

# Introduction to UML 2.0

Software Engineering Laboratory

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(slides from '06 CS550 by Prof.Bae)



# UML Introduction

# What is UML?

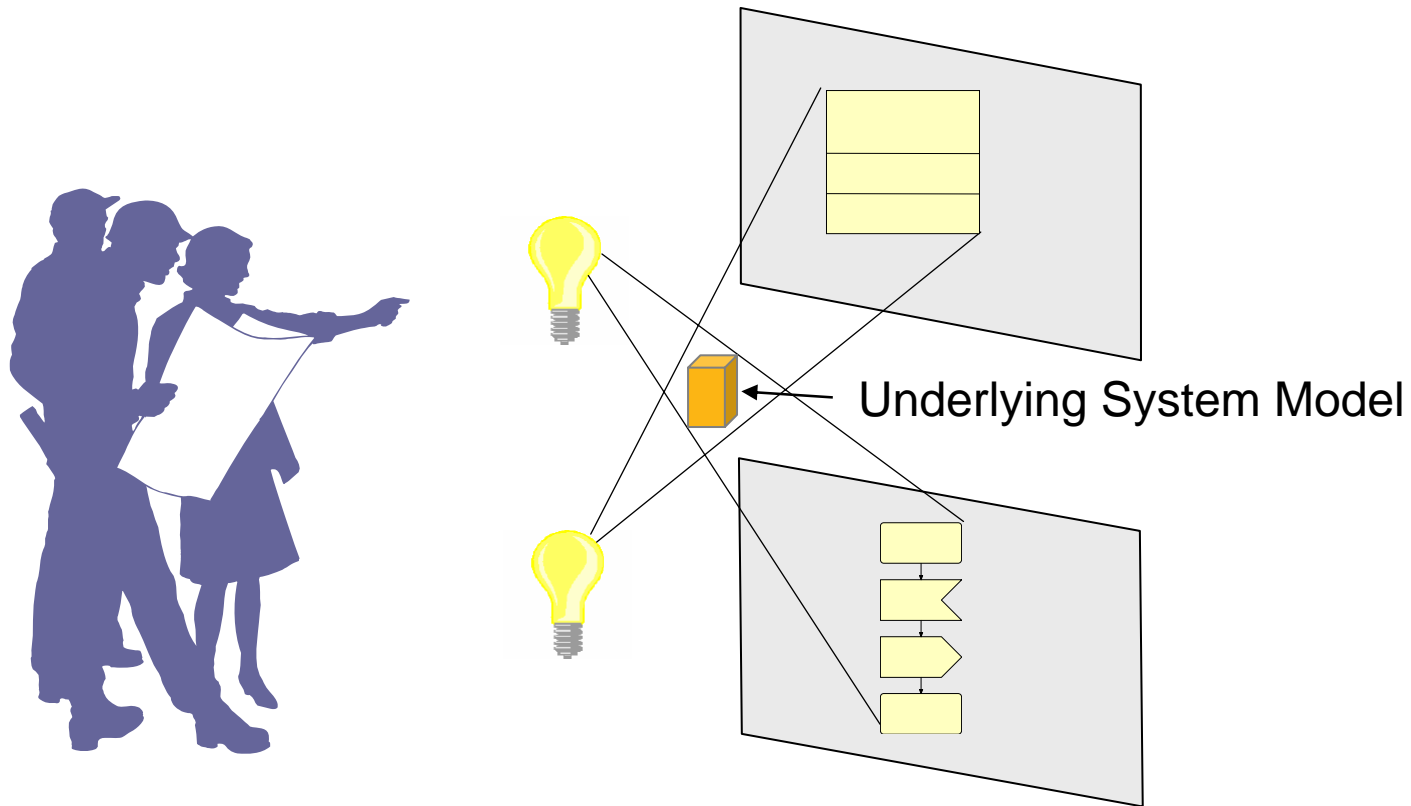
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- **Unified Modeling Language**
  - Visual language for specifying, constructing and documenting
- Maintained by the OMG (Object Management Group)
  - Website: <http://www.omg.org>
- Object-oriented
- Model / view paradigm
- Target language independent



# Model / View Paradigm

- Each diagram is just a view of part of the system
- Together, all diagrams provides a complete picture







# Use Case Diagrams

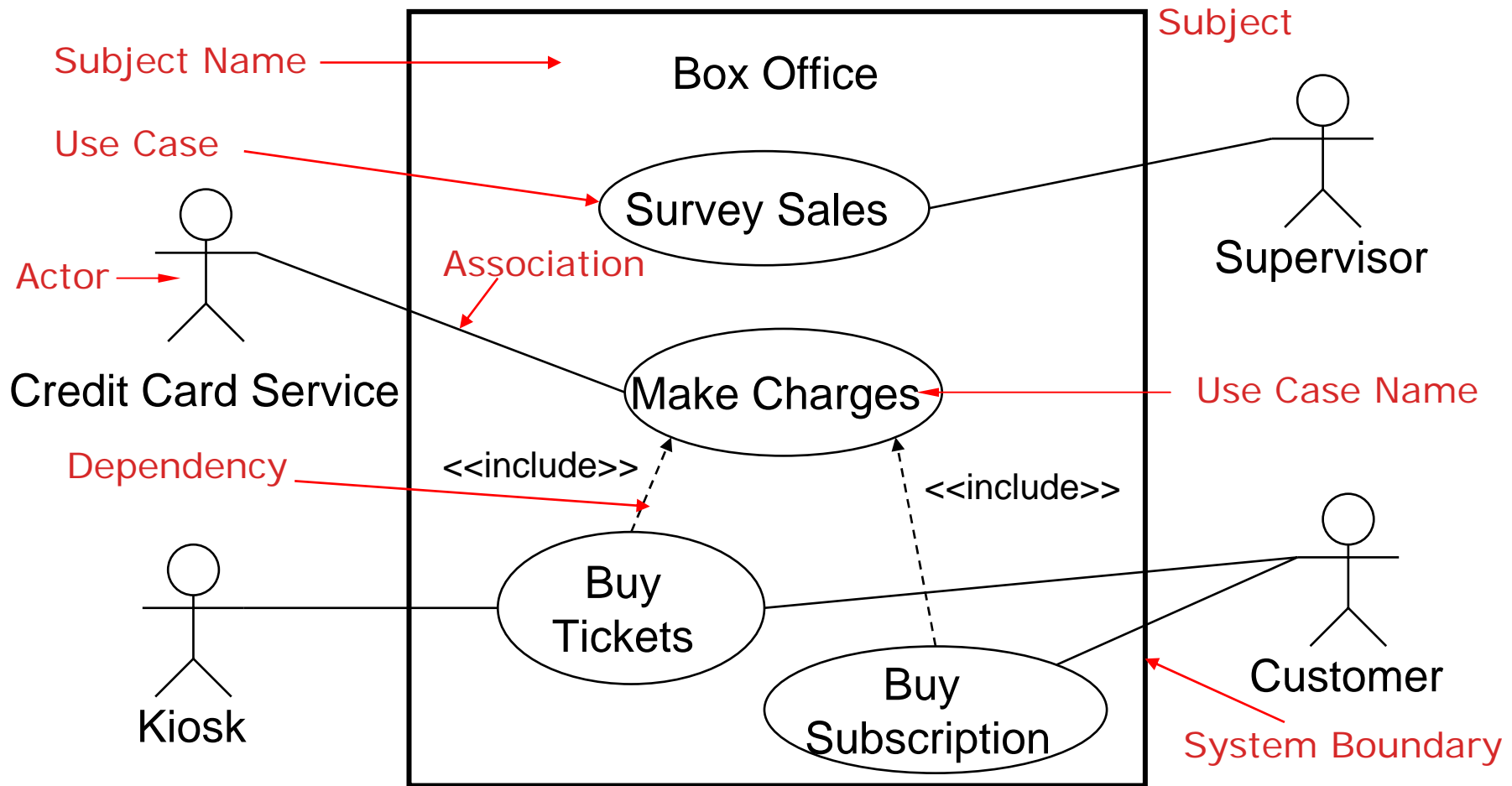
# What is a Use Case?

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*Use Case* ~ A **behavior** or coherent set of behaviors triggered by events **sent to the system** by human user(s), other systems, hardware components, or an internal clock

# Use Case Diagrams

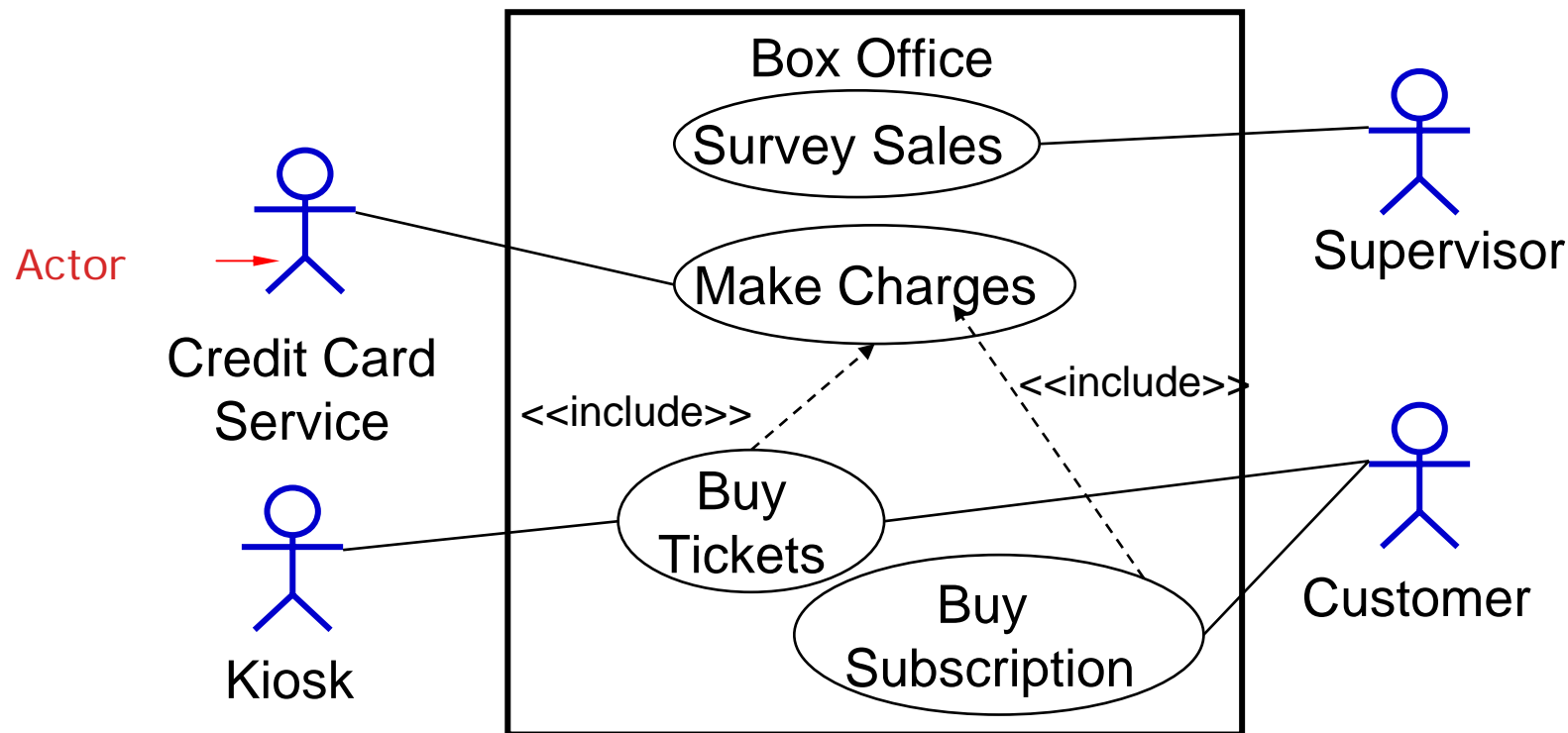
- Describe WHAT the system will do at a high-level





