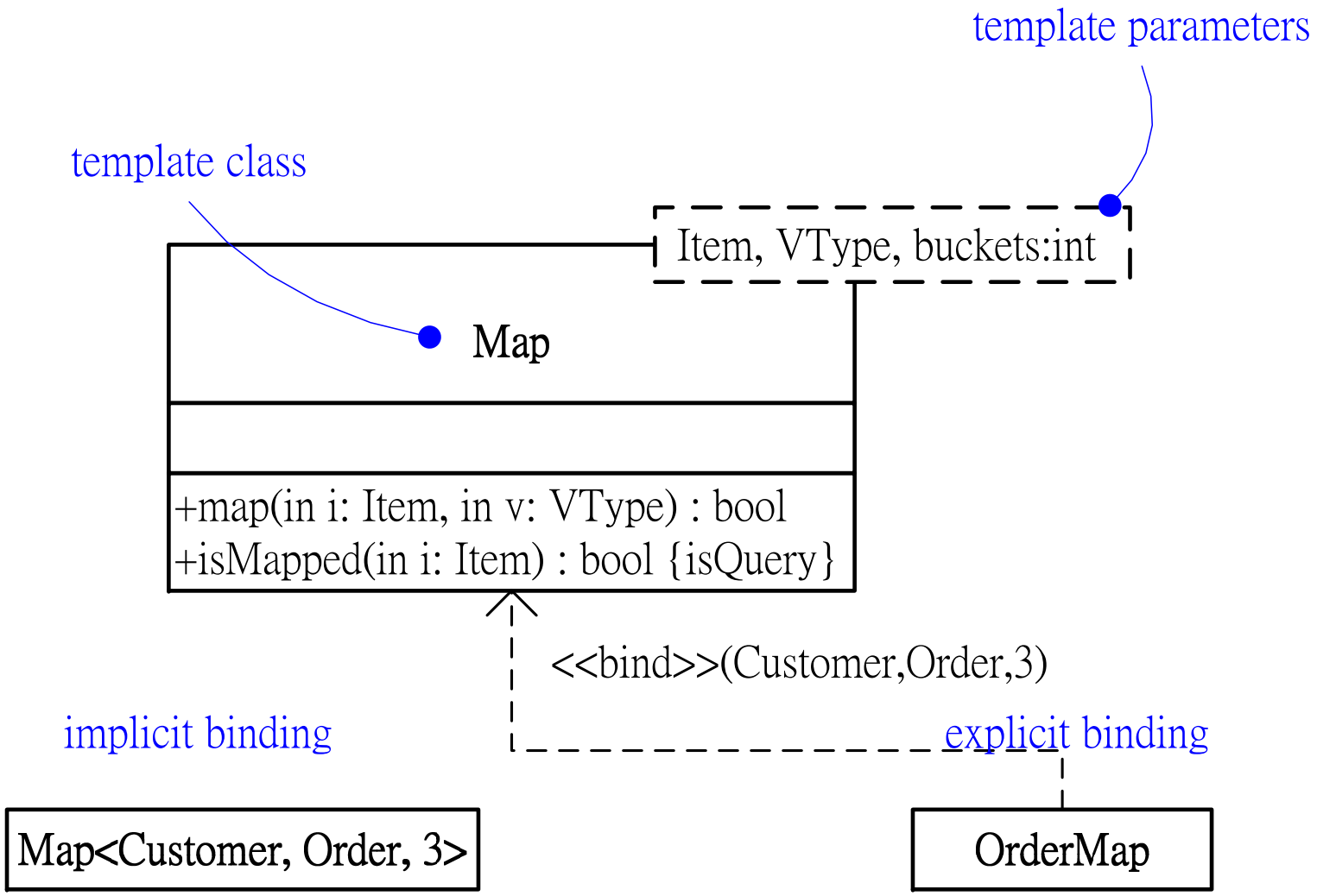
In general, those modeling elements that can have instances are called classifiers.

