From Requirements
Toward Design
Building an Object-Oriented Model for the Software Product

Use Cases → ??? → Design Classes
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

\[
\text{OMG} = \quad \text{“Object Management Group”,} \\
a \text{consortium, not a company} \\
\text{http://www.omg.org/}
\]
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.
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

Student ————> Course offering

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

- Student
  - Name
  - Address
  - Date of birth
  - Enrolled in

- Course offering

NO
Extending the Domain Model

Student

Course offering

Course

Semester

enrolled in

offering of
Extending the Domain Model

- Department
- Course
- Student
- Course offering
- Semester

Department controls Course

Student enrolled in Course offering

offering of Semester
Extending the Domain Model

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

- Major administers Course
  - 1

- Student majors in Course
  - 1..2

- Course offering
  - offering of Semester
  - *
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
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, ...
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
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
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