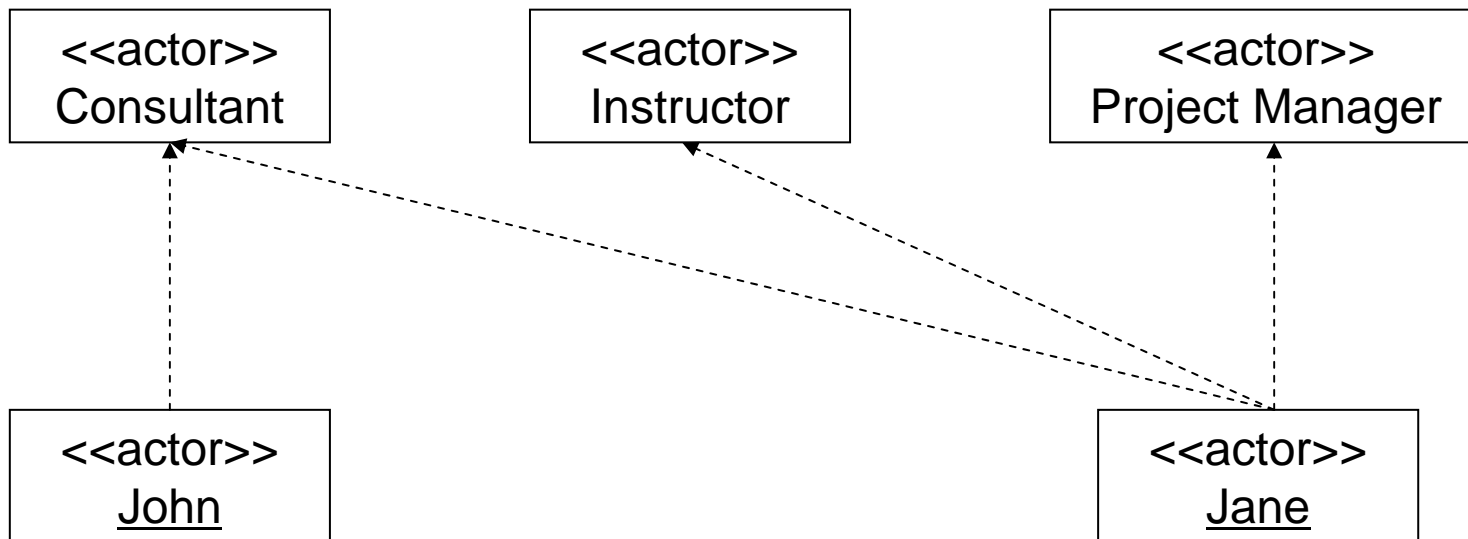
# Actor

- Someone or some thing that must interact with the system
  - Users, external systems, devices



# An Actor is a Role

- An actor defines a single role played by users in their interactions with the system:
  - Multiple users can play a single role
  - A single user may play multiple roles



# Identifying Actors

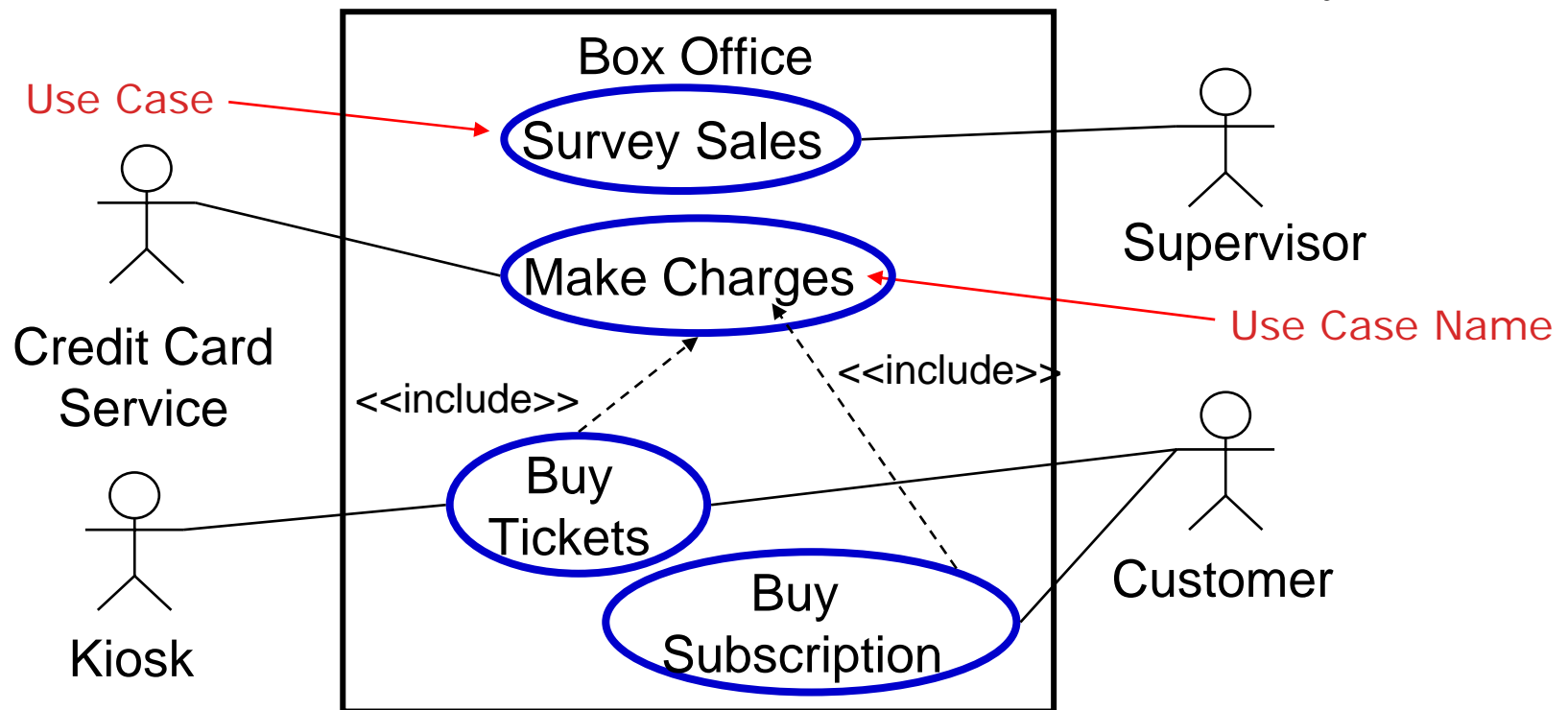
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- Useful questions
  - Who will **use the main functionality** of the system (primary actors)?
  - Who will need support from the system to their daily tasks?
  - Who will need to maintain, administrate, and keep the system working (secondary actors)?
  - Which hardware devices does the system need to handle?
  - With which other systems does the system need to interact?
  - Who or what has an interest in the results (the value) that the system produces?

(From [:oopsia.snu.ac.kr/research/UML/](http://oopsia.snu.ac.kr/research/UML/) )

# Use Case

- Unit of functionality expressed as a transaction among actors and the subject
- Interaction between one or more actors and the system



# Use Case

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- Identifying Use Cases
  - Which **functions** does the **actor require** from system?
  - Does the actor need to **read, create, destroy, modify, or store** some kind of **information** in the system?
  - Does the actor have **to be notified about events** in the system
  - Could the actor's daily work be simplified or made more **efficient through new functions** in the system

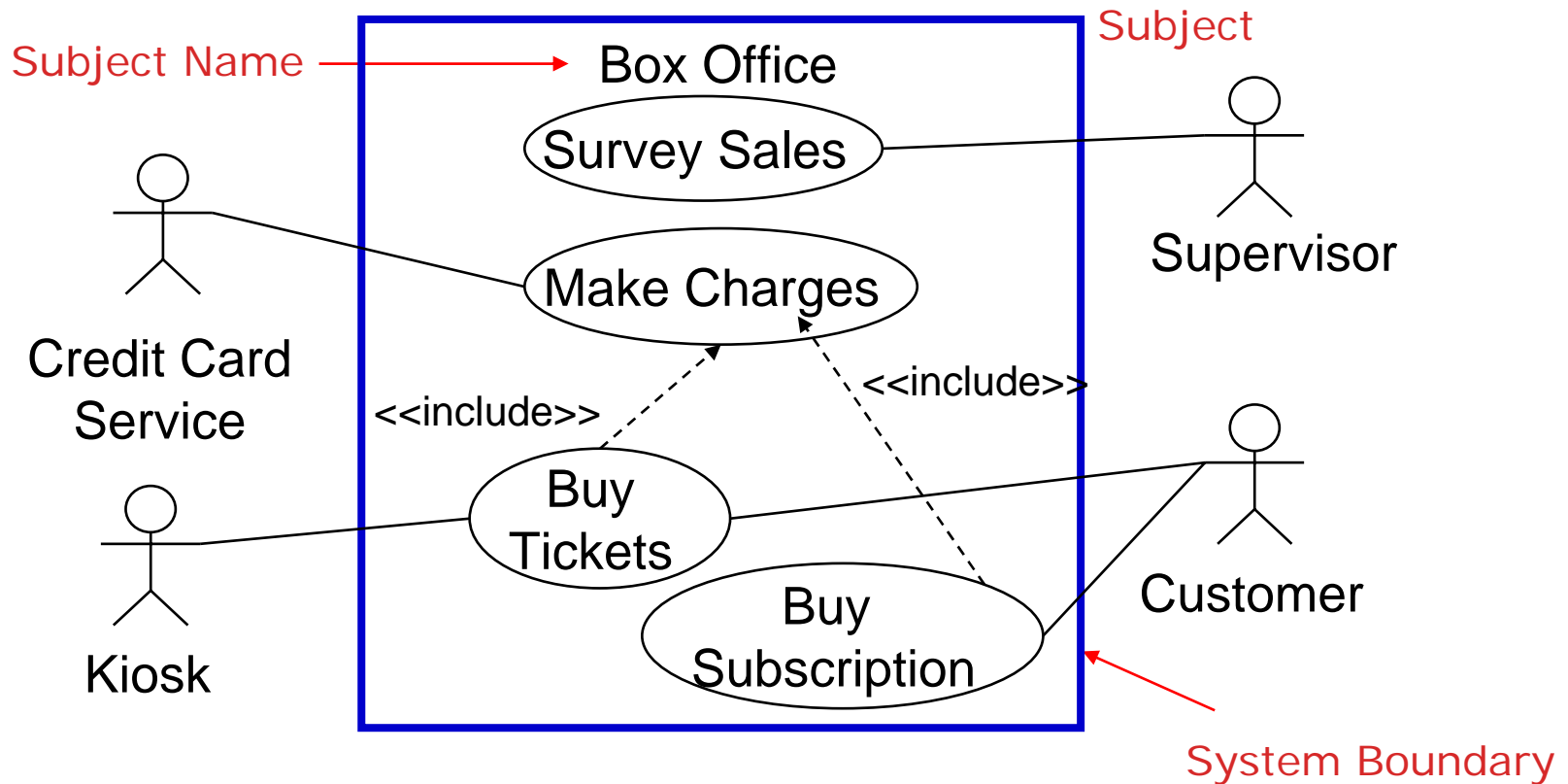
# An Example of Use Case Text

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- Buy a Product
  - **Main Success Scenario :**
    - 1 . **Customer browses catalog and selects items to buy**
    - 2 . **Customer goes to check out**
    - 3 . **Customer fills in shipping information (address ; next-day or 3-day delivery)**
    - 4 . **System presents full pricing information, including shipping**
    - 5 . **Customer fills in credit card information**
    - 6 . **System authorizes purchase**
    - 7 . **System confirms sale immediately**
    - 8 . **System sends confirming e-mail to customer**
  - **Extensions :**
    - 3a : Customer is regular customer**
      - .1 : System displays current shipping, pricing, and billing information
      - .2 : Customer may accept or override these defaults, returns to MSS at step 6
    - 6a : System fails to authorize credit purchase**
      - .1 : Customer may reenter credit card information or may cancel

