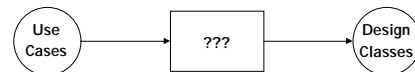
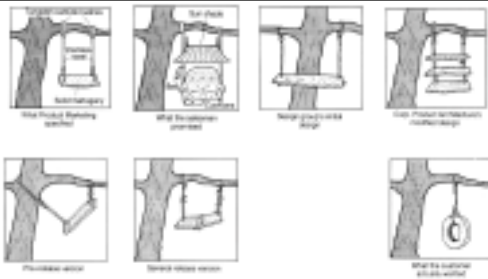


## From Requirements Toward Design

## Building an Object-Oriented Model for the Software Product



Avoid the possibility of a  
requirements/design disconnect



## Domain Modeling

## What is Domain Modeling?

- Modeling objects and concepts that actually exist or make sense in the environment or enterprise of the application.

## Reference

- Larman text, chapters 10-12

## What is the Purpose of Domain Modeling?


- A software product usually relates to some real-world domain.
- The domain model expresses **concepts** and their **interconnection**.
- By modeling the domain, we have a base from which to
  - relate to the user, and
  - conduct further design.

## Exhibiting a Domain Model

- Use UML class diagrams
  - Provide a “visual glossary”
  - Related to “data dictionary”
- Don't infer that these classes necessarily refer to ultimate implementation classes :
  - Some might, others might not
  - Larman calls them **conceptual classes**

## UML Modeling

- UML is a graphical language for modeling
- UML is not a programming language
- UML is standardized by the OMG

OMG =  “Object Management Group”, a consortium, not a company  
<http://www.omg.org/>



## UML

- Unified Modeling Language
- unifies the approaches of the “three amigos”:
  - Grady Booch
  - Ivar Jacobson
  - James Rumbaugh
- Includes E-R (Entity-Relationship) diagrams from database world.



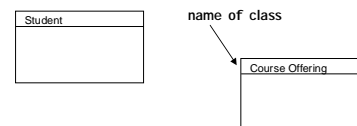
## Earlier Work on Modeling

- A lot of these ideas are traceable to celebrated work on **database modeling**, particularly the E-R (Entity-Relationship) Model originally proposed by Peter Chen in 1976.
- Entity = UML Class,  
Relationship = UML Association
- UML provides a significant set of extensions to those early ideas.



Prof. Peter Chen,  
Louisiana State Univ.

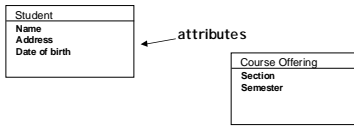
## UML: Classes are shown by boxes



*Classes, not actual objects*

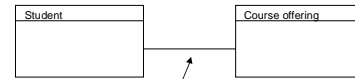
(Objects can also be shown by boxes;  
For objects, names are always underlined)

## Attributes may be listed



- In *domain* modeling:
  - Methods of classes are not listed.
  - These are not software classes, although some of them may become so.

## Associations are shown by lines connecting boxes



association:  
perhaps meaning that a student is enrolled in a course offering

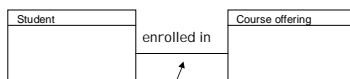
## Possible Associations

- Member-of
- Part-of
- Contained-in
- Owned-by
- Director-of
- Manages
- Adjacent-to
- Linked-to
- Controls
- Follows
- Describes
- Communicates-with

## Associations Show *Static* Structure

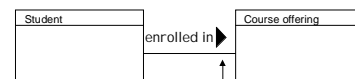
- Unlike Use Cases, which describe flow of events.
- A class diagram, with associations, only shows static relationships.
- Dynamic relationships, such as message-passing, may be *suggested* by associations.

## Naming Associations



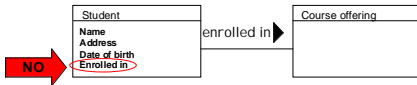
association:  
perhaps meaning that a student is enrolled in a course offering

## Directionality of Association Names

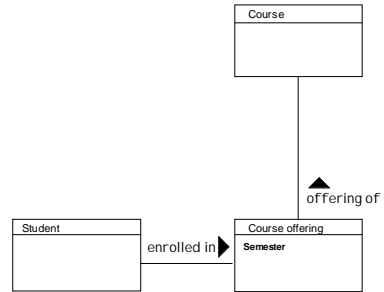


Arrowhead shows direction of *reading* the name of the association,  
e.g. "student **enrolled in** course offering".