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

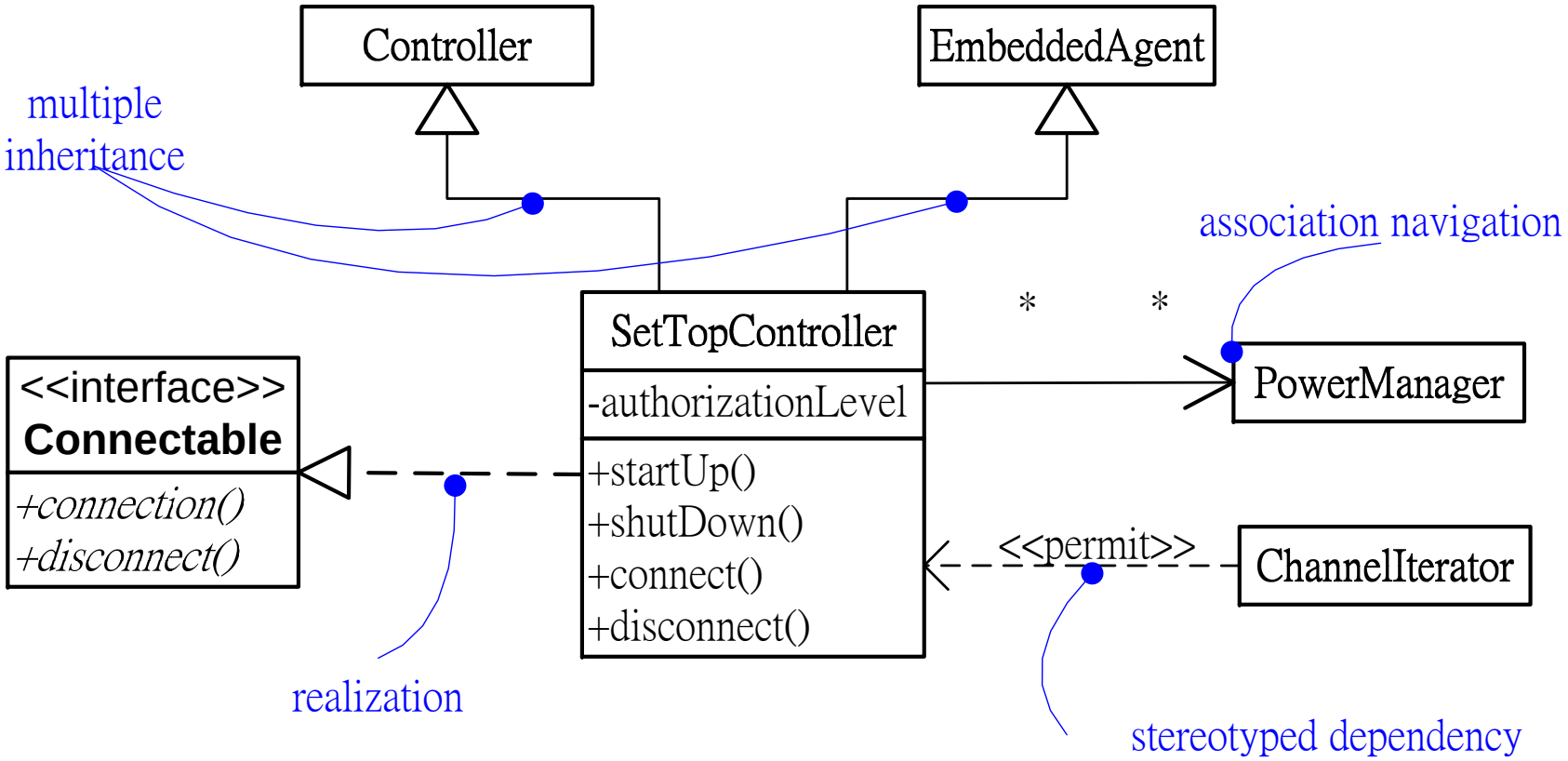
Abstract and Concrete Classes



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: **access, import**
  - Among use cases: **extend, include**
  - In state machines: **send**
  - In subsystems and models: **trace**

