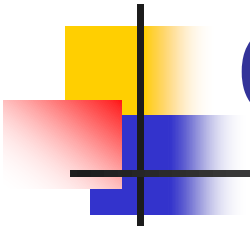
Software Engineering

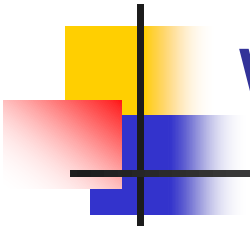
Lecture 05

UML



Outline

- What is UML and why we use UML?
- How to use UML diagrams to design software system?
- What UML Modeling tools we use today?



What is UML and Why we use UML?

- UML → “Unified Modeling Language”
  - Language: express idea, not a methodology
  - Modeling: Describing a software system at a high level of abstraction
  - Unified: UML has become a world standard

    Object Management Group (OMG): www.omg.org

What is UML and Why we use UML?

- More description about UML:

- It is a industry-standard graphical language for specifying, visualizing, constructing, and documenting the artifacts of software systems

- The UML uses mostly graphical notations to express the OO analysis and design of software projects.

- Simplifies the complex process of software design

What is UML and Why we use UML?

- Why we use UML?

- Use graphical notation: more clearly than natural language (imprecise) and code (too detailed).

- Help acquire an overall view of a system.

- UML is *not* dependent on any one language or technology.

- UML moves us from fragmentation to standardization**.**

Overview of UML Diagrams

Structural

: element of spec. irrespective of time

- Class
- Component
- Deployment
- Object
- *Composite structure*
- *Package*

Behavioral

: behavioral features of a system / business process

- Activity
- State machine
- Use case
- *Interaction*

Interaction

: emphasize object interaction

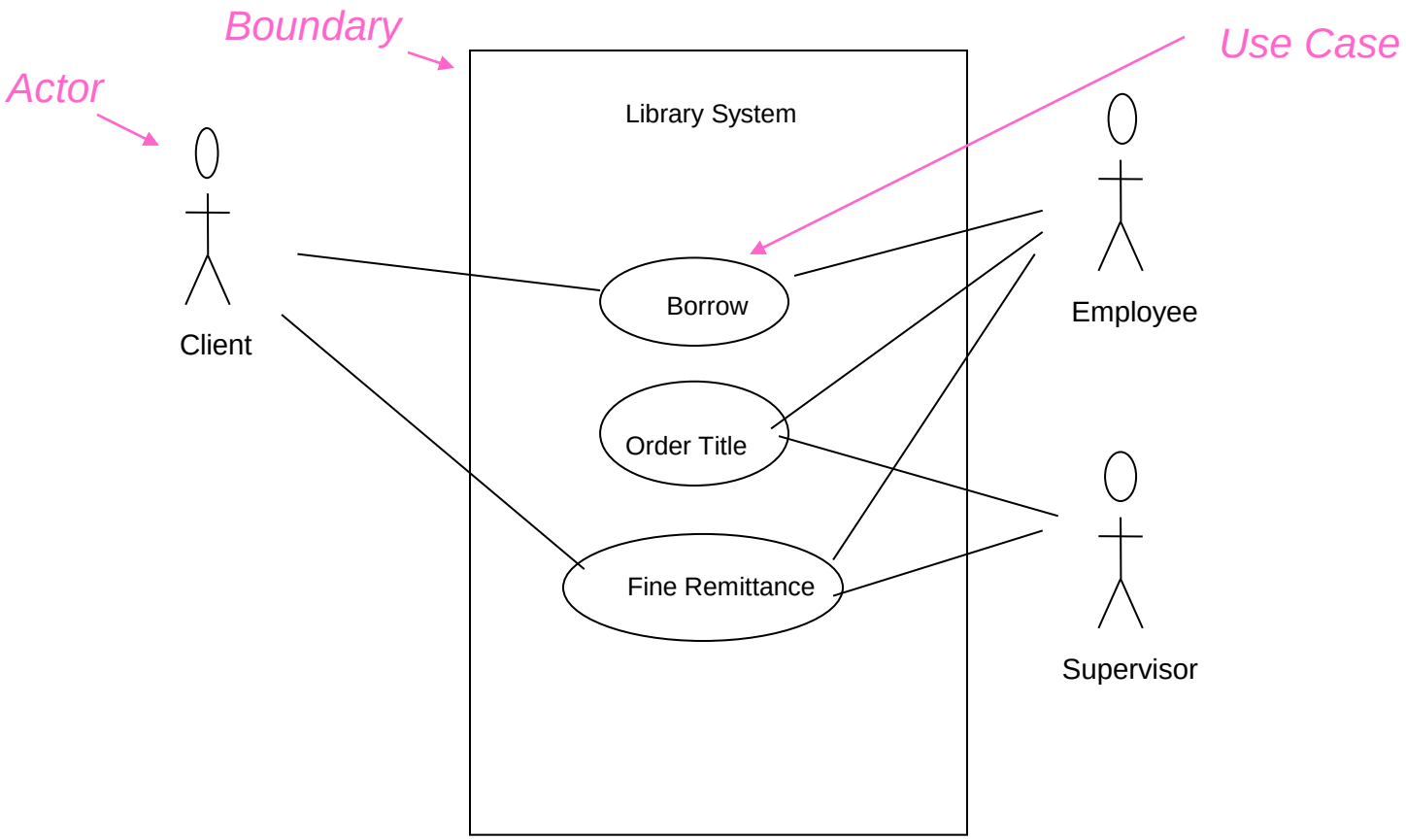
- Communication(collaberation)
- Sequence
- *Interaction overview*
- *Timing*

How to use UML diagrams to design software system?

- Types of UML Diagrams:
  - Use Case Diagram
  - Class Diagram
  - Sequence Diagram
  - Collaboration Diagram
  - State Diagram

This is only a subset of diagrams … but are most widely used

Use-Case Diagrams

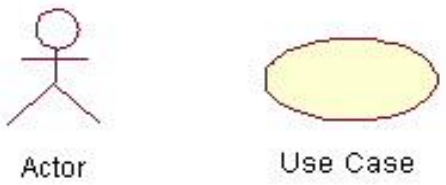


Use-Case Diagrams

- **Actors:** A role that a user plays with respect to the system, including human users and other systems. e.g., inanimate physical objects (e.g. robot); an external system that needs some information from the current system.

- **Use case:** A set of scenarios that describing an interaction between a user and a system, including alternatives.

- **System boundary**: rectangle diagram representing the boundary between the actors and the system.

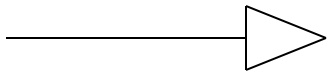


Use-Case Diagrams

- Association:

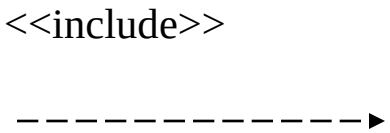
communication between an actor and a use case; Represented by a solid line.

- Generalization: relationship between one general use case and a special use case (used for defining special alternatives) Represented by a line with a triangular arrow head toward the parent use case.

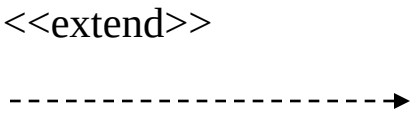


Use-Case Diagrams

Include: a dotted line labeled <<include>> beginning at base use case and ending with an arrows pointing to the include use case. The include relationship occurs when a chunk of behavior is similar across more than one use case. Use "include" in stead of copying the description of that behavior.