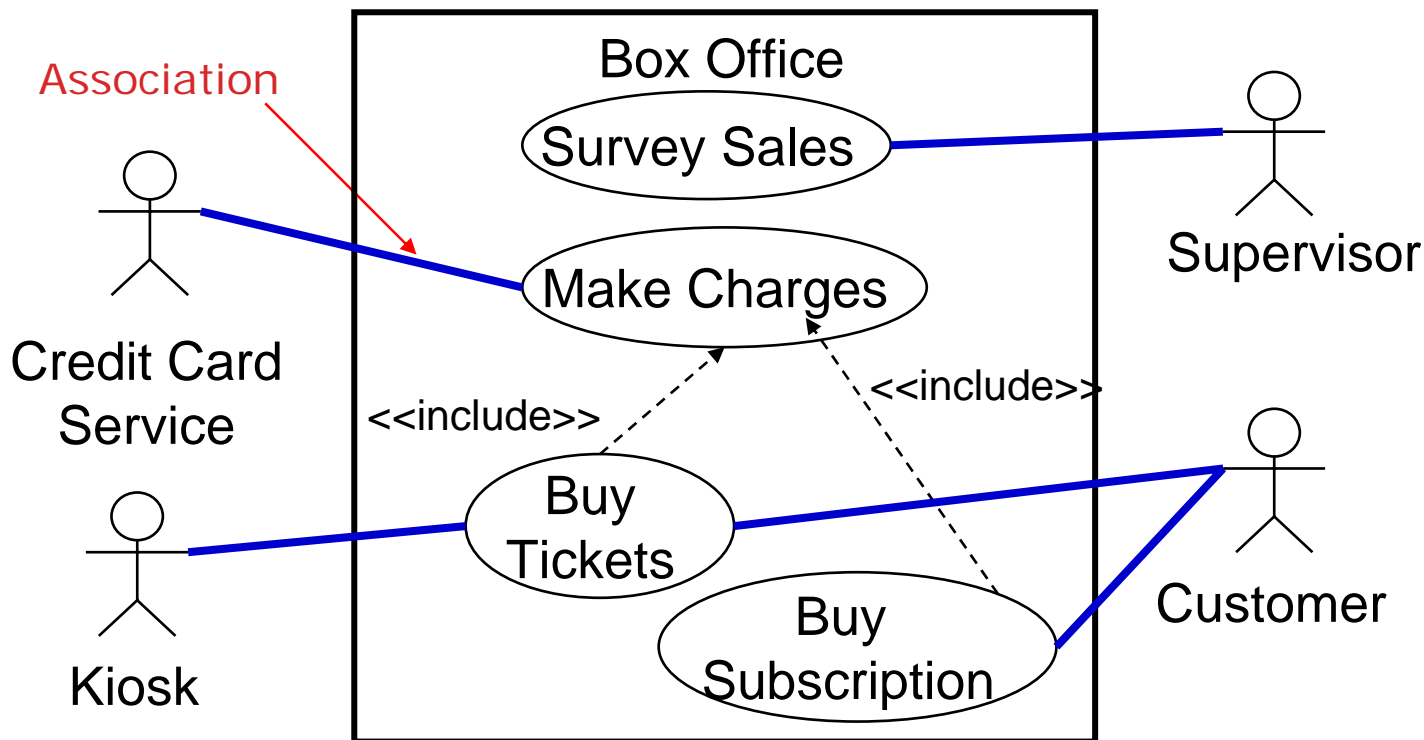
# Subject Symbol

- Indicate system boundary
  - Classifier that realizes behavior defined by a use case



# Association

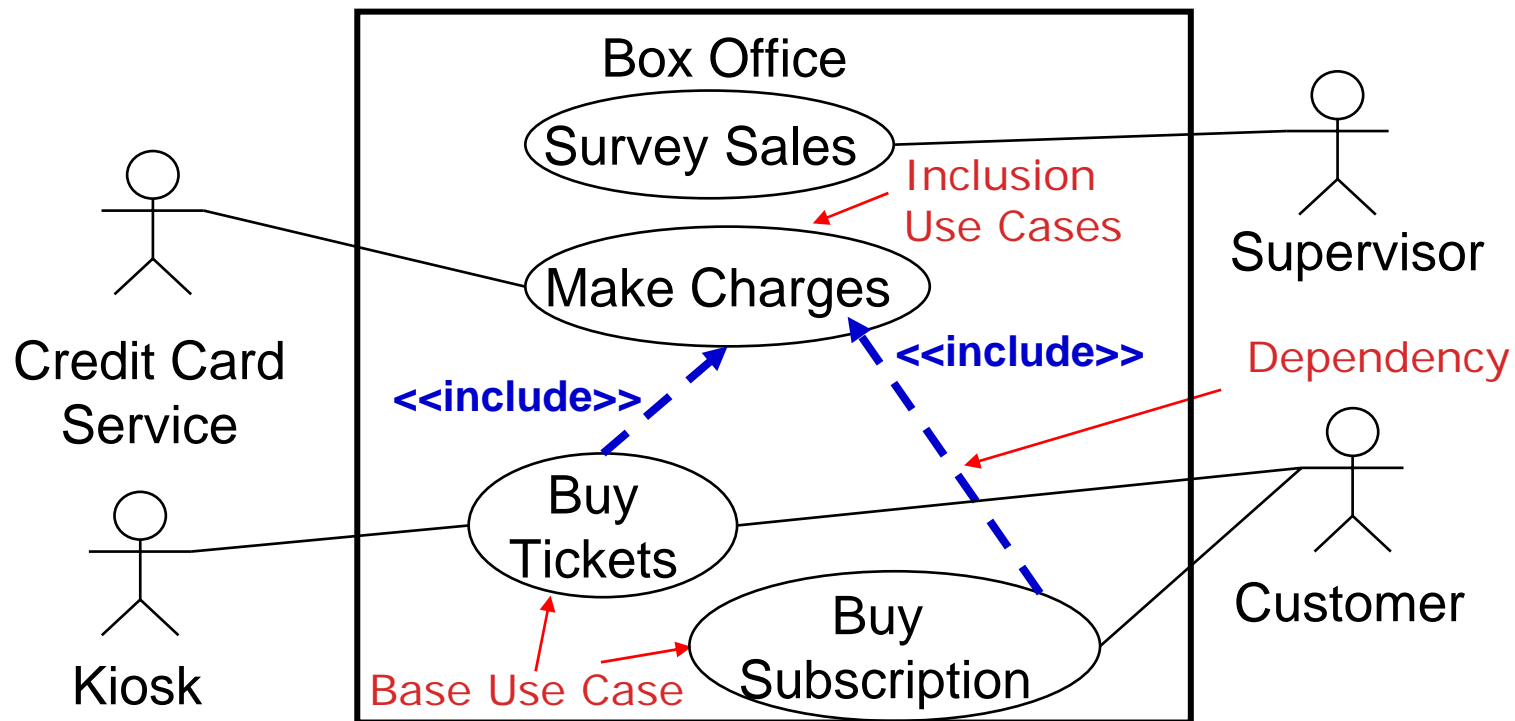
- Represent bi-directional communication between the actor and the system
- Drawn between an actor and a use case





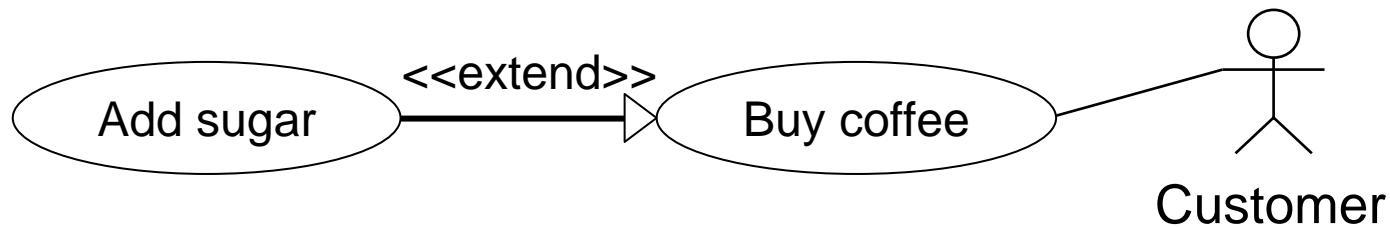
# Dependency – Include

- Represent relationship from a *base* to an *inclusion* use case
- Imply a Use Case **calls another Use Case**
- Primarily used to **reuse** behavior common to several Use Cases



# Dependency – Extend

- Used when some **additional** behavior should be added
  - Models **optional or conditional** behavior
  - Show infrequent events



# Tips for Use Case Modeling

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- Make sure that each use case describes a significant chunk of system usage that is **understandable by both domain experts and programmers**
- When defining use cases in text, use **nouns and verbs accurately and consistently** to help derive objects and messages for interaction diagrams
- **Factor out common usages** that are required by multiple use cases
  - If the usage is required use `<<include>>`
  - If the base use case is complete and the usage may be optional, consider use `<<extend>>`
- A use case diagram should
  - contain only use cases at the **same level of abstraction**
  - include **only actors** required
- Large numbers of use cases should be organized into packages

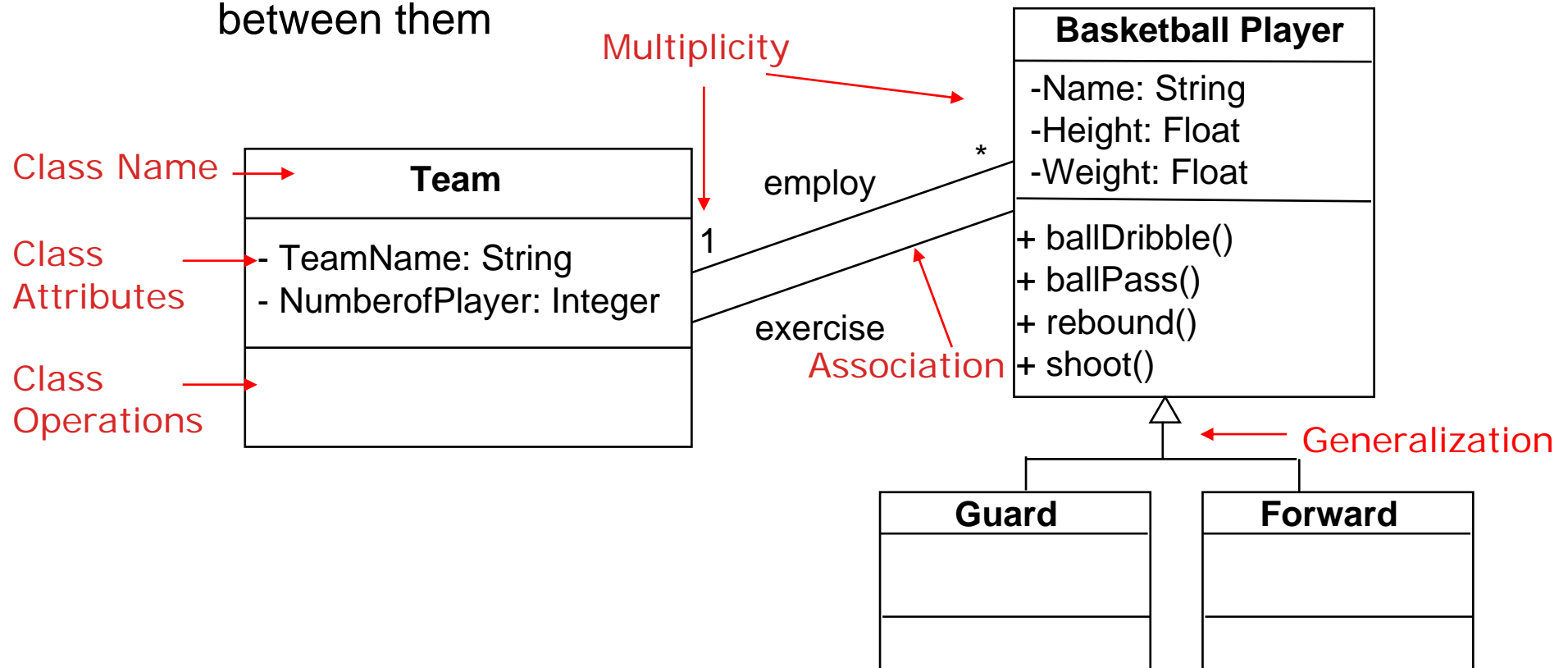
(From [:oopsia.snu.ac.kr/research/UML/](http://oopsia.snu.ac.kr/research/UML/) )