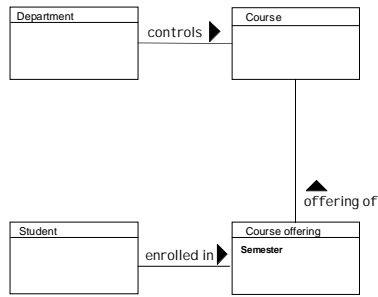
### Don't count Associations as Attributes



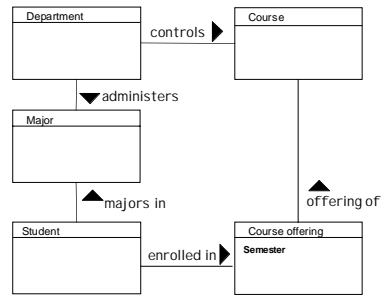
### Extending the Domain Model



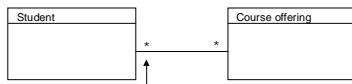
### Extending the Domain Model



### Extending the Domain Model

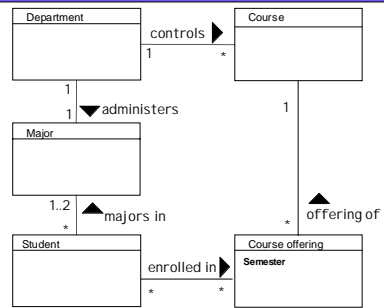


### Multiplicities of Associations



**Multiplicity Indicator:**  
 \* means that a course offering has 0 or more students.  
 Other options:  
 1 exactly 1 default  
 n exactly n  
 m..n between m and n inclusive  
 m.. m or more

### Possible Multiplicities

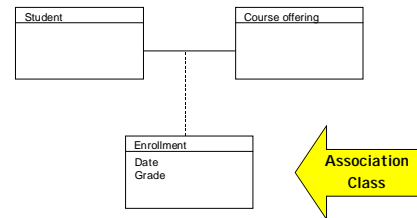


## Notes on Multiplicity

- Consideration of multiplicity can be deferred; it should not dominate early discovery processes.

## Association Classes

An association may have properties of its own.



See Larman, page 413.

## Exercise

- Form a Domain Model based on the following suggestive names:
  - Airline
  - Airport
  - Crew Member
  - Flight-Segment Instance
  - Flight-Segment (i.e. leg of a flight)
  - Flight
  - Passenger
  - Scheduled Arrival
  - Scheduled Departure

## Other Possible Domains for Consideration

- Consortium of Colleges/Universities
- Supermarket check-out system
- Automobile service station pumps
- Library
- Athletic Event
- Transit system
- Asset management system
- Subversive organization

## Extracting Domain Model from A Verbal Description

- Nouns and noun-phrases often suggest classes *or* attributes
- Attributes are distinguished from classes:
  - Attributes have an ephemeral **value**; the exact identity of the value is not important
  - Examples: date, time, price, name, boolean attributes, enumerated types, ...

## Example: I Identify Classes and Attributes

### Door Security Card System

The administrator can register a new card at the central unit or at a door terminal. After identifying and authenticating herself, the administrator may register a new card to the system. The new card is classified and information about the user is added. The information added is the social security number or another identification number.

Once a card is registered to the system, access control can be added. The administrator can register which doors the card should have access to. This can be done both from a door terminal and from the central unit.

The administrator is also allowed to unregister a card and withdraw access privileges. This is done in the same manner as the registering and granting of access, i.e. both from a door terminal and from the central unit.

When the user has been granted access to a room, she can open the door by inserting her card in the card reader. The door terminal asks her for her Personal Identification Number (PIN). The PIN is validated with the card, and if it is correct, the door is opened. If the user enters an erroneous code three times, the access privileges are withdrawn.

## Foreign Keys

- See Larman, Section 12.5, pp 172-173
- A Foreign Key is an attribute value that can be used to identify an object, e.g. the name attribute of an object.
- In domain analysis, foreign keys are to be avoided in favor of associations.
- They may obscure useful associations.

## Factoring

- When classes appear to be getting too large (too many attributes or associations), consider the possibility of factoring the class into smaller classes.

## Combining with Use Cases

- Use-Cases: Dynamic
- Domain Classes: Static
- Eventually these need to be related to each other:
  - Names of objects mentioned in use cases should be identified with classes in the domain.

### Example Use Case from Meeting Scheduler:

**DissolveSet:** Dissolve a Participant Set Having a Given Label

- Goal: To enable a **set definer** to dissolve a **set** no longer used.
- Actors: Set definer
- Initiator: Set definer
- Description: The set definer dissolves an existing list. **Participants** on are notified.
- Pre-conditions: A set with the label exists.
- Post-conditions: No set with the label exists.
- Exception: No set with the label exists.
- Options
- Scenario



## Noun/Verb Heuristic for Transforming Description to Classes

- **Description** could be use cases or other
- **Nouns** suggest classes
- **Later in Design:**
  - **Verbs** suggest methods/responsibilities
  - **Subject/object** relationships suggest methods

## Example: I identify Domain Classes

Door Security Card System

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