Extend: a dotted line labeled <<extend>> with an arrow toward the base case. The extending use case may add behavior to the base use case. The base class declares "extension points".



Use-Case Diagrams

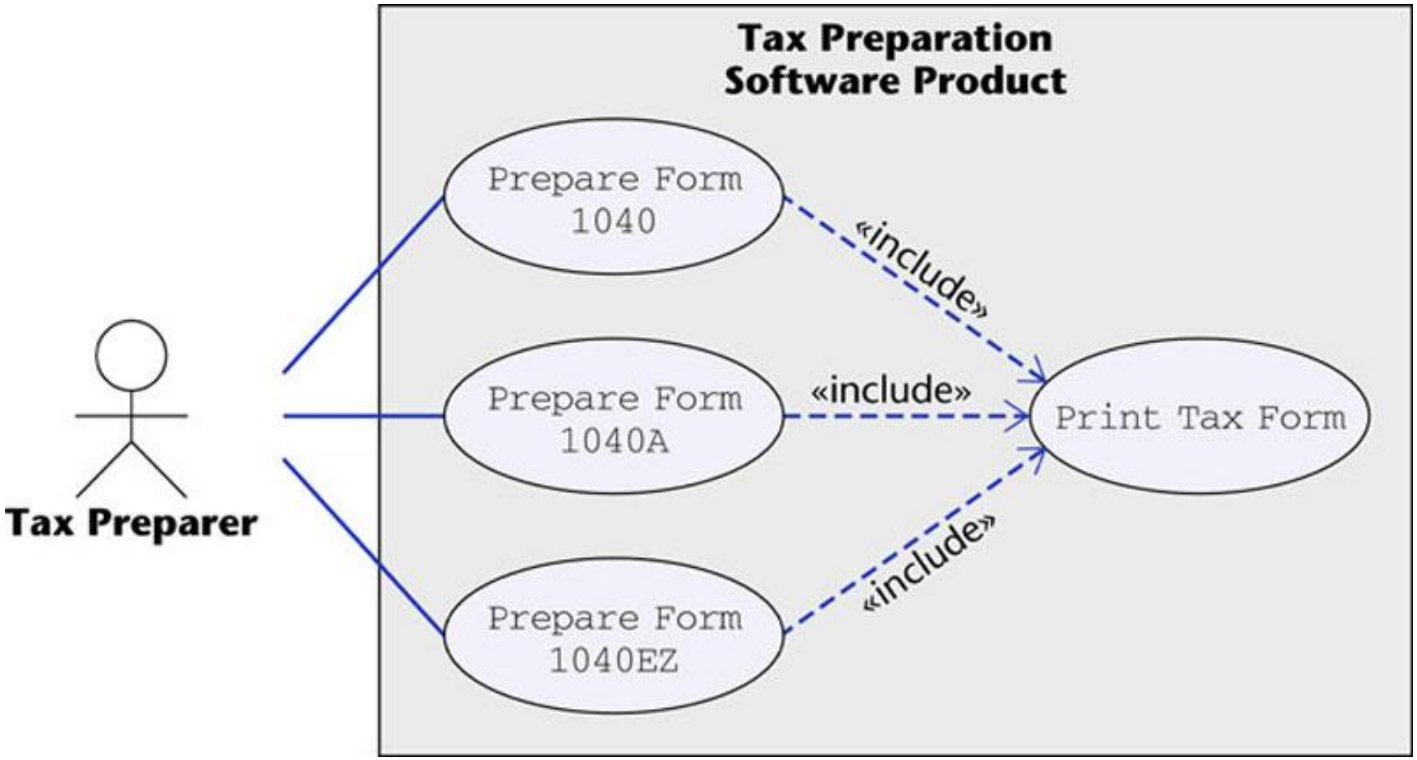
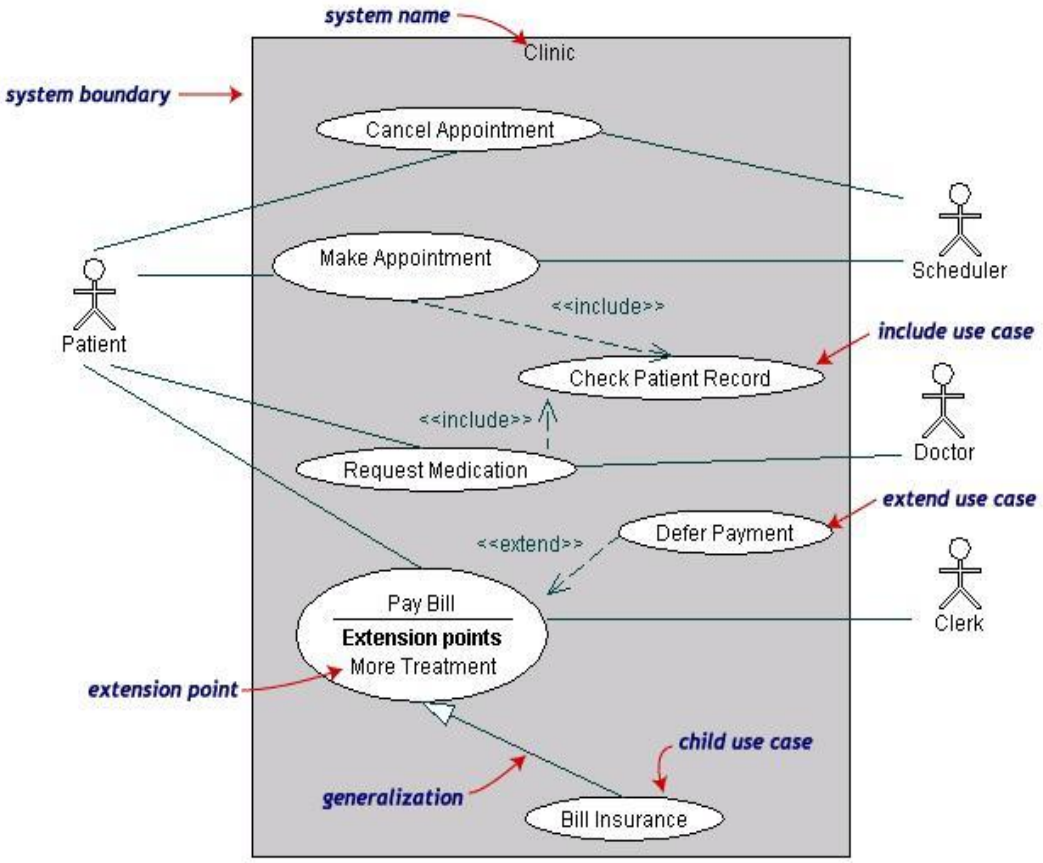


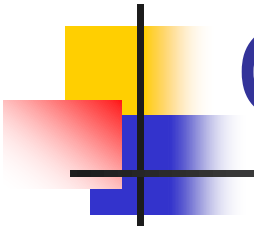
Figure 16.12

Use-Case Diagrams

- Both **Make Appointment** and **Request Medication** include **Check Patient Record** as a subtask (include)
- The **extension point** is written inside the base case **Pay bill**; the extending class **Defer payment** adds the behavior of this extension point. (extend)
- **Pay Bill** is a parent use case and **Bill Insurance** is the child use case. (generalization)