# Class Diagrams

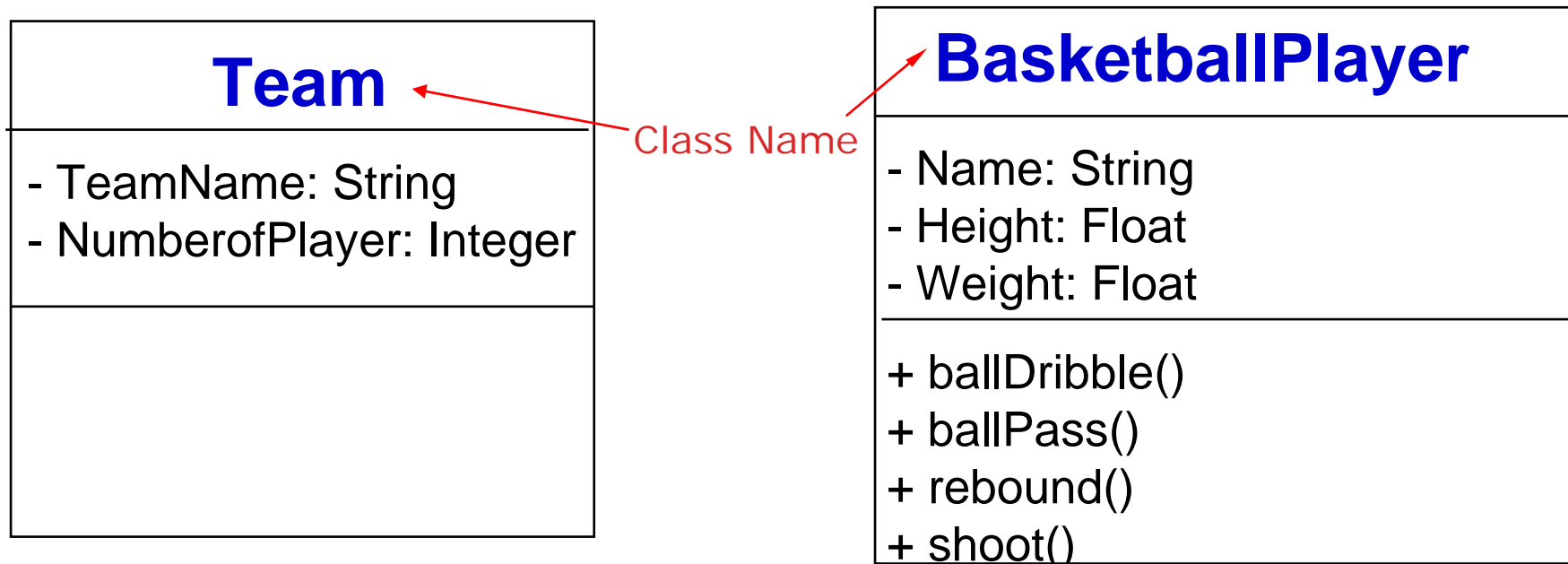
# Class Diagrams

- Description of **static** structure
  - Showing the **types** of objects in a system and the **relationships** between them



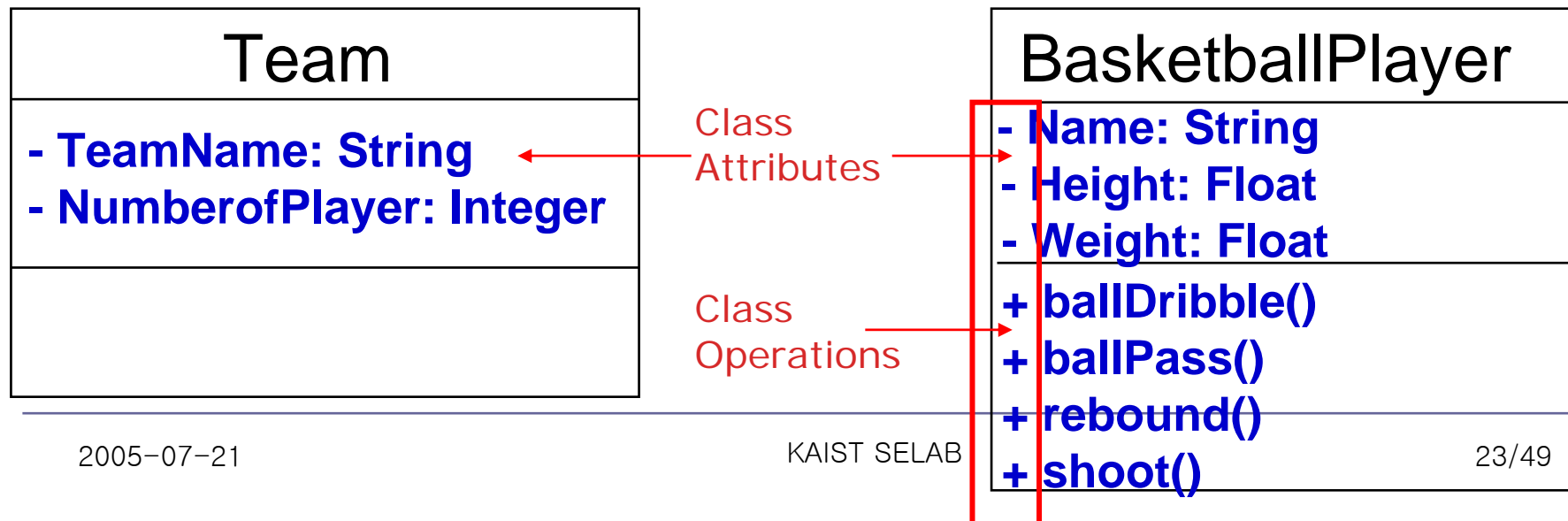
# Classes

- Most important building block of any object-oriented system
- Description of a set of objects
- Abstraction of the entities
  - Existing in the problem/solution domain



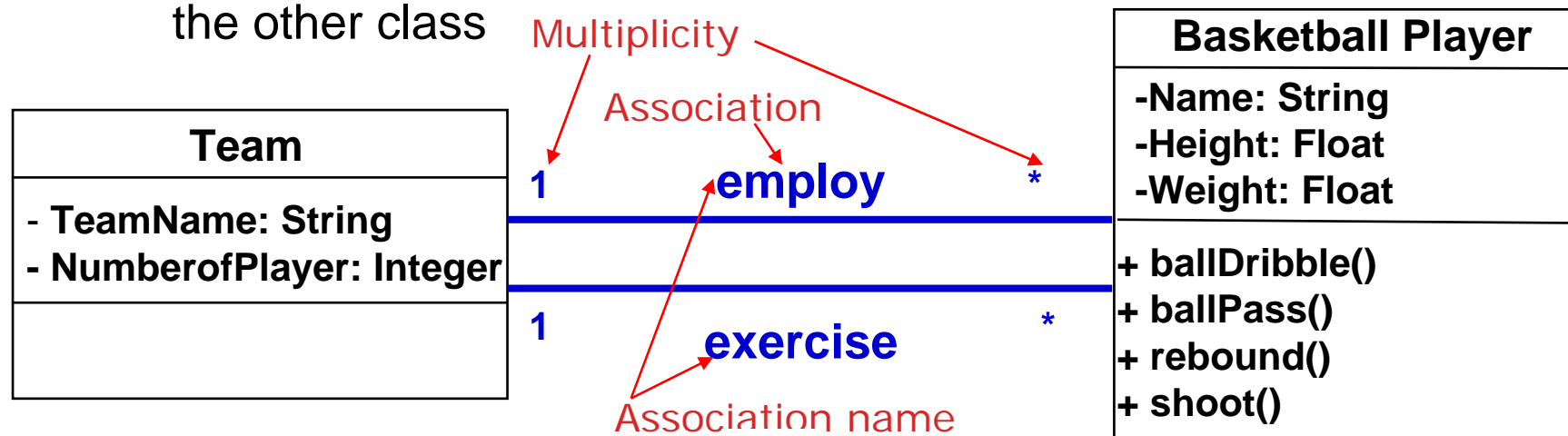
# Attributes and Operations

- Attributes
  - Represent some property of the thing being modeled
  - Syntax: attributeName : Type
- Operations
  - Implement of a service requested from any object of the class
  - Syntax: operationName(param1:type, param2:type, ...) : Result



# Association and Multiplicity

- Association
  - Relationship between classes that specifies connections among their instances
- Multiplicity
  - Number of instances of one class related to ONE instance of the other class

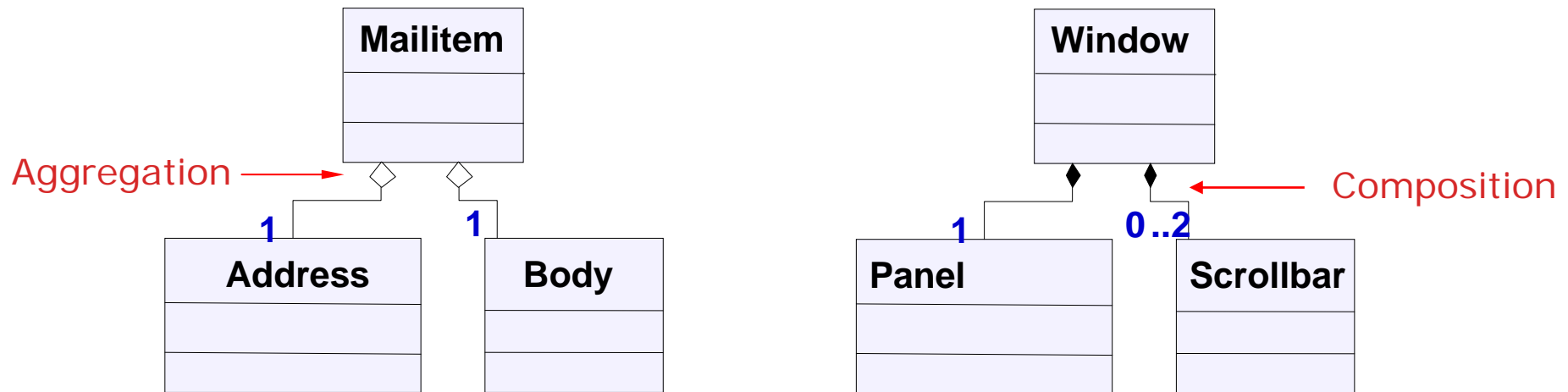


“Team employs one or more basketball players”  
“ Basketball players exercise in the team”