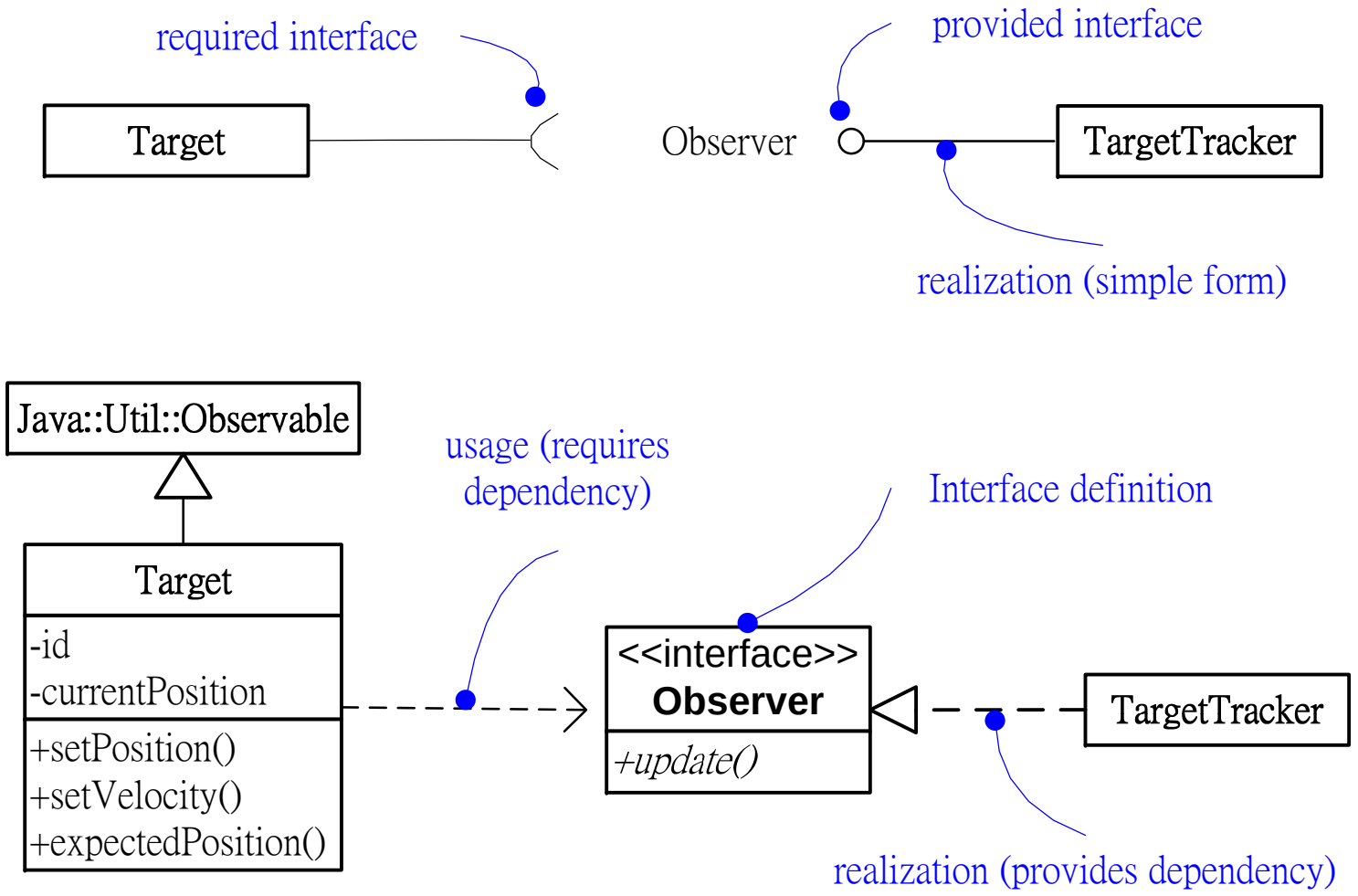
Advanced Relationships (cont.)