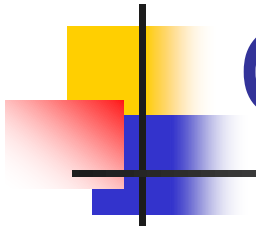
(TogetherSoft, Inc)



Class diagram

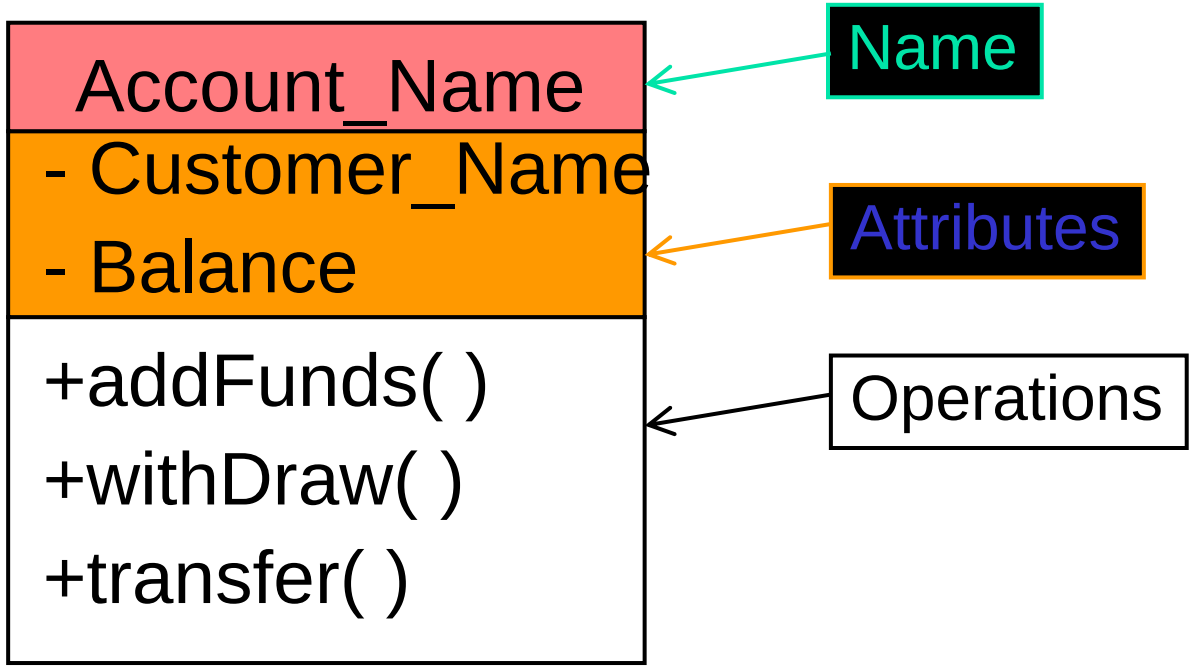
- A class diagram depicts classes and their interrelationships
- Used for describing structure and behavior in the use cases
- Provide a conceptual model of the system in terms of entities and their relationships
- Used for requirement capture, end-user interaction
- Detailed class diagrams are used for developers

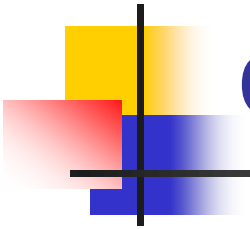
Class diagram



- Each class is represented by a rectangle subdivided into three compartments
  - Name
  - Attributes
  - Operations
- Modifiers are used to indicate visibility of attributes and operations.
  - '+' is used to denote *Public* visibility (everyone)
  - '#' is used to denote *Protected* visibility (friends and derived)
  - '-' is used to denote *Private* visibility (no one)
- By default, attributes are hidden and operations are visible.

Class diagram

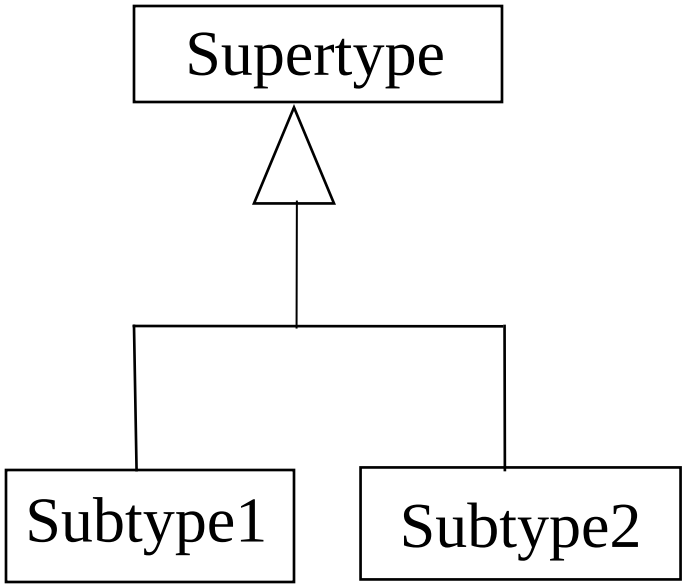




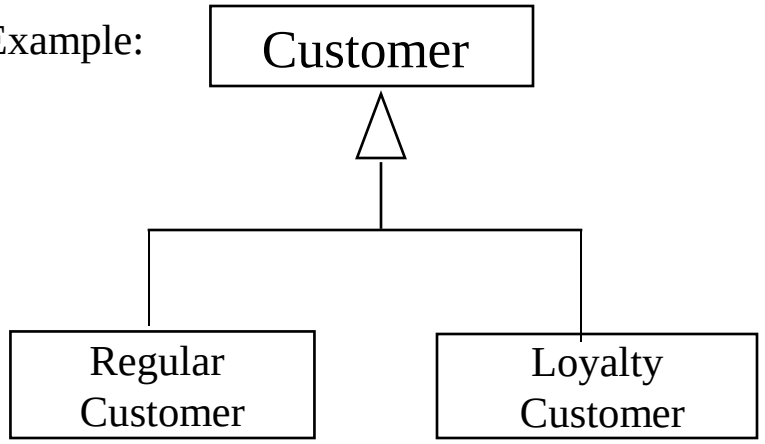
OO Relationships

- There are two kinds of Relationships
  - Generalization (parent-child relationship)
  - Association (student enrolls in course)
- Associations can be further classified as
  - Aggregation
  - Composition

OO Relationships: **Generalization**



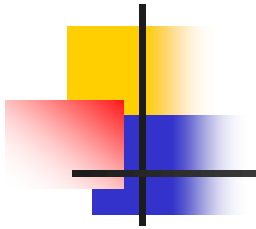
Example:



-Inheritance is a required feature of object orientation

-Generalization expresses a parent/child relationship among related classes.