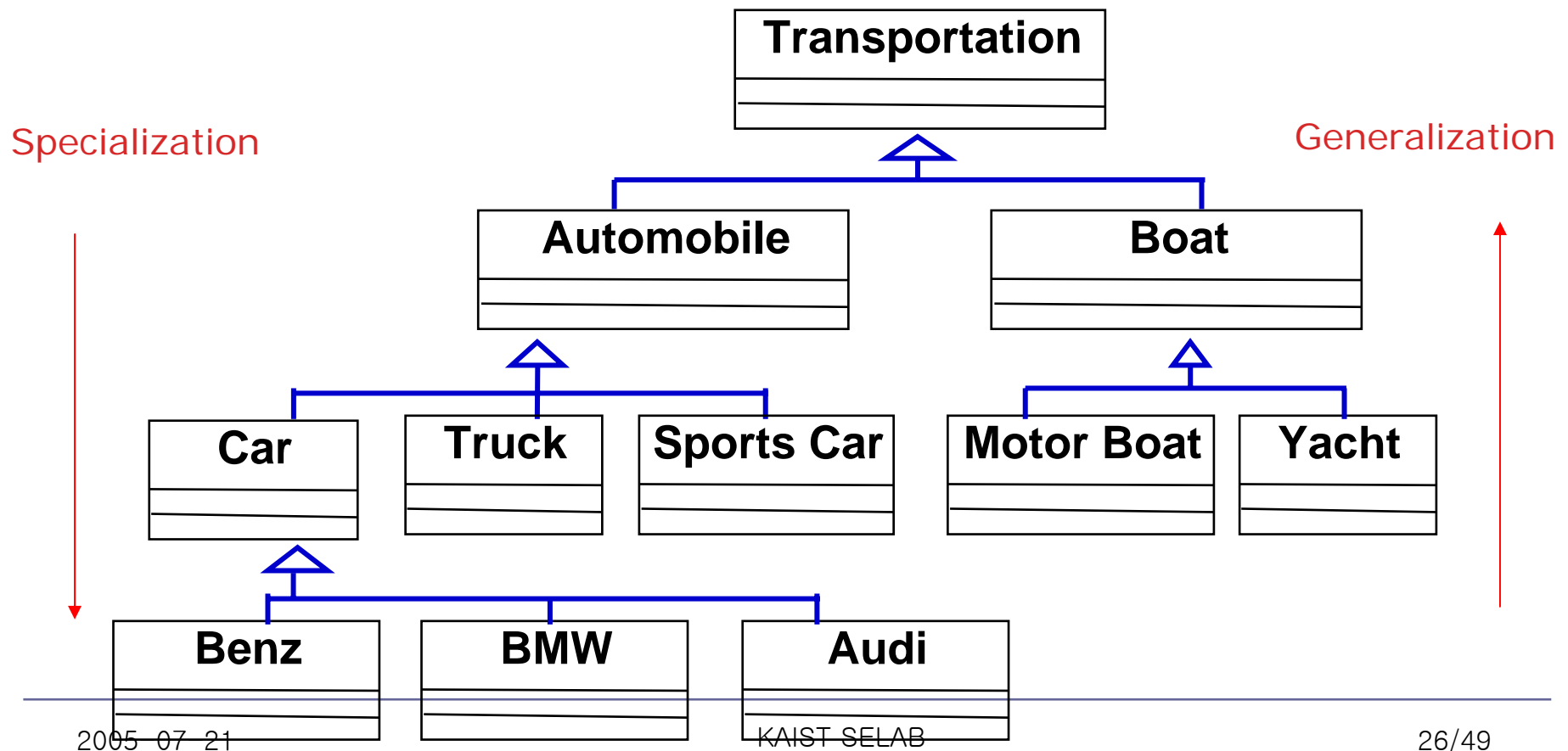
# Aggregations and Compositions

- Aggregation
  - **Weak** “whole-part” relationship between elements
    - Mailitem ‘has a’ address
- Composition
  - **Strong** “whole-part” relationship between elements
    - Window ‘contains a’ scrollbar



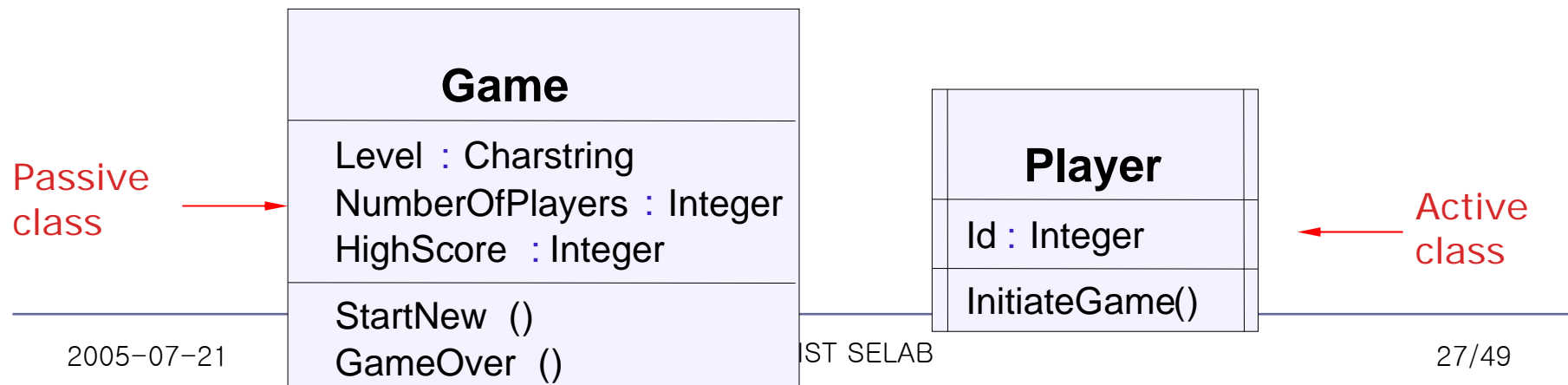
# Inheritance

- Relationship between **superclass** and **subclasses**
  - All attributes and operations of the superclass are part of the subclasses



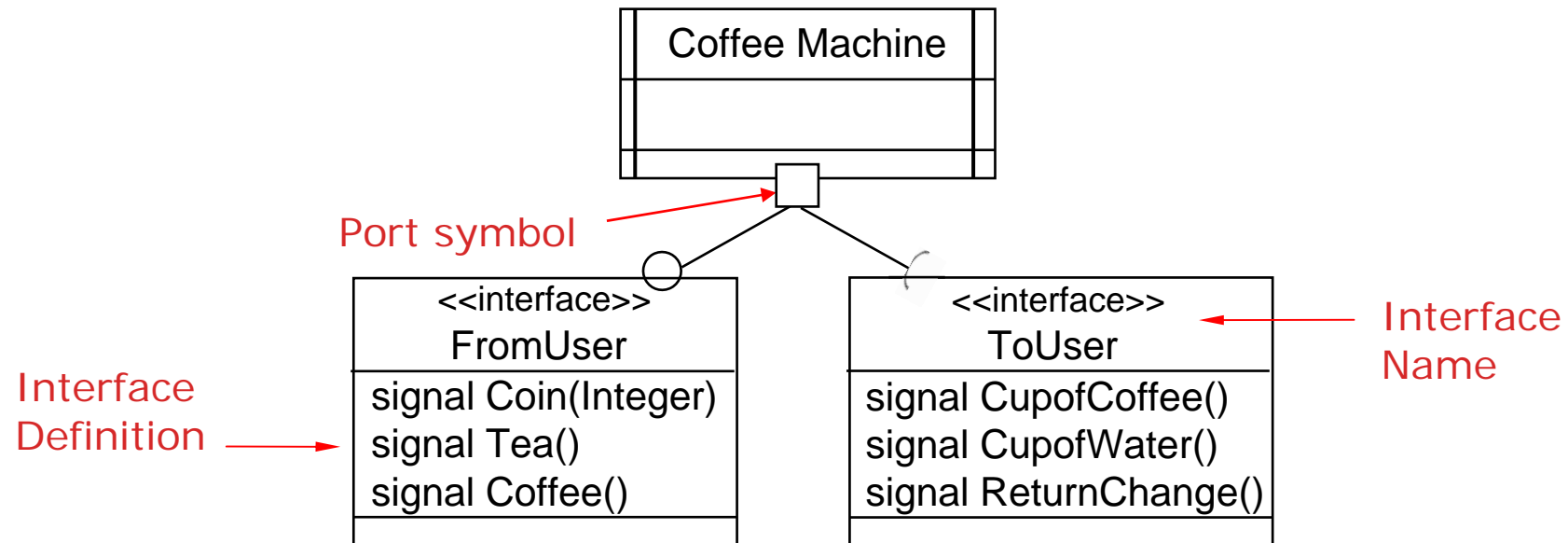
# Active vs. Passive Class

- Active class
  - Own a **thread control** and can initiate control activity
    - Used when asynchronous communication is necessary
    - Typically modeled with a state machine of its behavior
    - Encapsulated with **ports** and **interfaces**
- Passive class
  - Own address space, but not thread of control
    - Executed under a control thread anchored in an active object



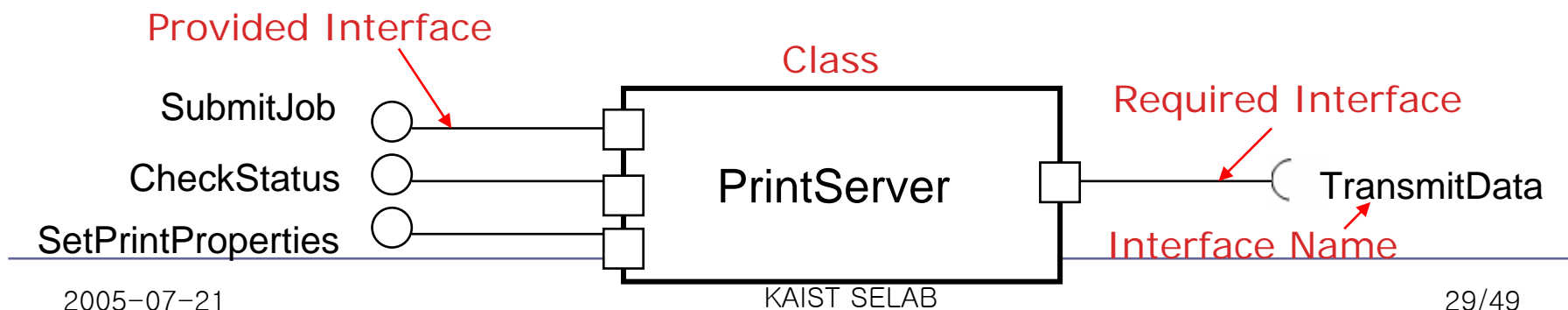
# Ports and Interfaces

- Ports
  - Define an interaction point on a classifier with **external environment**
- Interfaces
  - Describe behavior of objects without giving their implementations
    - **Each class implements the operations found in the interface**