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

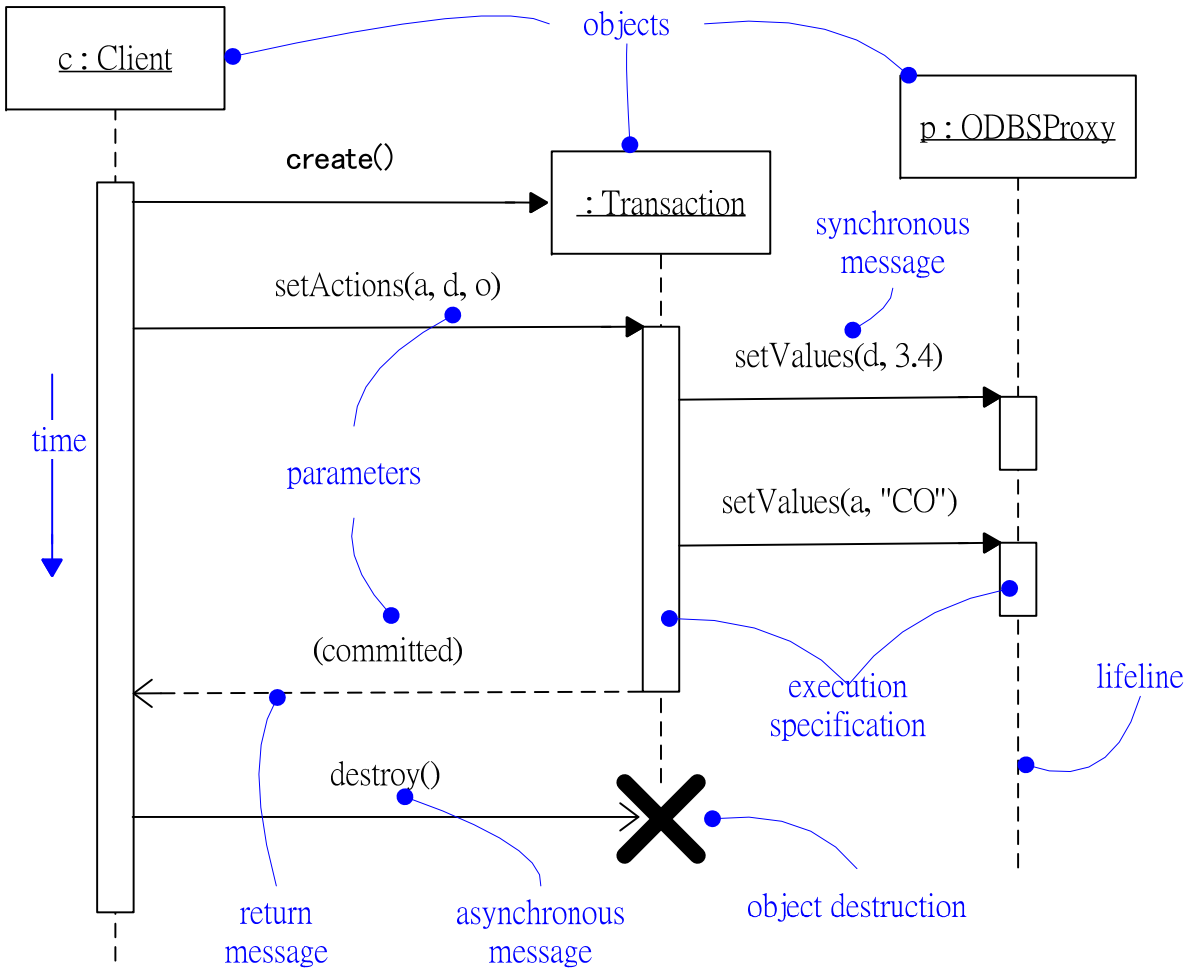
Advanced Relationships (cont.)