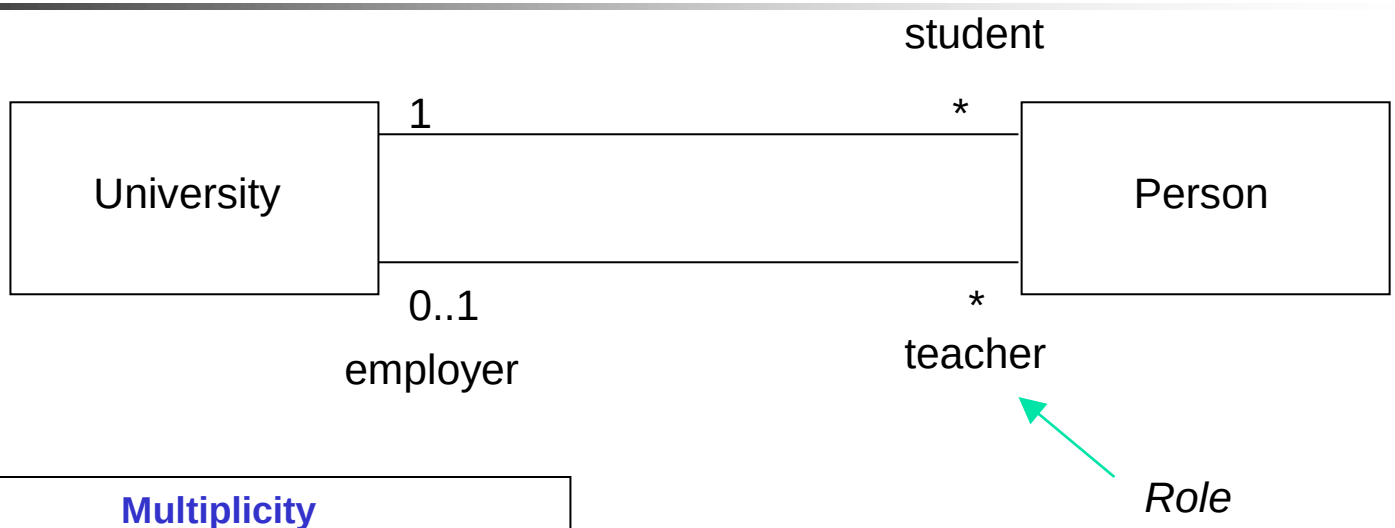
-Used for abstracting details in several layers



OO Relationships: **Association**

- Represent relationship between instances of classes
  - Student enrolls in a course
  - Courses have students
  - Courses have exams
  - Etc.
- Association has two ends
  - Role names (e.g. enrolls)
  - Multiplicity (e.g. One course can have many students)
  - Navigability (unidirectional, bidirectional)

Association: Multiplicity and Roles



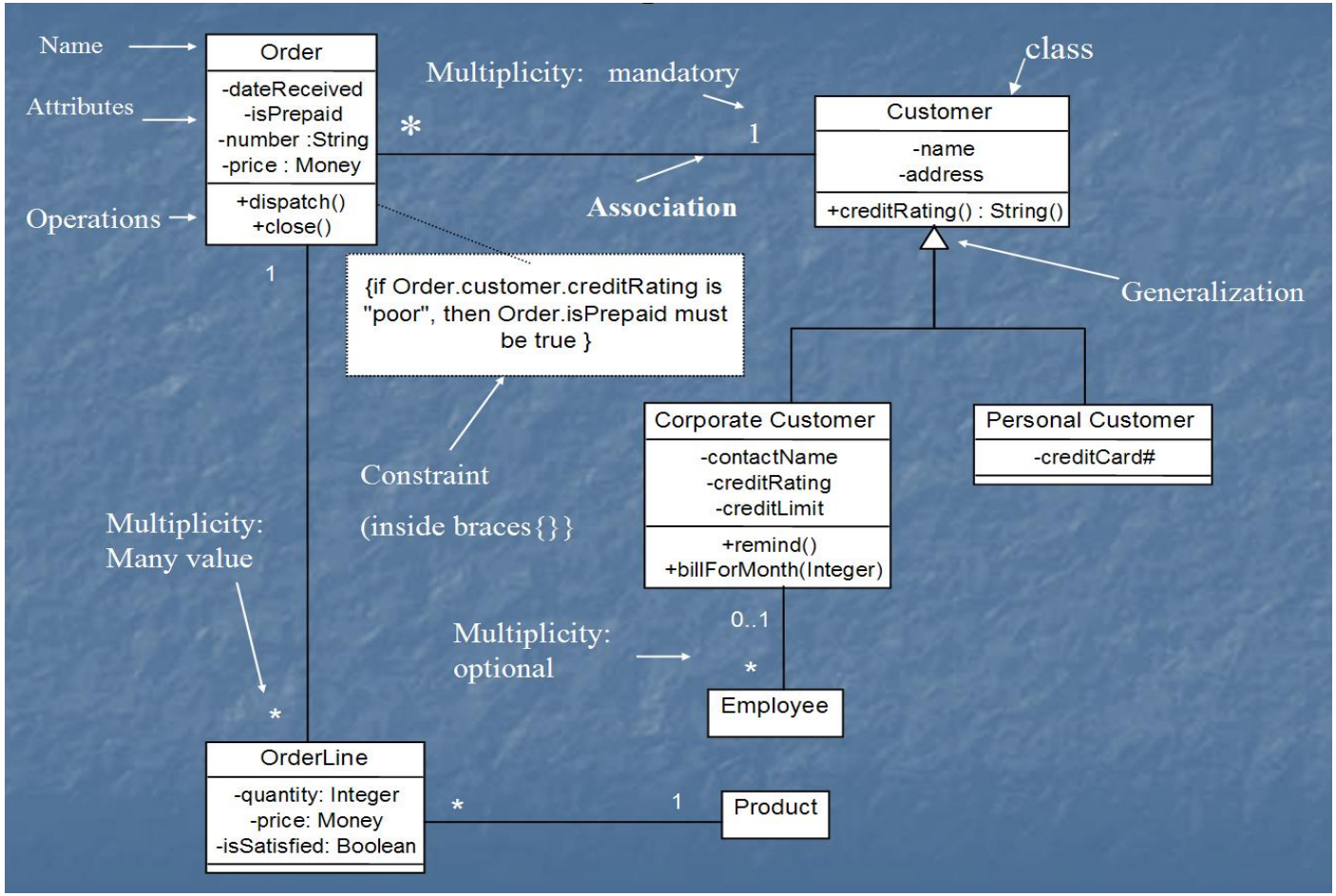
Multiplicity

Symbol	Meaning
1	One and only one
0..1	Zero or one
M..N	From M to N (natural language)
*	From zero to any positive integer
0..*	From zero to any positive integer
1..*	From one to any positive integer

Role

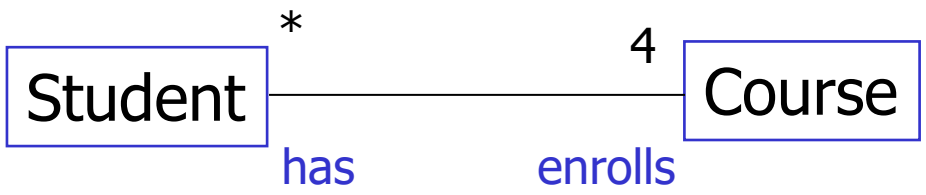
"A given university groups many people; some act as students, others as teachers. A given student belongs to a single university; a given teacher may or may not be working for the university at a particular time."