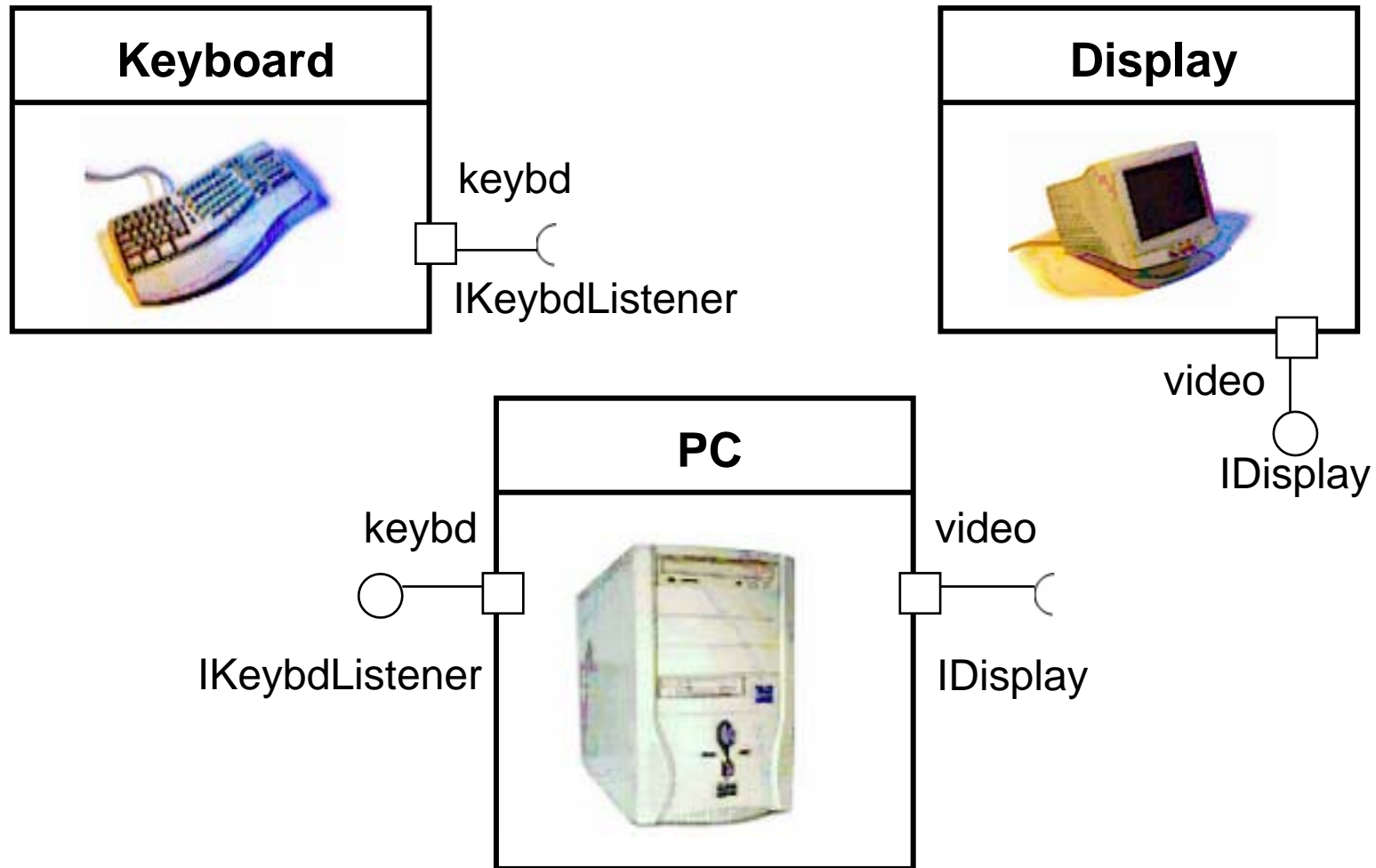


# Provided/ Required Interface

- Provided interface
  - Class provides the services of the interface to outside callers
  - What the **object can do**
  - Services that a message **to** the port may request (incoming)
- Required interface
  - Class uses to implement its internal behavior
  - What the object **needs to do**
  - Services that a message **from** the port may require from external environment (outgoing)



# Computer Device Example



# Tips for Class Modeling

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- Finding Classes
  - Do we have that should be stored or analyzed ?
  - Do we have external system ?
    - **External system is modeled as class**
  - Do we have any patterns, class libraries, components, and so on ?
  - Are there devices that the system must handle ?

(From [:oopsia.snu.ac.kr/research/UML/](http://oopsia.snu.ac.kr/research/UML/) )

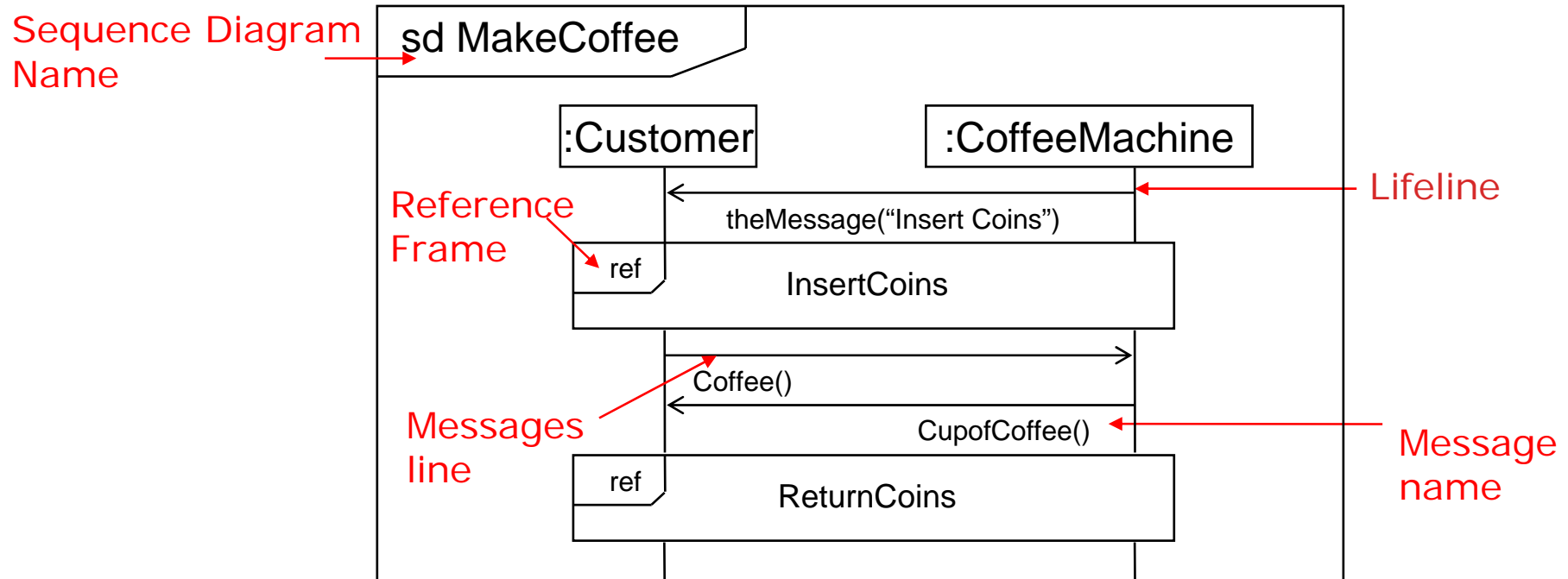


# Sequence Diagrams



# Sequence Diagrams

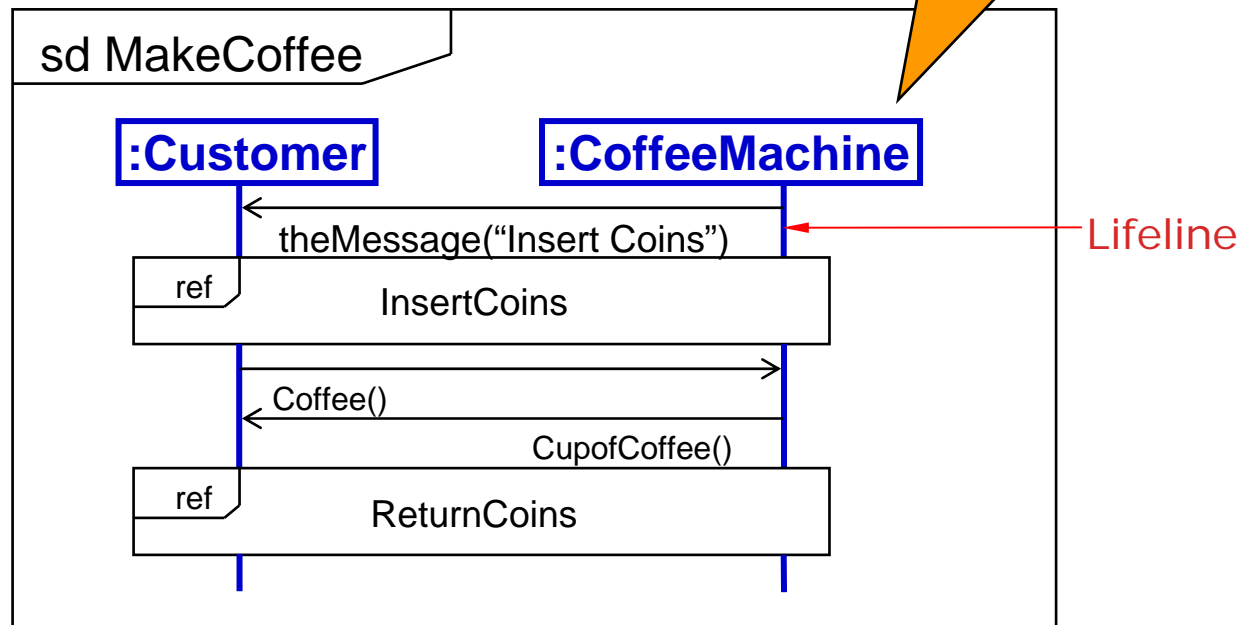
- Show sequences of messages (“interactions”) between instances in the system
- Emphasize time ordering



# Lifelines

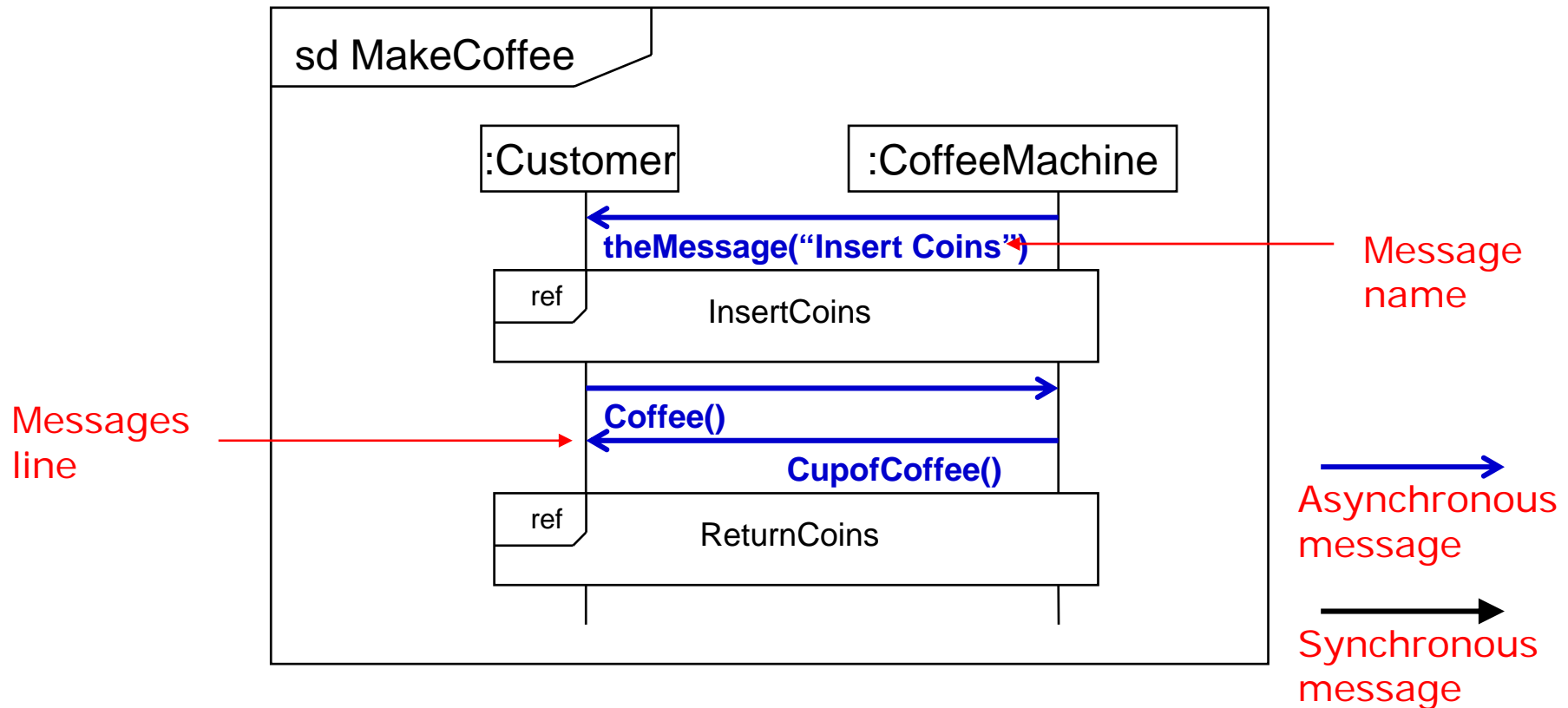
- Individual participant in the interaction over period time
  - Subsystem/ object/ class
  - Actor

