Lecture 19: OO Design Methods: Mathiassen, Part 1

Kenneth M. Anderson

Object-Oriented Analysis and Design

CSCI 6448 - Spring Semester, 2001

Goals of Lecture

- Begin to examine the OO Analysis and Design Method described in the Mathiassen, et al., textbook
- In particular, we will look at their take on problem domain analysis
  - This involves classes, structure, and behavior

Problem Domain Analysis

- In Mathiassen
  - Begin with a class activity
    - identify a candidate set of classes and events
  - Followed by a structure activity
    - define the structural relationships between classes
  - End with a behavior activity
    - specify the behavior of each class

Classes

- The Mathiassen method begins problem domain analysis using classes
  - Trying to answer the question
    - Which objects and events should we include in the model and which should we leave out?
  - Steps
    - We *abstract* problem domain phenomena by seeing them as objects and events
    - We *classify* objects and events and *select* which classes and events the system will maintain information on
- Classes are the first means to define and limit a problem domain; e.g. Mathiassen uses classes as designations; a means for setting our scope

Classification

- Classify objects in the problem domain
  - Challenges
    - Formalizing Existing Concepts
      - Humans may use a term, such as "course", to refer to many different things; we may need to disambiguate between "course", "seminar", and "lab"
    - Different Interpretations
      - In a business context, accounting, production, and sales may all use the term "order" to mean different things
  - Approach: identify phenomena as objects, classify these objects and the events they can produce

Objects and Events

- For Mathiassen, objects are entities with identity, state, and behavior
- Objects are characterized by events
  - events are defined as "instantaneous incidents involving one or more objects"
- Example
  - Bank customer
  - Possible Events: Deposit, Withdraw, Apply for Loan, Buy Bonds, etc.

More on Events

- An event is an abstraction of an activity
  - We can abstract the activity of a "withdrawal" in order to describe the behavior of a bank customer
- Activities have duration, events do not
  - "loan approved"
- Events tie objects together
  - A "deposit" involves a customer and an account; the event is assigned to both objects
- Events have unique names (they live in a global namespace)

Problem Domain Analysis, cont.

- Having identified a set of objects
  - We find a set of classes to model them
  - Mathiassen recommends brainstorming as many different classes as possible, at first
    - you will later evaluate this list to identify the core set of classes that will be needed to model the system
  - Mathiassen also recommends that this process be performed with the user

Generating Potential Classes

- nouns
  - and noun phrases
  - as given by users
- general types
  - physical things
  - people and roles
  - organizations
  - places, concepts
  - descriptions
  - resources
  - devices
  - systems
- Remember
  - brainstorm
  - do not (yet) evaluate
- Chose
  - simple names
  - that originate in the problem domain
  - indicate a single instance

Problem Domain Analysis, cont.

- Having a set of potential classes
  - We now must identify events
  - Start with the verbs that your users use
  - Draw on general event types
    - work and production, transportation, consumption, life cycle, career and education, contracting and exchange, monitoring and control, planning and management, decision making and communication
  - Choose event names that are simple, originate in the problem domain and indicate a single event

Beware Verb Tense

- In choosing the verb form for event names, Mathiassen identifies three choices
  - present tense, past tense, present participle
    - reserve, reserved, reserving
  - Potential Problems
    - present tense verbs are difficult to distinguish from method names
    - past tense verbs are difficult to distinguish from the state reached after the event has occurred
    - the third form contradicts the fundamental property of an event as being instantaneous

Problem Domain Analysis, cont.

- Evaluate classes/events systematically
  - General evaluation criteria
    - Is the class or event within the system definition
    - Is the class or event relevant for the problem domain
    - «Note the similarity to the principle of domain relevance»
  - Classes and Events should concern only the problem domain at this point, not the application domain

Evaluation Criteria for Classes

- Can you identify objects from the class?
  - Is there a recognition rule?
- Does the class contain unique information?
  - If the class contains information that can be derived from other classes, then you are modeling functionality and not classes
- Does the class encompass multiple objects?
  - Singleton classes are rare
- Does the class have a suitable and manageable number of events?
  - A class with few events may be too simple; too many events and it may be better to split the class into smaller, more simple, classes

Evaluation Criteria for Events

- Is the event instantaneous?
  - If you want to model multiple events throughout an activity, include start, stop, and interval events; we want to know that an event has occurred
- Is the event atomic?
  - If you have an event that can be broken down into sub-events; include the sub-events directly and discard the composite event
- Can the event be identified when it occurs?
  - Would you be able to implement a system that can observe the event?