Class diagram



[from *UML Distilled Third Edition*]

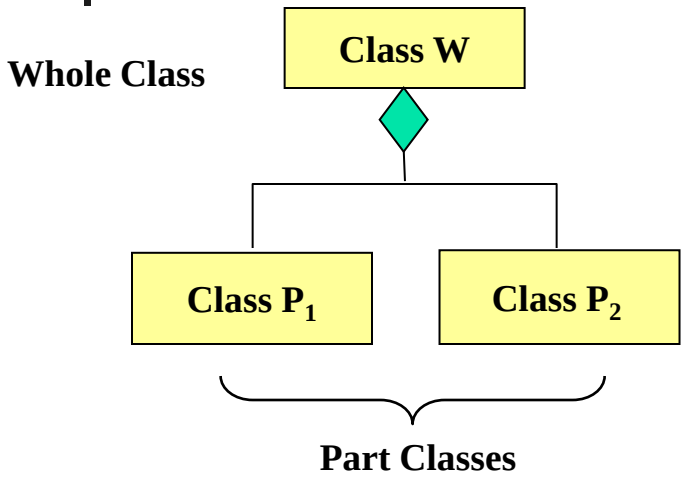
Association: Model to Implementation




```
Class Student {
    Course enrolls[4];
}

Class Course {
    Student have[];
}
```

OO Relationships: **Composition**



[From Dr.David A. Workman]

Example

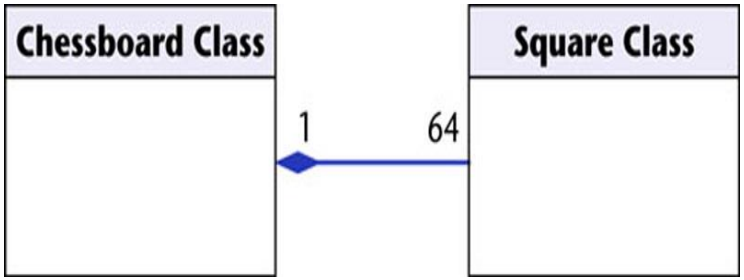


Figure 16.7

Association

Models the part–whole relationship

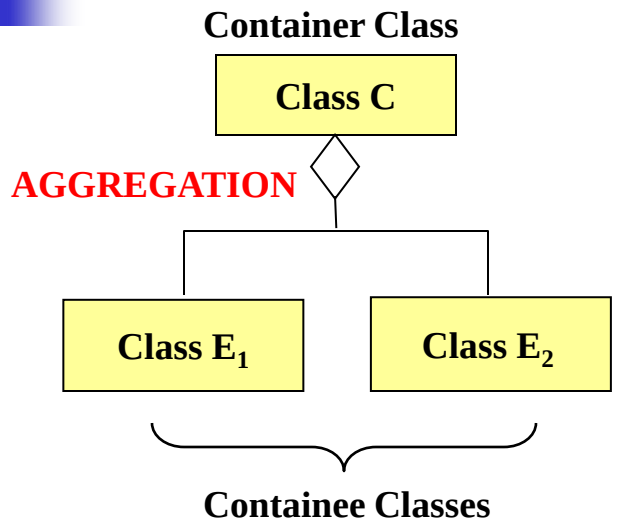
Composition

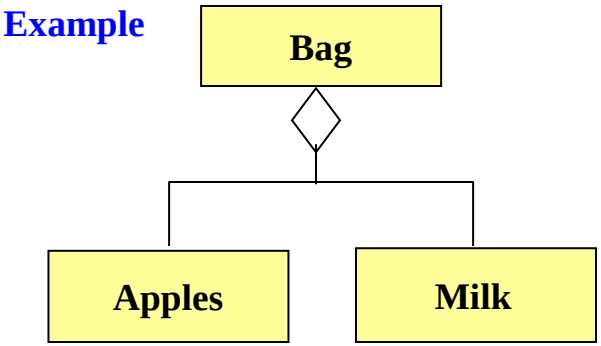
Also models the part–whole relationship but, in addition, Every part may belong to only one whole, and If the whole is deleted, so are the parts

Example:

A number of different chess boards: Each square belongs to only one board. If a chess board is thrown away, all 64 squares on that board go as well.

OO Relationships: **Aggregation**



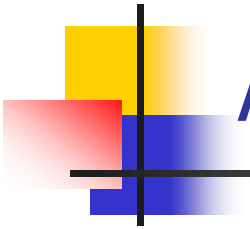


[From Dr.David A. Workman]

Aggregation:
expresses a relationship among instances of related classes. It is a specific kind of Container-Containee relationship.

express a more informal relationship than composition expresses.

Aggregation is appropriate when Container and Containees have no special access privileges to each other.



Aggregation vs. Composition

- **Composition** is really a strong form of **association**
  - components have only one owner
  - components cannot exist independent of their owner
  - components live or die with their owner
  - e.g. Each car has an engine that can not be shared with other cars.

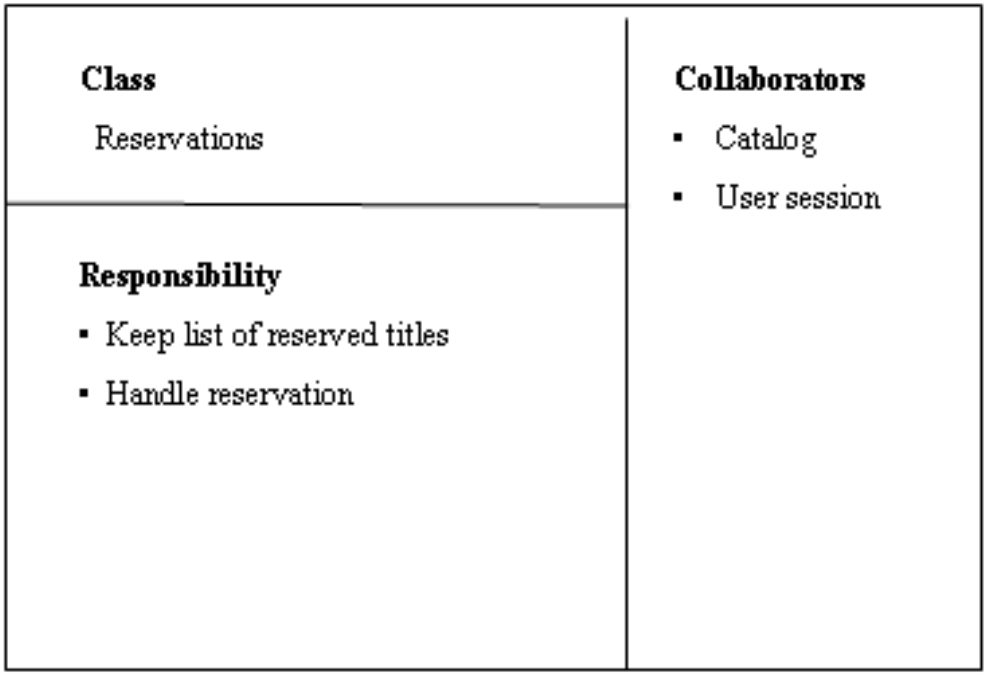
- **Aggregations**

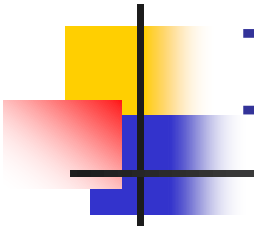
may form "part of" the association, but may not be essential to it. They may also exist independent of the aggregate. e.g. Apples may exist independent of the bag.

Good Practice: CRC Card

Class Responsibility Collaborator

- easy to describe how classes work by moving cards around; allows to quickly consider alternatives.