Instance name (object) :  
Type name (class)



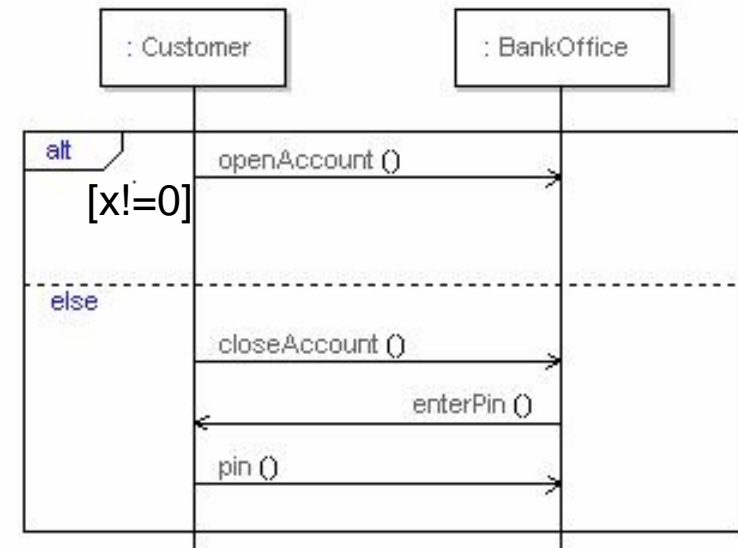
# Messages

- One-way communication between two objects
- May have parameters that convey values



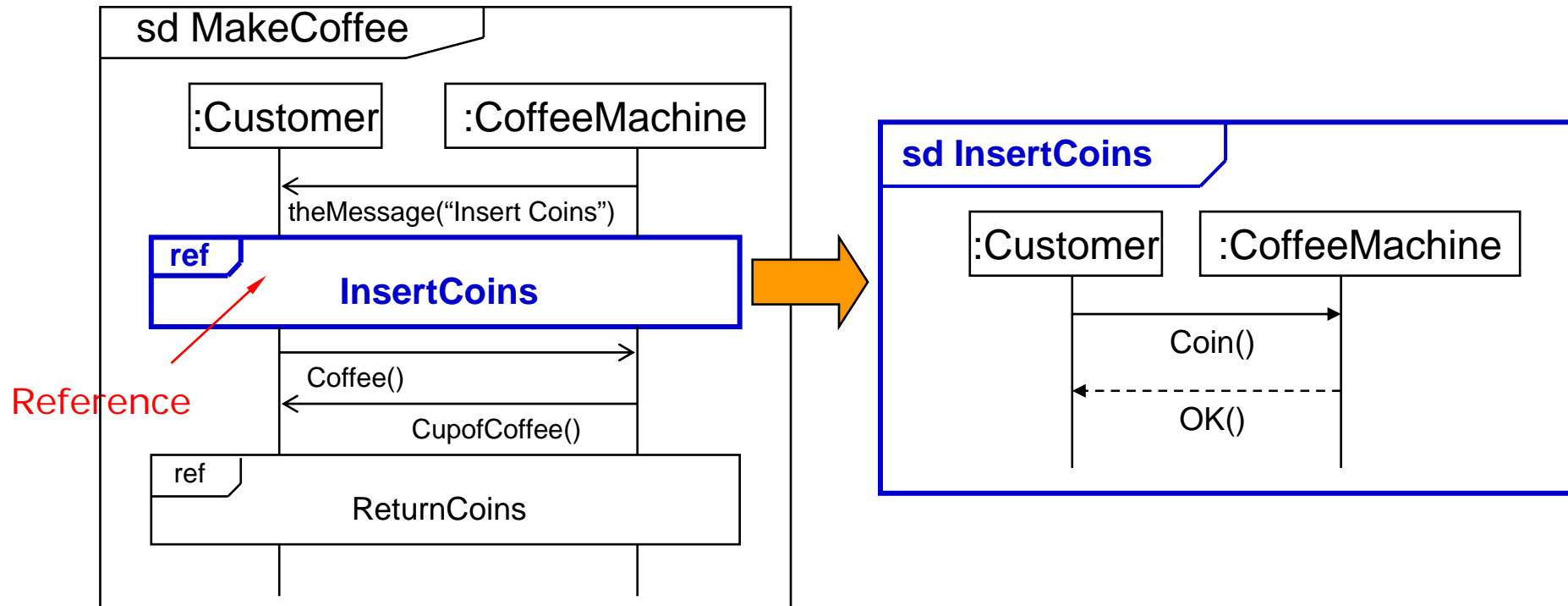
# Combined Fragment Frame

- Defines an expression of interaction fragments
- Interaction operators define how the contents describe behavior
  - Alt: each section is one alternative
    - E.g. **alt [a>0]**
  - Ref: reference to another Use Case
  - Loop: specifies a repeated sequence of behavior
    - E.g. **'loop [1,5]'**, **'loop [6]'**



# Referencing

- Reuse already existing sequence diagrams
  - Avoid unnecessary duplication



# Tips for Sequence Diagram

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- Set the **context** for the interaction.
  - E.g. one use case
- Express the flow from left to right and from top to bottom.
- Put active instances to the left/top and passive ones to the right/bottom.

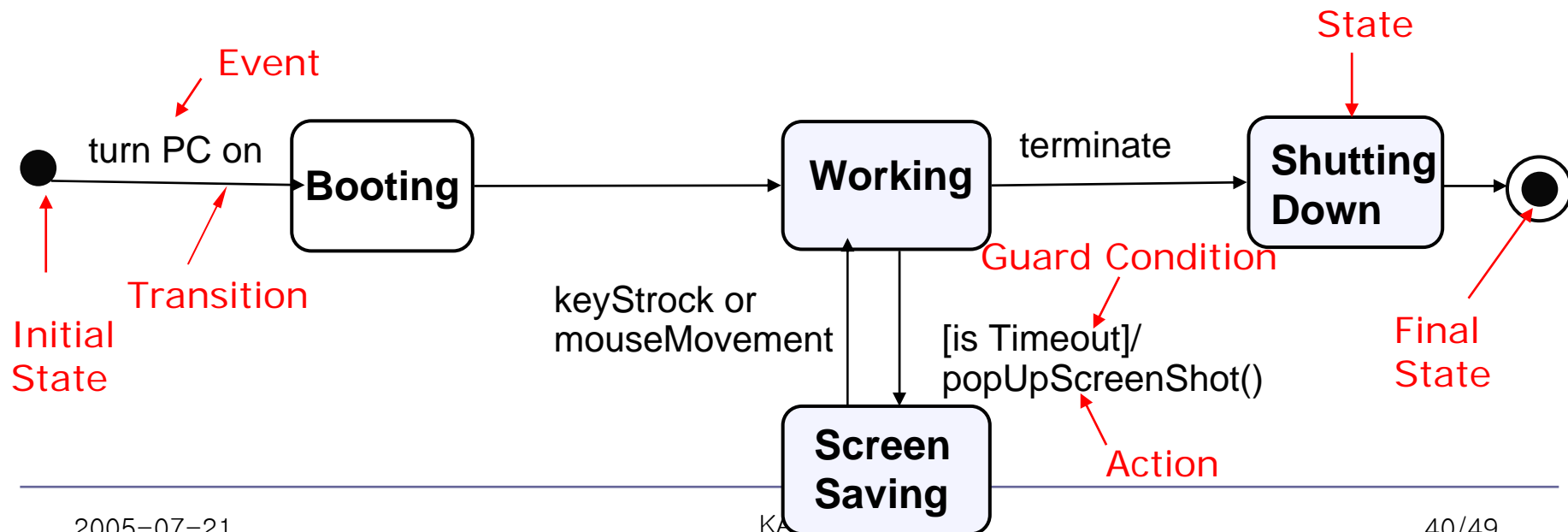
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# State Machine Diagrams

# State Machine Diagrams

- Describe the dynamic behavior of **objects** over time by modeling the lifecycles of **objects of each class**
- Show
  - The **event** that cause a transition from one state to another
  - The **actions** that result from a state change