- Properties of association
  - Navigation
  - Visibility
  - Qualification
  - Interface specifier
  - Composition
  - Association classes
  - Constraints: **implicit, ordered, changeable, addonly, frozen**

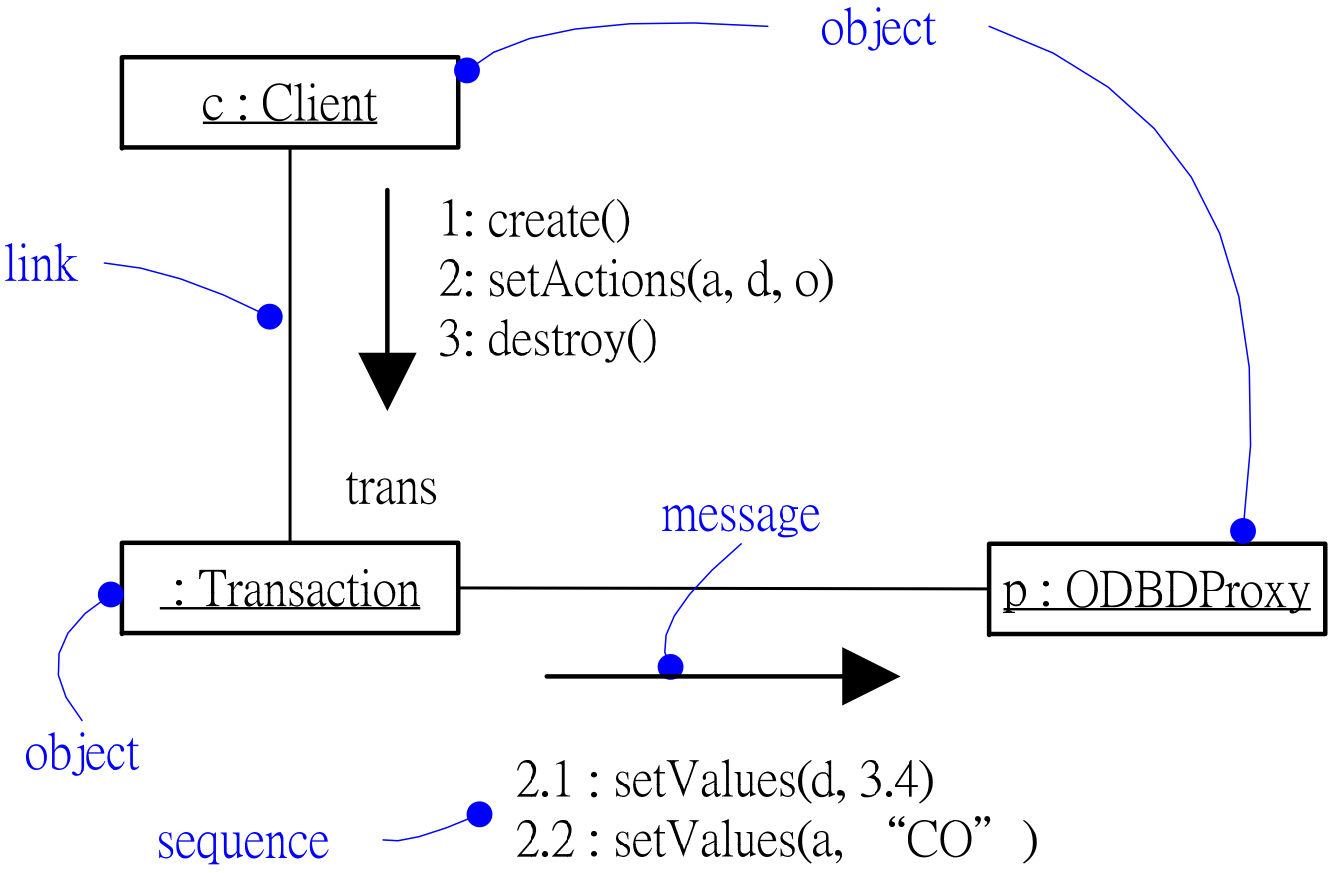
Realizations



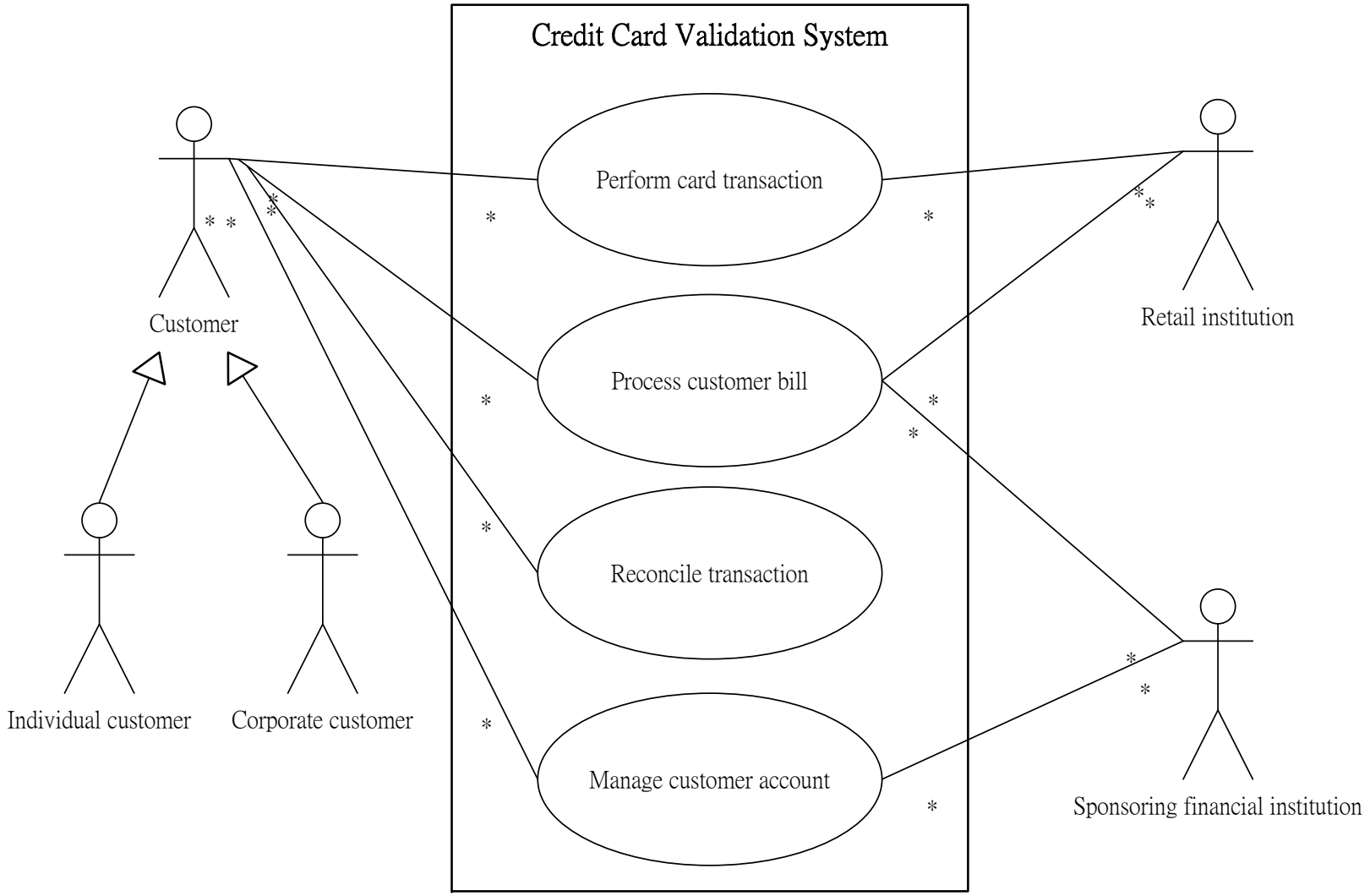
Sequence Diagram