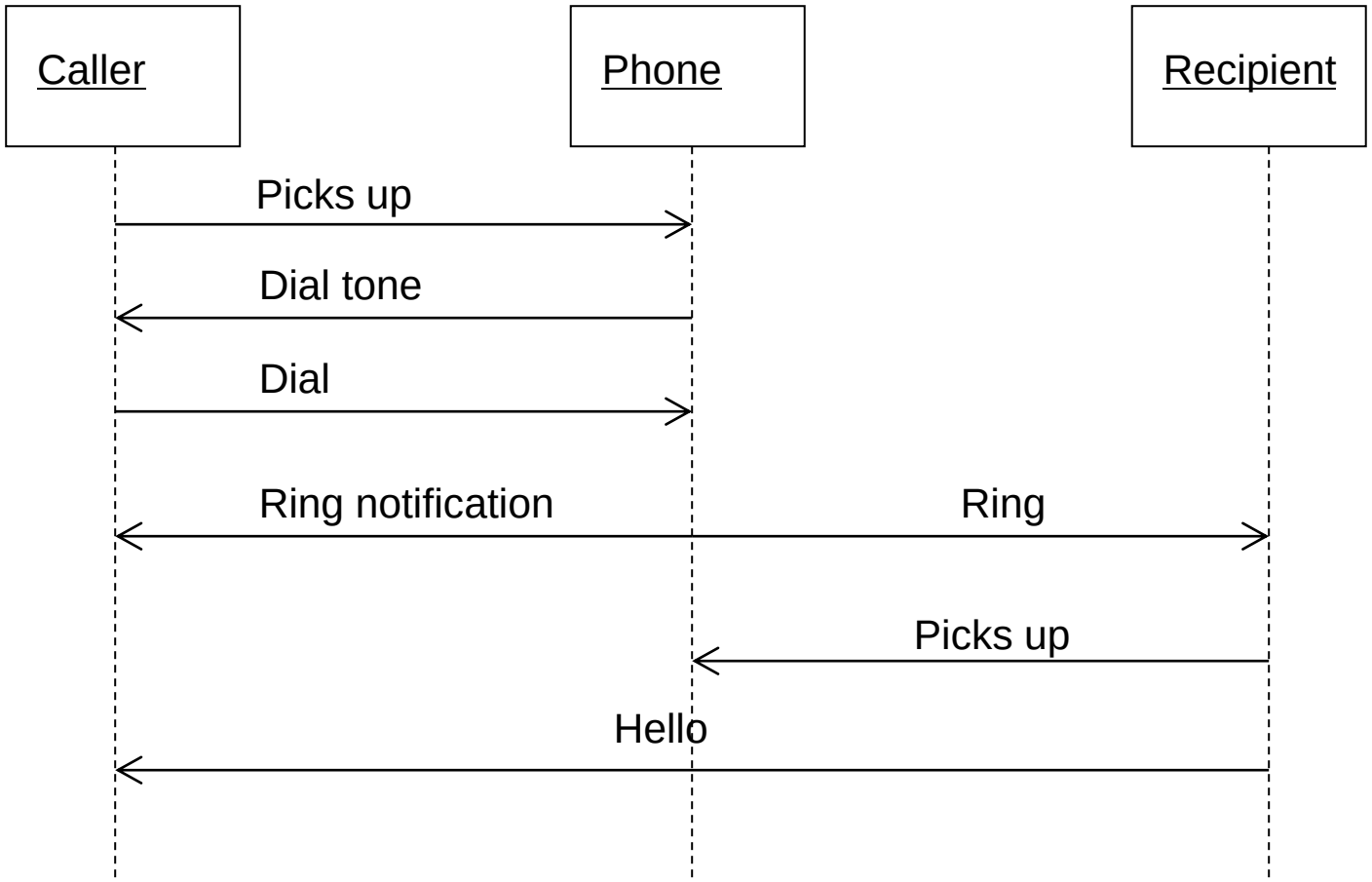




Interaction Diagrams

- show how objects interact with one another
- UML supports two types of interaction diagrams
  - Sequence diagrams
  - Collaboration diagrams

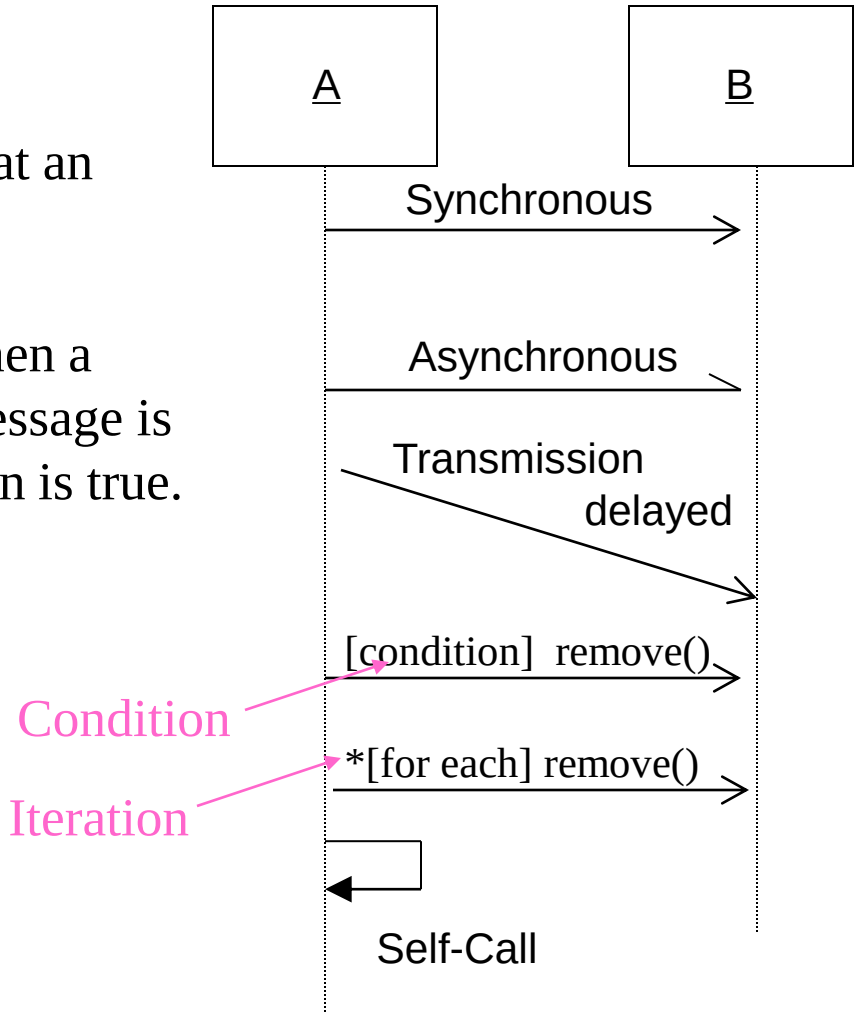
Sequence Diagram(make a phone call)