Assigning Events to Classes

- The class activity ends by creating an event table that relates events to classes; see Figure 3.1 on page 50
- Guidelines for creating the event table
  - Which events is this class involved in?
  - What classes are involved in this event?
- Effective for evaluating the cohesion and coupling of your classes and events

Structure Activity

- Goal
  - Produce a class diagram
- Purpose
  - Model abstract, general relationships between classes and concrete, specific relationships between objects
- Benefit
  - provides a coherent problem domain overview by describing all structural relations between classes and objects in our model

Starting the structure activity

- What are the specific relations between objects in the problem domain?
  - Identify two types of object relationships
    - aggregation structures
    - associations
- What is the conceptual relationships between two or more classes in the problem domain?
  - Identify two types of class relationships
    - generalization
    - clusters (e.g. a collection of related classes)

Important Point

- Class structures are static, conceptual relationships
  - they do not change, unless we somehow change the class descriptions themselves
- Object structures are concrete, dynamic relationships
  - They can freely change at runtime without impacting our class description

Steps of the Structure Activity

- Find candidate structures
- Evaluate Patterns
- Evaluate candidate structures and select the relevant relationships
- (See Figure 4.3 on page 72)
- *Note: this process is iterative and may require backtracking to the class activity*

Find Candidate Structures

- Find "is-a" relationships
  - A taxi is a car…
  - Remember that subclasses are mutually exclusive
- Find clusters
  - A cluster is a collection of classes that helps us achieve a problem-domain overview
  - See, for example, page 75
- Find associations and aggregations between objects; specify as class relationships

More on clusters

- Clusters (denoted using a folder symbol) enable an understanding of the problem domain by breaking it down into sub-domains
- Within a cluster, classes are related using generalization and aggregation
  - between clusters, classes are related using associations

Identifying Generalizations

- Approach 1
  - Examine every pair of selected classes and determine if a generalization structure exists
    - if so, the superclass's events must be a subset of the subclasses's events
- Approach 2
  - Determine if a relevant generalization exists for pairs of selected classes
    - this may introduce new classes
- Approach 3
  - examine each class and attempt to define a relevant generalization or specialization; may also add new classes

Identify Aggregations

- Approach One
  - Examine each pair of classes to see if the objects of one are decompositions of the objects of the other
- Approach Two
  - Determine if it is relevant to aggregate the objects from each pair of classes into objects from a newly created class
- Approach Three
  - Examine each class to see if new classes can be added that represent relevant "parts" or "wholes"

Types of Aggregation

- Whole-Part
  - the whole is the sum of the parts; if we add or remove any part, we change the whole fundamentally
  - delete the whole; delete the parts
- Container-Content
  - the whole is a container for the parts; the whole does not change fundamentally if we add or remove parts
- Union-Member
  - the whole is an organized union of members; similar to container-content except there is a lower bound on the number of members

Identify Associations/Clusters

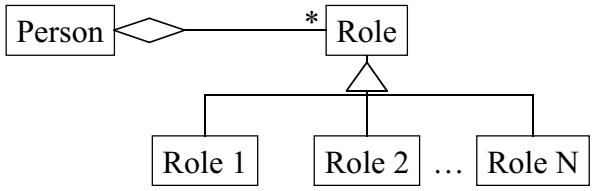
- Add associations whenever you need to administrate, monitor, or control relations between objects that are not otherwise related
- Add clusters to identify specific sub-domains
  - Note: classes cannot belong to more than one cluster

Explore Patterns

- Object Oriented Patterns are generalized descriptions of a problem and a related solution
  - We will cover patterns, in more detail, later in the semester
- For now, we look at four patterns particularly concerned with structure
  - Role, Relation, Hierarchy, Item-Descriptor

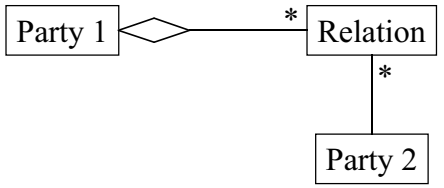
Role Pattern

- Used to model a situation where a single person can have multiple roles in a problem domain
- Solution: have a Person object aggregate one or more Role objects; each Role object can be a different subclass of Role



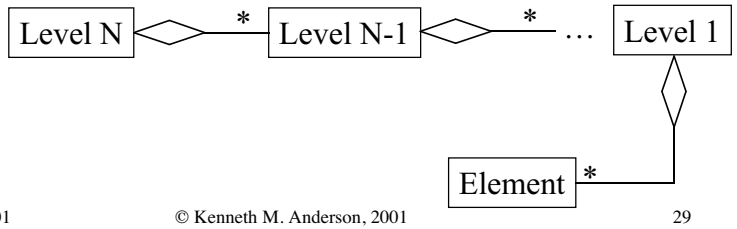
Relation Pattern

- A means for relating two objects, where the relation itself has properties
  - what we called association classes earlier
- A "party" to the relation aggregates a number of Relation objects; each Relation object is associated with some other "party"



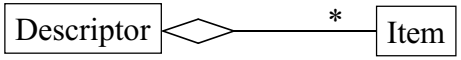
Hierarchy Pattern

- Used to organize elements into a series of layers
- Have each layer, aggregate instances of the layer below it; the bottom layer is some relevant element



Item-Descriptor Pattern

- Helps to distinguish between an item and its description
  - books and copies
  - each copy has its own identity; but shares properties described by the book object



Evaluate Systematically

- Principle
  - Model only the necessary structural relationships
- Critieria
  - Structures must be used correctly
  - Structures must be conceptually true
    - Do the structures represent the problem domain for a future user of the system
  - Structures must be simple

Structures Must be Used Correctly

- Do not mix generalization and aggregation
  - "is-a" versus "has-a" and "is-part-of"
- Use aggregation to capture fundamental, definitive relations; use associations for more fluid relations
  - Can the objects exist independently of each other?
  - Are the objects equally ranked?
  - Can the connection from an object from the one class change to other objects from the other class
- If you answer "yes" to two or more, use association
  - otherwise use aggregation