From Requirements Toward Design
Building an Object-Oriented Model for the Software Product
Avoid the possibility of a requirements/design disconnect

- Tungsten carbide bushes
  - Stainless steel
  - Solid mahogany
  - What Product Marketing specified

- Sun shade
  - Bell
  - Cushions
  - What the salesman promised

- Design group's initial design

- Corp. Product Architecture's modified design

- Pre-release version

- General release version

- What the customer actually wanted
Domain Modeling
What is Domain Modeling?

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

<table>
<thead>
<tr>
<th>Student</th>
<th>Course offering</th>
</tr>
</thead>
</table>

**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

Student enrolled in Course offering

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

Student
Name
Address
Date of birth
Enrolled in

enrolled in

Course offering
Extending the Domain Model

Student \[\rightarrow\] enrolled in \[\rightarrow\] Course offering

Course offering

Course

offering of

Semester
Extending the Domain Model

- Department
  - controls
  - Student
    - enrolled in
  - Course offering
    - offering of
    - Semester
  - Course
Extending the Domain Model

- **Department** controls **Course**
- **Major** administers **Student**
- **Student** majors in **Major**
- **Major** majors in **Department**
- **Student** enrolled in **Course offering**
- **Course offering** offering of **Course**
- **Semester**
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

- **Department** controls **Course**
  - 1
  - 1

- **Major** administers **Student**
  - 1
  - 1..2

- **Student** majors in **Course offering**
  - *
  - 1

- **Semester** offering of **Course offering**
  - *
  - *
Consideration of multiplicity can be deferred; it should not dominate early discovery processes.
An association may have properties of its own.
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
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 in the overall design.
  - Examples: date, time, price, name, boolean attributes, enumerated types, ...
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.

Example: Identify Classes and Attributes
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 a 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**
Other Possible Domains for Consideration

- Library
- Transit system
- Asset management system
- Supermarket check-out system
- Consortium of colleges/universities
- Athletic events management system
- Automobile service station pump system
- Subversive organization