Sequence Diagram:Object interaction

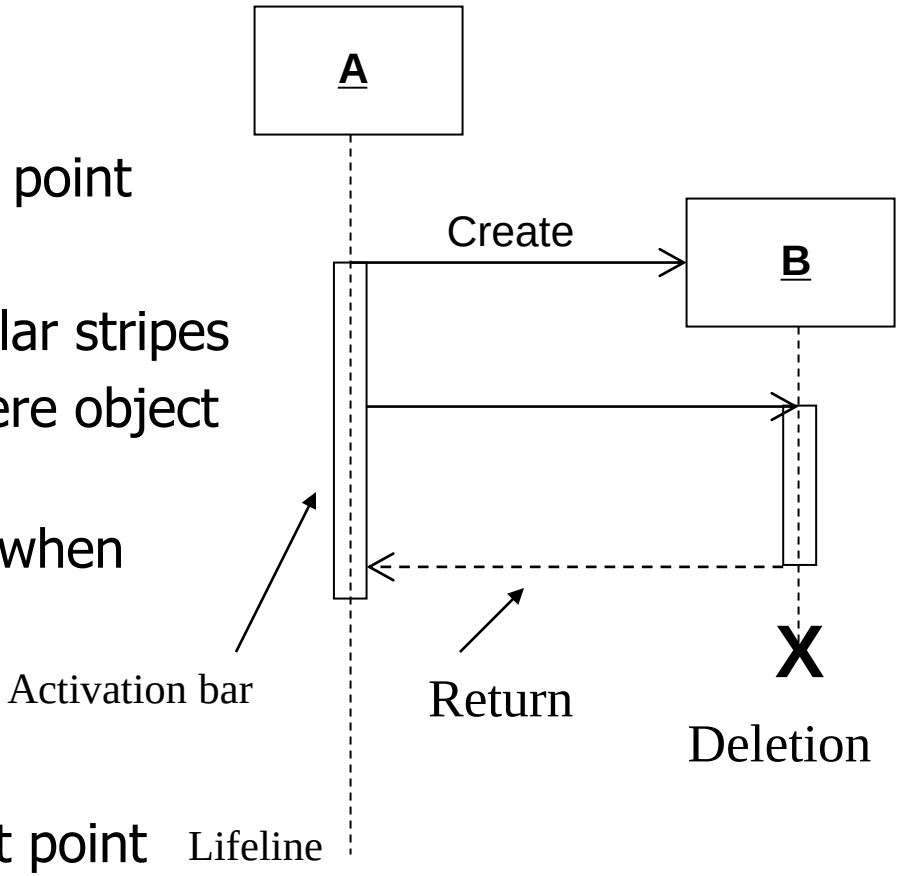
Self-Call: A message that an Object sends to itself.

Condition: indicates when a message is sent. The message is sent only if the condition is true.



Sequence Diagrams – Object Life Spans

- Creation
  - Create message
  - Object life starts at that point
- Activation
  - Symbolized by rectangular stripes
  - Place on the lifeline where object is activated.
  - Rectangle also denotes when object is deactivated.
- Deletion
  - Placing an 'X' on lifeline
  - Object's life ends at that point



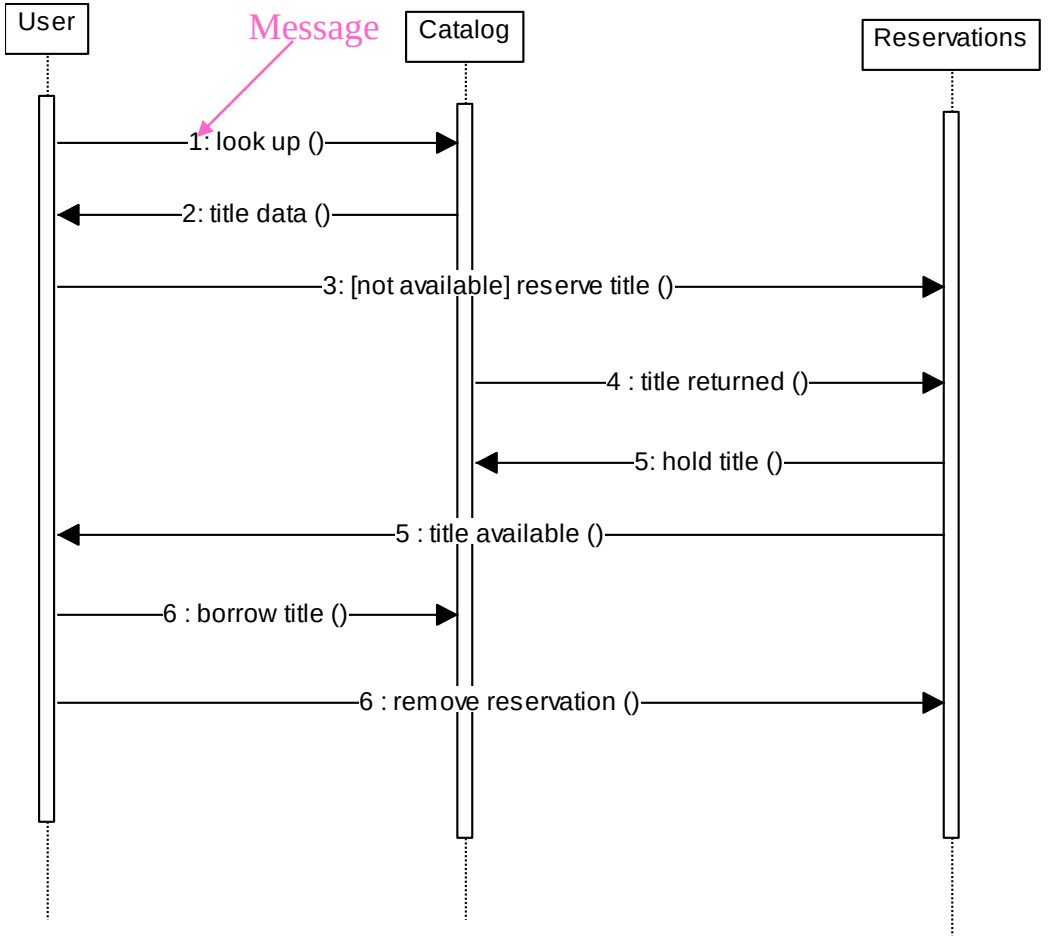
Sequence Diagram

•Sequence diagrams demonstrate the behavior of objects in a use case by describing the objects and the messages they pass.

