Lecture 8: Introduction to OO Analysis (by example)

Kenneth M. Anderson
Object-Oriented Analysis and Design
CSCI 6448 - Spring Semester, 2003

Credit where Credit is Due

- Some material presented in this lecture is taken from section 2.2 of Maciaszek's "Requirements Analysis and System Design". © Addison Wesley, 2000

Goals for this Lecture

- Work through the tutorial in Section 2.2 of the textbook
  - Provides overview of OO Analysis
  - Provides insight into how UML is used

Tutorial in Analysis Modeling

- Tutorial provides an example of analysis modeling with respect to the task of "on-line shopping"
  - We will develop four types of models
    - The use case model
    - The state model
    - The behavior model
    - The state change model
- Slides will provide background information; book will provide diagrams

OnLine Shopping – Order Processing

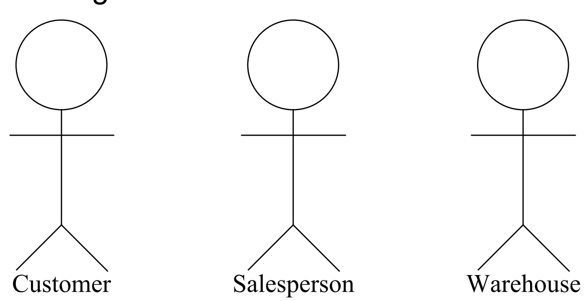
- Buying computers via Internet - page 47
- The customer can select a standard configuration or can build a desired configuration online
- To place an order, the customer must fill out the shipment and payment information
- The customer can check the order status online at any time
- The ordered configuration is shipped to the customer together with the invoice

Step 1: Find Use Cases

- The tutorial begins by talking about use cases
  - Each use case represents a complete unit of functionality that is required by an actor
    - An actor is any entity that interacts with our system; typically a human, but could also be an external software system
    - Since actors are external to the system, use cases document outwardly visible and testable system behavior

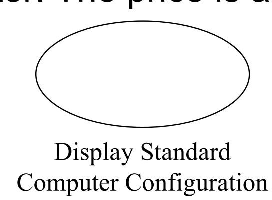
Actors

- Consider the requirement: After the **customer's** order has been entered into the system, the **salesperson** sends an electronic request to the **warehouse** with details of the ordered configuration



Use cases

- Consider the requirement
  - The customer uses the shopping web page to view the standard configuration of the chosen server, desktop or portable computer. The price is also shown



Use Cases, continued

- Some use cases may not interact directly with actors
  - Instead, they support other use cases
  - In particular, if several use cases each share a common task, it makes sense to encapsulate the common task in its own separate use case
- A use case diagram is a visual representation of actors and use cases
  - Note: UML diagram is synonymous with UML model

Step 1, continued

- The tutorial starts the process of modeling by transforming the problem statement (page 47) into a set of extended requirements (page 48-49)
  - These are not meant to be a complete list of requirements; simply a first set that can be derived directly from the problem statement

Step 1, continued

- Next, the requirements are placed in a table to help identify use cases and actors (pg. 50 and 51)
  - Useful for deriving an initial set of use cases;
    - more will be found later as information about the domain is discovered or as a result of working on other models
  - Some requirements lead to multiple use case

Step 1, continued

- Having identified use cases and actors, a use case diagram can be constructed
  - (page 52)
- A use case diagram is meant to show relationships between use cases and actors
  - Two types of relationships shown
    - association - a communication path
    - extend - a use case can define extension points where behavior may be customized; an extends relationships indicates that a use case is providing a customization of another use case

Narrative use case specification

- A use case diagram only shows relationships between use cases
  - it does not provide any information about the details of a use case
  - thus, each use case needs to be documented textually (page 53); see next slide

Documenting use cases

- **Brief Description**
- **Actors** involved
- **Preconditions** necessary for the use case to start
- **Detailed Description** of flow of events that includes:
  - **Main Flow** of events, that can be broken down to show:
    - **Subflows** of events (subflows can be further divided into smaller subflows to improve document readability)
  - **Alternative Flows** to define exceptional situations
- **Postconditions** that define the state of the system after the use case ends