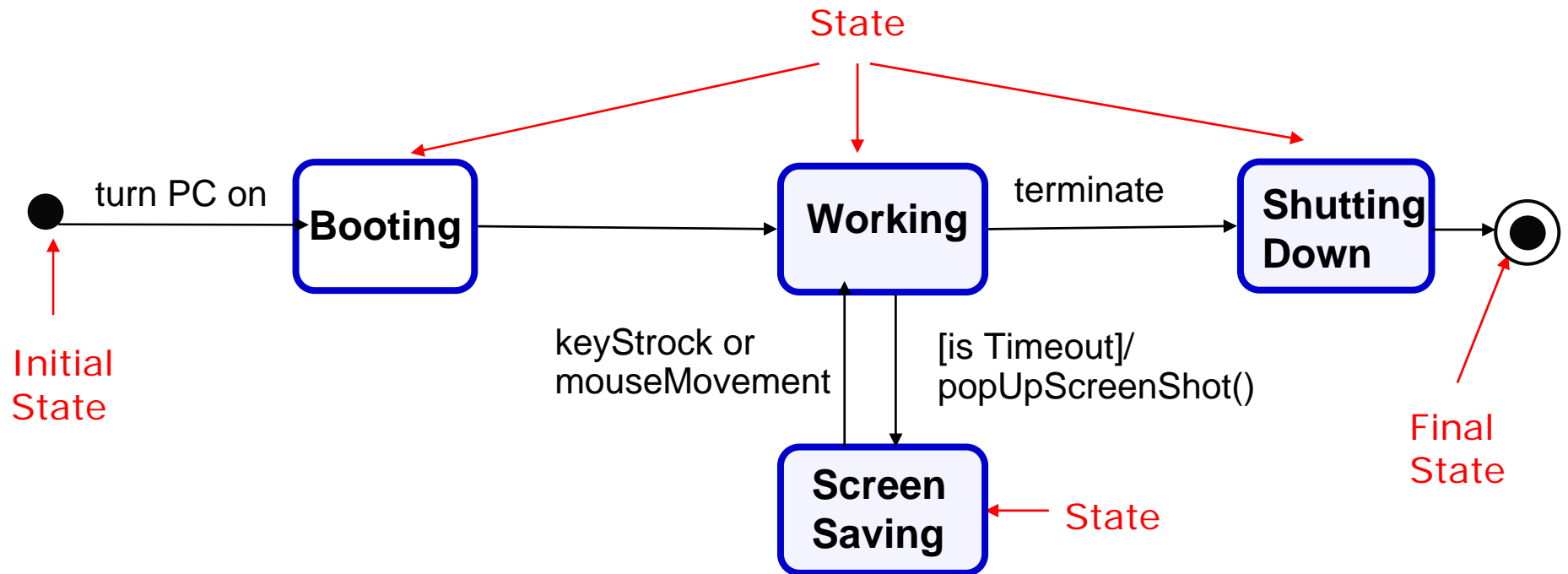


# States

- State

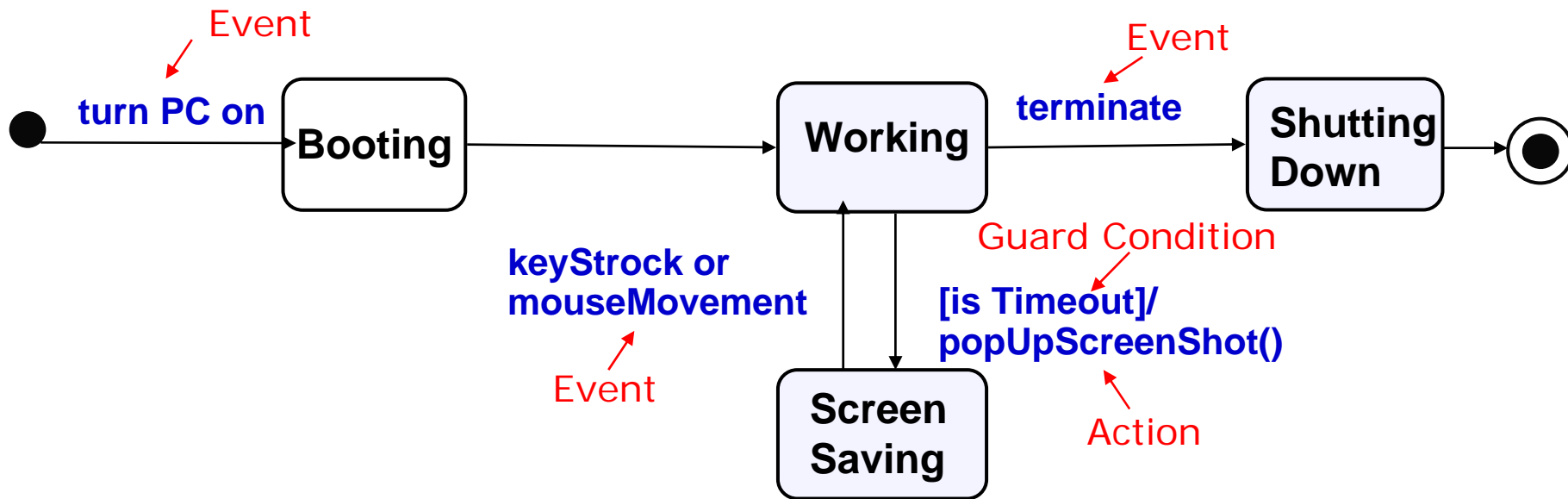
- Condition or situation during the life of an object

- Satisfies some condition, performs some activity or waits for some event



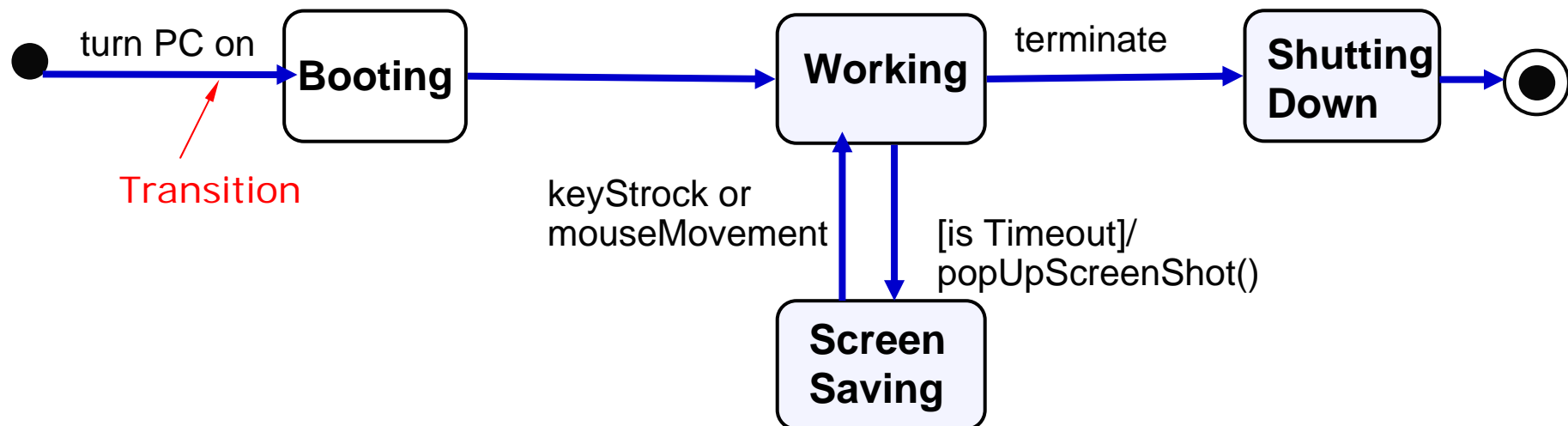
# Event and Action

- Event
  - Stimulus which causes the object to change state
- Action
  - Output of a signal or an operation call



# Transition

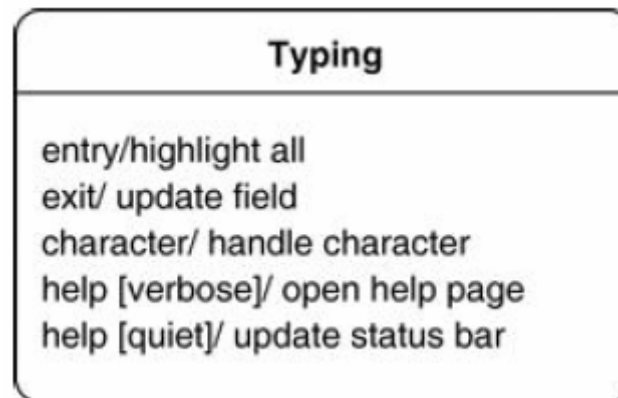
- Change state from one to another triggered by an event
- Occur only when guard condition is true
- Syntax: event(arguments)[condition]/action



# Internal Activities

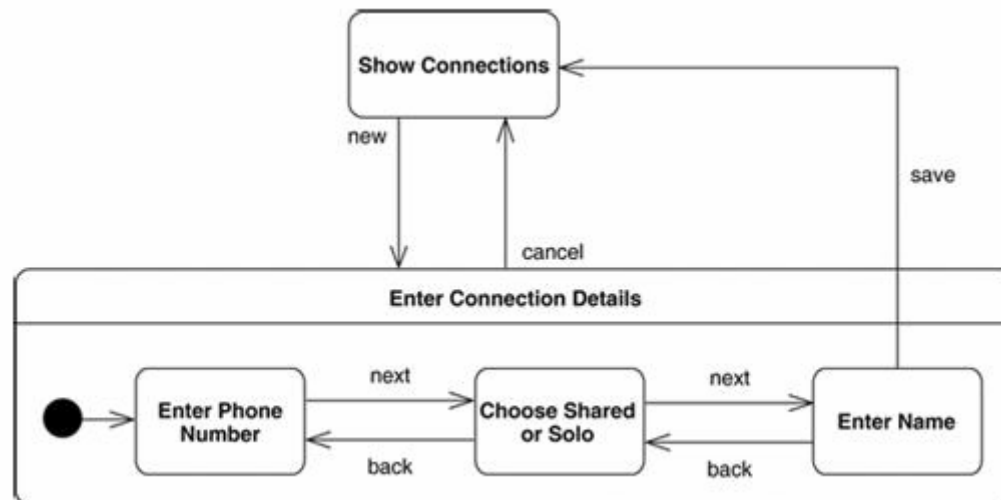
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- States can react to events without transition
  - Putting the event, guard, and activity inside the state box
  - Two special activities
    - The entry and exit activities
- Internal activities do not trigger the entry and exit activities



# Superstates

- Several states share common transitions and internal activities
  - Move the shared behavior into a superstate
  - A behavior can be expressed in a modular/hierarchical way



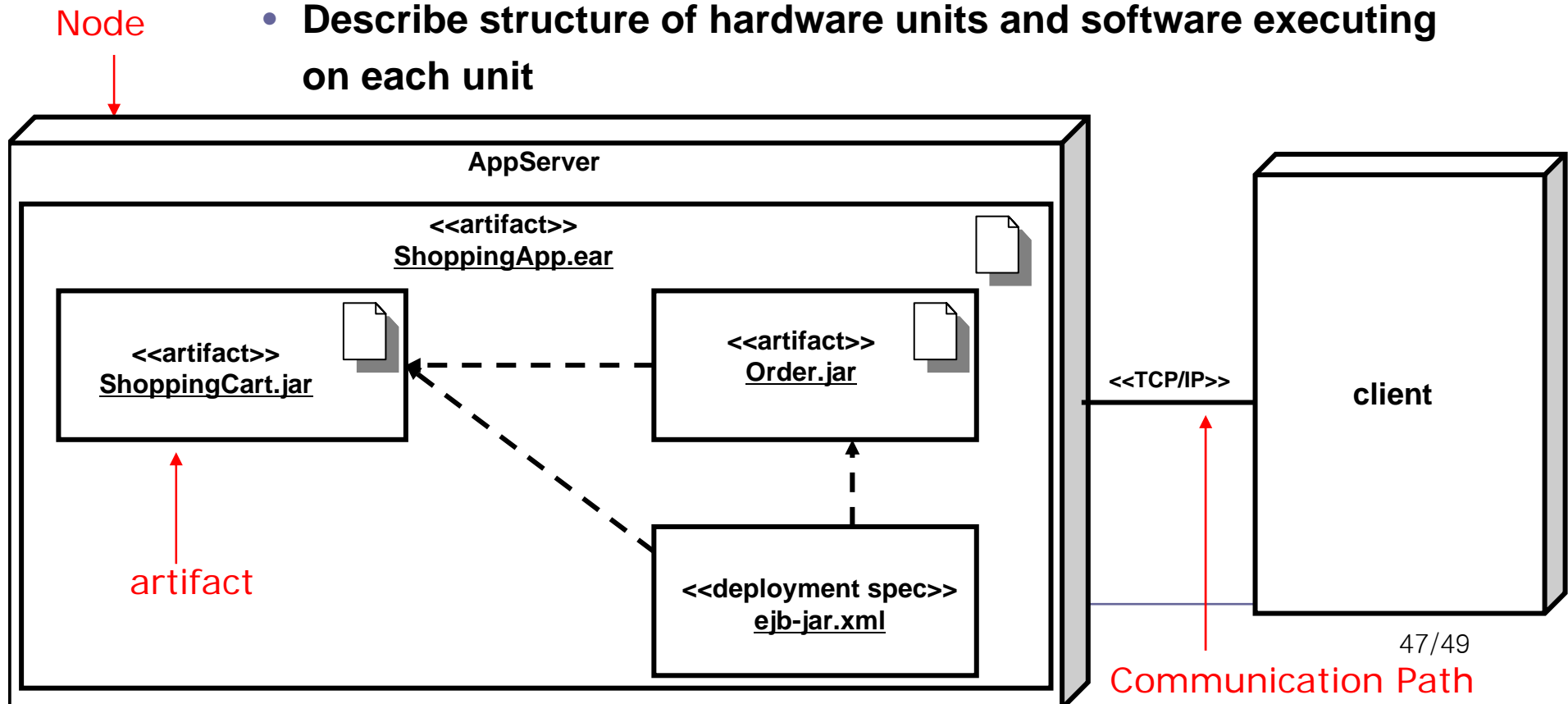


# Deployment Diagrams

# Deployment Diagrams

- Show runtime architecture of devices, execution environments, and artifacts in architecture
  - Physical description of system topology

- Describe structure of hardware units and software executing on each unit



# Deployment Diagrams

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- Node
  - Computational resource upon which artifacts may be deployed for execution
- Communication path
  - Show connection between nodes
    - **Stereotype can be used for communication protocol or network used**
- Artifact
  - Specification of a physical piece of information that is used or produced by a software development process, or by deployment and operation of a system.
    - **Examples of artifacts include model files, source files, scripts, and binary executable files, a table in a database system, a development deliverable, or a word-processing document, a mail message.**



# Summary

- UML can be used as
  - Sketch level
  - Blue print level
  - Programming language level
- Use appropriate UML diagrams for different goals
  - If you just starts your SE projects, **start** with
    - **Use-case diagrams with use-case texts**
  - If you want to look at behavior across **many use cases** or many threads,
    - **Activity diagram**
  - If you want to look at the behavior of **several objects** within a single use case,
    - **Sequence diagrams**
  - If you want to look at the behavior of a **single object** across many use cases,
    - **State diagrams**