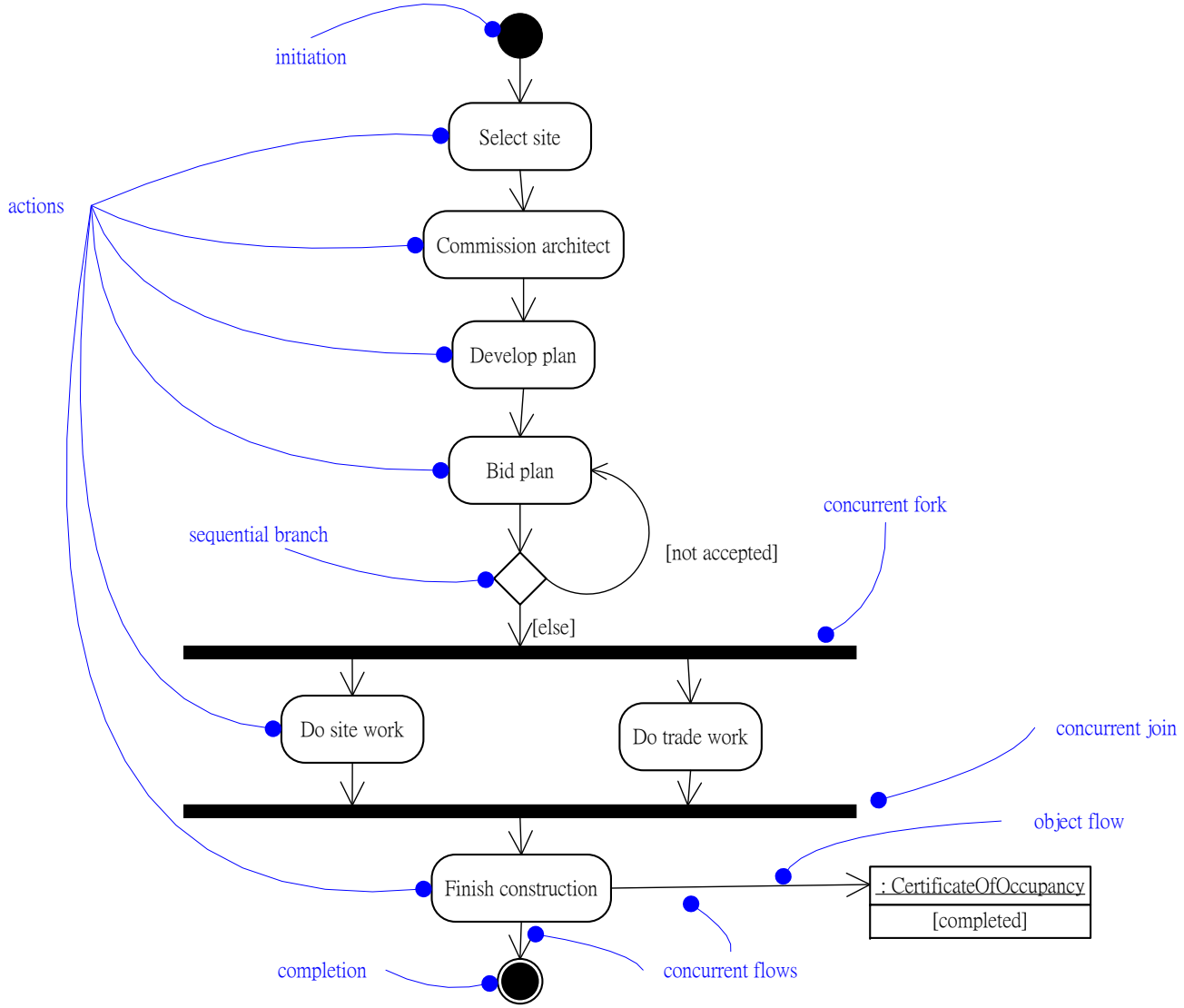
Communication Diagram



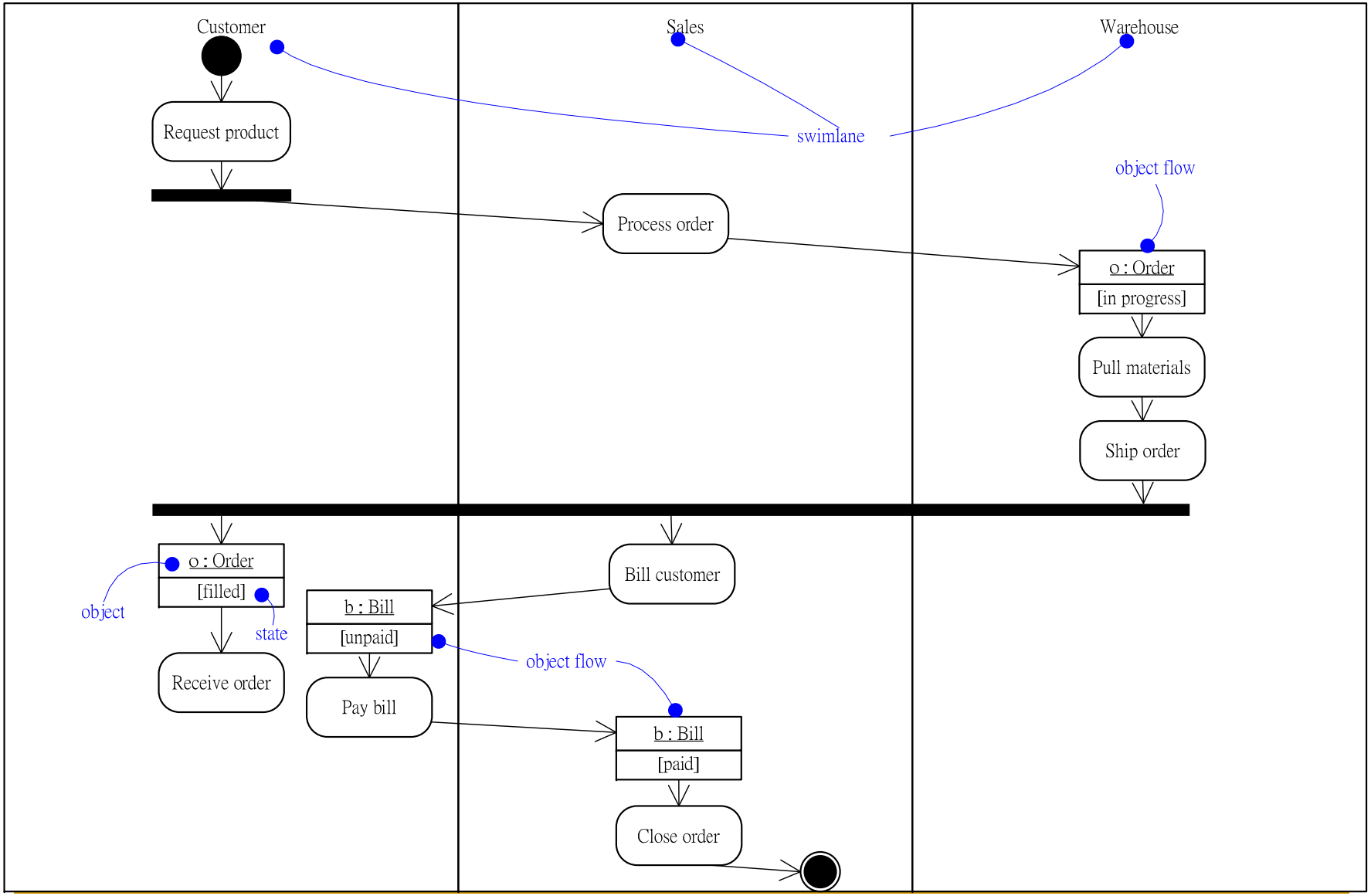
Use Case Diagram



Activity Diagram



Swimlanes and Object Flow



Remarks

- The best way to learn the UML is by actually using it.
- The term project is designed partly for this purpose.
- 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.