Step 2: Find Activities

- The textual information of a use case provides details about the flow of events that occur when carrying out its task
  - This information can be depicted graphically with an **activity model**

Activity Diagrams

- An **activity diagram** shows the steps of a computation
  - Each step is a **state** where the system is doing something; aka an **activity state**
    - activities take time to complete; if an activity completes quickly, it is referred to as an **action**
  - The diagram indicates the sequential and/or concurrent flow of activity states
    - The flow of control from one state to the next is called a **transition**

Step 2, continued

- To find activities, we examine the main and alternative flows of a use case
  - (page 55 shows this analysis for the `Order Configured Computer` use case; the outcome is shown on page 56)
  - Important: Use cases are written from the perspective of an **external** actor; activities however should be specified in terms of an **internal** system's viewpoint

Step 2, continued

- Once the activities have been found, we can display their interactions using an activity diagram (page 56)
  - There is one initial state but there may be multiple final states
  - Some transitions are guarded
    - The use of [timeout] indicates that the transition can only be taken if the timeout event has occurred
- To complete the activity modeling step, an activity diagram should be constructed for each use case!

Step 3: Find Classes

- The tutorial now begins to construct a **state model**, also known as a **class model**
  - State is represented via the classes of objects that the system contains, their attributes, operations, and relationships
  - These are shown in a **class diagram**
- Note: steps 2 and 3 are typically done in parallel; or via rapid iteration between the two
  - Use cases facilitate class discovery and vice versa, class models can lead to the discovery of overlooked use cases

Classes

- So far, we have used classes to define "business objects": `Order`, `Shipment`, `Customer`, etc.
  - aka entity classes (model), because they represent long-lived persistent database objects
- We also need other classes
  - those that define GUI objects, aka boundary classes (view)
  - those that control the program's logic, aka control classes
- Boundary and control classes may or may not be addressed in requirements analysis (since they are not a direct part of the application domain)
  - as such their specification may be delayed until design

Step 3, continued

- To find classes, the tutorial returns to the initial set of requirements
  - we first used them to define use cases, now we are looking for classes (pg. 58)
- This exercise may produce more classes than needed
  - these are referred to as **candidate classes**
  - we must ask questions to eliminate unnecessary classes

Classes: Asking Questions

- Is this a class?
  - Is the concept a container for data?
  - Does it have separate attributes that will take on different values?
  - Would it have many instance objects?
  - Is it in the scope of the application domain?
- See page 59

Step 3, continued

- Having found a set of initial classes, the next step is to determine the attributes for each class
  - Attributes define the structure of a class
    - "obvious" attributes are added immediately after the initial classes have been selected
    - other attributes will be discovered as analysis continues
  - See page 60

Step 3, continued

- Associations are added next (page 61)
  - Here, it is critical to use the use cases to determine which classes need to communicate with each other
  - For instance, the *Order Configured Computer* use case came from a requirement that gave rise to the *Customer*, *Order*, and *ConfiguredComputer* classes;
    - this implies that these classes will need to share information

Step 3, continued

- Aggregations and Generalizations can be considered next
  - Are there classes which are “composed” of other classes
  - Are some of the candidate classes specializations or generalizations of other classes
- See page 62 (aggregations), 63 (generalizations), and 64 (completed class diagram) for the evolution of the tutorial’s class diagram

Step 4: Model Interactions

- Interaction modeling captures interactions between objects that need to be performed to satisfy a use case
  - This type of modeling occurs once the class diagram has stabilized
- Interaction modeling is similar to activity modeling but at a lower level of abstraction
  - Activity modeling shows the sequencing of events without assigning those events to objects
  - Interaction modeling shows the sequencing of events (messages) between collaborating objects

Interaction Diagrams

- Two Types
  - Sequence Diagram
    - focus is on events over time
  - Collaboration Diagram
    - focus is on object relationships
- Our textbook uses sequence diagrams in analysis and uses collaboration diagrams in design