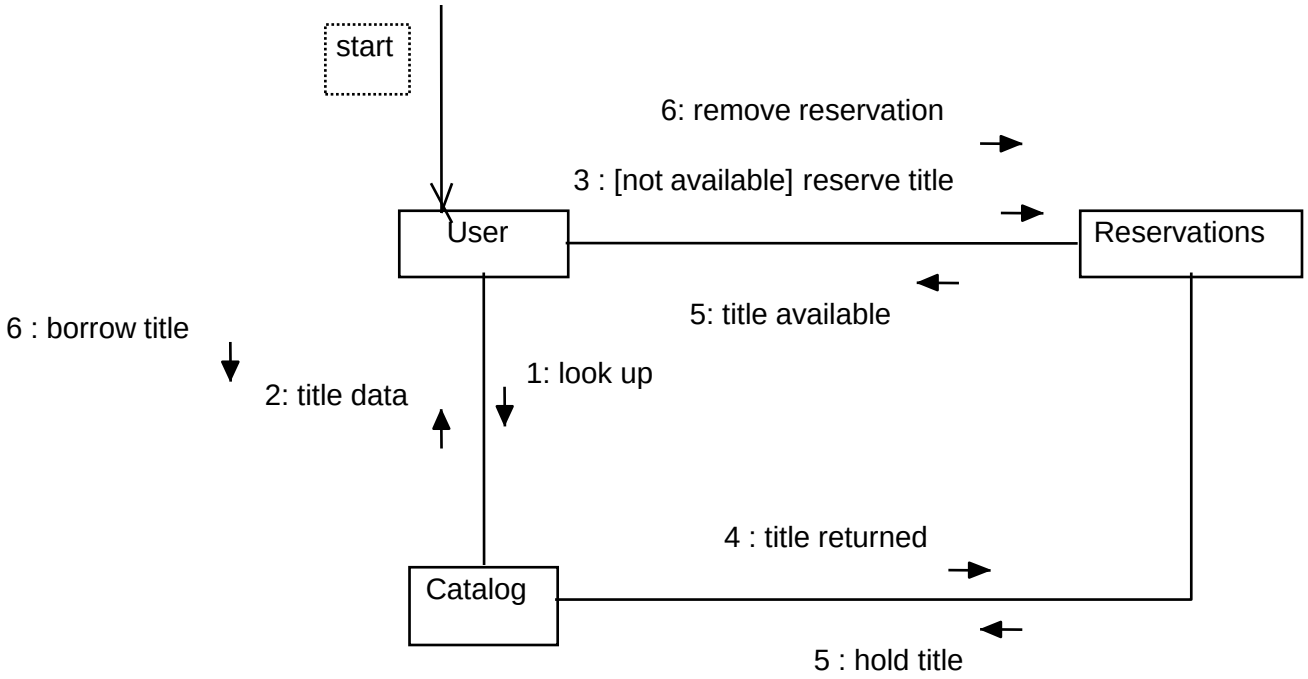
•The horizontal dimension shows the objects participating in the interaction.

•The vertical arrangement of messages indicates their order.

•The labels may contain the seq. # to indicate concurrency.



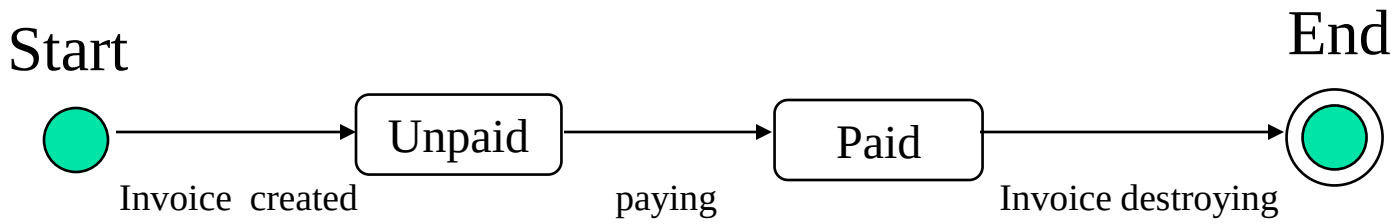
Interaction Diagrams: Collaboration diagrams



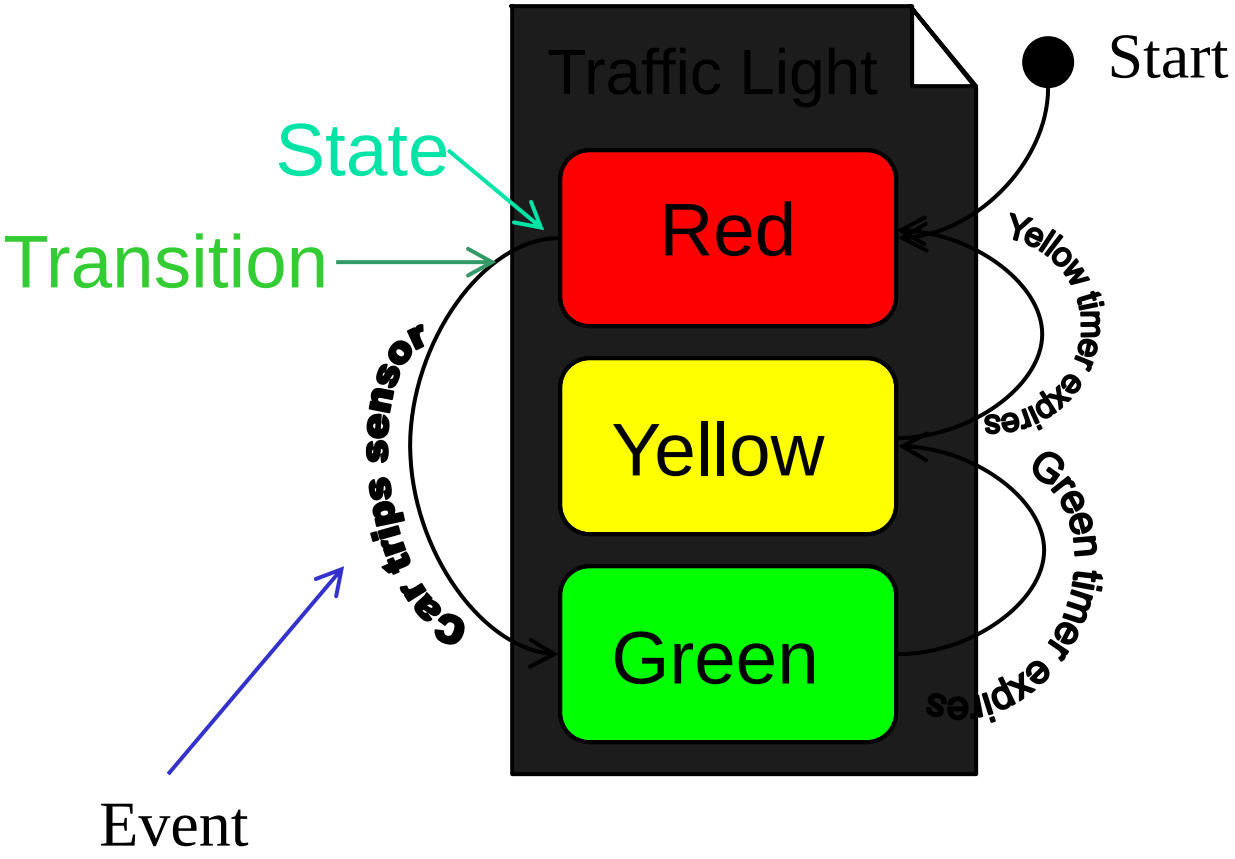
- Collaboration diagrams are equivalent to sequence diagrams. All the features of sequence diagrams are equally applicable to collaboration diagrams
- Use a sequence diagram when the transfer of information is the focus of attention
- Use a collaboration diagram when concentrating on the classes

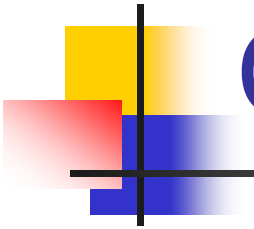
State Diagrams (Billing Example)

State Diagrams show the sequences of states an object goes through during its life cycle in response to stimuli, together with its responses and actions; an abstraction of all possible behaviors.



State Diagrams (Traffic light example)





Conclusion

- UML is a standardized specification language for object modeling
- Several UML diagrams:
  - use-case diagram: a number of use cases (use case models the interaction between actors and software)
  - Class diagram: a model of classes showing the static relationships among them including association and generalization.
  - Sequence diagram: shows the way objects interact with one another as messages are passed between them. Dynamic model
  - State diagram: shows states, events that cause transitions between states. Another dynamic model reflecting the behavior of objects and how they react to specific event
- There are several UML tools available