Interactions

- An **interaction** is a set of **messages** (that define a behavior) exchanged between **objects** over **links**
- A **sequence diagram** represents an interaction with a two-dimensional graph
  - with **objects** arrayed **across the top**
  - **event sequences** shown **top to bottom**
  - events occur between object **lifelines** as a **message** from a **sender** to an **operation** in the **target** (actual parameters can be specified)

More on Sequence Diagrams

- Showing the return of control from the target to the calling object is not necessary
  - however, it is sometimes done to show return values;
- If a message needs to be sent to a collection of objects, the message name is prefixed with an asterisk, aka the iteration marker
  - this means that the indicated message is sent to each object in the collection

Step 4, continued

- The tutorial begins the iteration modeling activity by picking the first activity state (Display Current Configuration) of the activity diagram developed in step 2
  - and constructs a sequence diagram for it on page 66; a screen shot of a proposed user interface after this interaction has completed execution is also shown on page 66
- This diagram has led to the definition of operations on some of the identified classes (page 67)

Step 4, continued

- The tutorial then steps up a level of abstraction and constructs a sequence diagram for the entire activity diagram (pg 69)
  - Note how certain details from the first sequence diagram are hidden in the second diagram
    - Part of analysis is deciding how much detail is “enough” for the task at hand
    - You may start by drawing the second diagram first in a real analysis situation and then add detail to the sequence diagram as you progress through analysis (perhaps because you need more information about a particular class)

Step 4, continued

- To finish interaction modeling, develop sequence diagrams for each activity diagram
  - Activity diagrams model the details of use cases; these details help discover classes
  - Sequence diagrams further elaborate the details of activity diagrams; these new details help to discover class operations
- Interaction modeling can be incremental
  - you may only need to construct a few sequence diagrams at first; return later to construct more

Step 5: Model Object States

- A state chart model gives a detailed description of a class
  - In much the same way that an interaction model provides a detailed specification of a use case
- In particular, a statechart depicts how objects of a particular class change state over time
  - these state changes will typically describe the behavior of an object across multiple use cases
  - state, in this sense, is defined as the values of an object's attributes

Statechart Diagram

- A statechart diagram is a graph of states (rounded rectangles) and transitions (arrows) caused by events
  - These "states" and "events" are the same concepts that we know from activity diagrams, except
    - an activity diagram shows the states of executing a computation
    - while a statechart diagram documents the states of a single object

States and transitions

- Objects change values of their attributes but not all such changes cause state transitions
  - Bank account example on page 70
  - We construct state models for classes that have "interesting" state changes, not just any state changes
- The tutorial shows a possible statechart diagram for the Invoice object on page 71
  - again transitions are labeled with events

Statechart Diagram

- Normally attached to a class, but can be attached to other modeling concepts, e.g. a use case
- When attached to a class, the diagram determines how objects of that class react to events
  - Determines – for each object state – what action the object will perform when it receives an event
  - The same object may perform a different action for the same event depending on the object's state
  - The action's execution will typically cause a state change

Statechart Diagram

- The complete description of a transition consists of three parts
  - event (parameters) [guard] / action
    - event - a message, can have parameters
    - guard - transition can only occur if guard is true (otherwise the event is ignored)
    - Action – short atomic computation that executes when the transition fires
      - can also be associated with a state, e.g. the action executes when the state is entered (or exited)
    - Activity – longer computation associated with a state

Statechart Diagrams, continued

- States can be composed of other states, aka nested states
  - The composite state is abstract, it is simply a generic label for the nested states
  - A transition taken out of the composite state's boundary means that it can fire from any of the nested states
    - this helps to avoid cluttered diagrams

Step 5, continued

- The tutorial develops a state diagram for the Order class (page 72)
  - It contains nested states, guarded transitions, transitions from nested states, and one action
- Statechart modeling continues until all classes with "interesting" states have been modeled with a statechart diagram

Step 6? Iterate!

- Having performed these steps, its time to iterate
  - each new model may reveal "missing" information in the previous models
  - Analysis continues until all models have stabilized
    - At which point you are ready to move on to design
- What's Next?
  - Over the next few weeks, we will look at each of these analysis steps (and their associated diagrams) in more detail