OBJECT-ORIENTED MODELING AND DESIGN

Domain Analysis

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1. Overview of Analysis
- The problem statement should not be taken as immutable, but rather as a basis for refining the requirements.
- Analysis is divided into two sub stages
  - Domain analysis
  - Application analysis

Fig 12.1 Overview of Analysis
2. Domain Class Model

- First step in analyzing the requirements is to construct a domain model.
- Static structure of the real world system is captured.
- The domain model describes real-world classes and their relationships to each other.
- Information for the domain model comes from the problem statement, artifacts from related systems, expert knowledge of the application domain and general knowledge of the real world.

The steps to be performed to construct a domain class model:

- Find Classes.
- Prepare a data dictionary.
- Find associations.
- Find attributes of objects and links.
- Organize and simplify classes using inheritance.
- Verify that access paths exist for likely queries.
- Iterate and refine the model.
- Reconsider the level of abstraction.
- Group classes into packages

• Finding classes

- Classes often correspond to nouns. Ref figure 12.2.
- Eg. “a reservation system sell tickets to performances at various theater”- Tentative classes would be Reservation, System, Tickets, Performance and Theaters.
- Idea is to capture concepts. not all nouns are concepts, and concepts are also expressed in other parts of speech.

Figure: 12.2 Finding Classes-by considering nouns
For the Case study of the ATM: The following are the classes extracted from problem statement nouns. Figure 12.3

- Additional classes that do not appear directly in the statement but can be identified from our knowledge of the problem domain

Figure: 12.3 ATM classes extracted from problem statement nouns

- Domain Class Model: Keeping the right classes
  - Discard unnecessary and incorrect classes according to the following criteria
  - Redundant classes: If two classes express the same concept, you should keep the most descriptive name.
    - ATM example. Customer and user are redundant; we retain customer because it is more descriptive.
  - Irrelevant classes
    - Apportioning cost is outside the scope of the ATM software.
  - Vague classes: class should be specific.
Attributes: Names that primarily describe individual objects should be restated as attributes.

Operations: If a name describes an operation that is applied to objects and not manipulated in its own right, then it is not a class.

Eg-if we are simply building telephones, then call is part of the state model and not a class.

Roles: The name of a class should reflect its intrinsic nature and not a role that it plays in an association.

- Owner of a car.. in a car manufacturing database, not correct as a class. It can be a person( owner, driver, lessee)

Implementation Constructs:
Eliminate constructs from the analysis model that are extraneous to the real world. We may need them during design and not now.

Derived classes:
As a general rule, omit classes that can be derived from other classes. mark all derived classes with a preceding slash(‘/’) in the class name.

Keeping the right classes:

**Bad Classes**

- vague
  - System
  - Security Provision
  - Recordkeeping Provision
  - Banking Network

- attribute
  - Account Data
  - Receipt
  - Cash
  - Transaction Data

- redundant
  - User

- irrelevant
  - Cost
  - Access
  - Software
  - Transaction Log
  - Communications Line

**Good Classes**

- Account
- ATM
- Bank
- Bank Computer
- Cash Card
- Cashier
- Cashier Station
- Central Computer
- Consortium
- Customer
- Transaction

**Figure:** 12.5 Eliminating unnecessary classes from ATM Problem.
Preparing a Data Dictionary

- Prepare a data dictionary for all modeling elements.
- Describe the scope of the class within the current problem, including all assumptions or restrictions on its use.
- DD also describes associations, attributes, operations and enumeration values

Data Dictionary for the ATM classes

<table>
<thead>
<tr>
<th>Account</th>
<th>ATM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank</td>
<td>BankComputer</td>
</tr>
<tr>
<td>CashCard</td>
<td>Cashier</td>
</tr>
<tr>
<td>cashierStation</td>
<td>CentralComputer</td>
</tr>
<tr>
<td>Consortium</td>
<td>Customer</td>
</tr>
<tr>
<td>Transaction</td>
<td></td>
</tr>
</tbody>
</table>

Finding associations

- A structural relationship between two or more classes is an association.
- A reference from one class to another is an association.
- Associations often correspond to verbs or verb phrases.
- Idea here is to capture relationships

<table>
<thead>
<tr>
<th>Verb phrases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banking network includes cashier stations and ATMs</td>
</tr>
<tr>
<td>Consortium shares ATMs</td>
</tr>
<tr>
<td>Bank provides bank computer</td>
</tr>
<tr>
<td>Bank computer maintains accounts</td>
</tr>
<tr>
<td>Bank computer processes transaction against account</td>
</tr>
<tr>
<td>Bank owns cashier station</td>
</tr>
<tr>
<td>Cashier station communicates with bank computer</td>
</tr>
<tr>
<td>Cashier enters transaction for account</td>
</tr>
<tr>
<td>ATMs communicate with central computer about transaction</td>
</tr>
<tr>
<td>Central computer clears transaction with bank</td>
</tr>
<tr>
<td>ATM accepts cash card</td>
</tr>
<tr>
<td>ATM interacts with user</td>
</tr>
<tr>
<td>ATM dispenses cash</td>
</tr>
<tr>
<td>ATM prints receipts</td>
</tr>
<tr>
<td>System handles concurrent access</td>
</tr>
<tr>
<td>Banks provide software</td>
</tr>
<tr>
<td>Cost apportioned to banks</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Implicit verb phrases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consortium consists of banks</td>
</tr>
<tr>
<td>Bank holds account</td>
</tr>
<tr>
<td>Consortium owns central computer</td>
</tr>
<tr>
<td>System provides recordkeeping</td>
</tr>
<tr>
<td>System provides security</td>
</tr>
<tr>
<td>Customers have cash cards</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Knowledge of problem domain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash card accesses accounts</td>
</tr>
<tr>
<td>Bank employs cashiers</td>
</tr>
</tbody>
</table>
Keeping the Right Association
Discard unnecessary associations, using the following criteria:

- Associations between eliminated classes.
- Irrelevant or implementation associations.
- Actions: An association should describe a structural property of the application domain not a transient event.
- Ternary associations.
- Derived associations :they may be redundant

Further specify the semantics of associations as follows:

- Misnamed associations.
- Association end names.
- Qualified associations.
- Multiplicity
- Missing associations
- Aggregation.
- Fig 12.9 shows class diagram with remaining associations

Figure: 12.9 Initial class diagram for ATM system
Find attributes of objects and links.

- Attributes are data properties of objects
- Attribute values should not be objects; use an association to show any relationship between objects.
- Attributes usually correspond to nouns followed by possessive phrases, such as “the color of the car”

Keeping the right attributes:
Eliminate unnecessary and incorrect attributes with the following criteria:
- Objects . Discordant attributes
- Qualifiers . Boolean attributes.
- Names
- Identifiers
- Attributes on associations
- Internal values
- Fine detail

Figure: 12.10 ATM class model with attributes
Refining With Inheritance
Organize classes by using inheritance to share common features:
- Bottom up generalization.
- Top-down generalization
- Generalization vs. enumeration.
- Multiple inheritance
- Similar associations
- Adjusting the inheritance level.
- Fig 12.11 shows the ATM class model after adding inheritance

Figure: 12.11 ATM class model with attributes and inheritance

- Verify that access paths exist for likely queries.
  Trace access paths through the class model to see if they yield sensible results.
• Iterate and refine the model.  
  A class model is rarely correct after a single pass, so iterate and refine the model.  
• Fig 12.12 shows a revised class diagram that is simpler and cleaner.

Figure:12.12 ATM class model after further revision.

• Reconsider the level of abstraction.  
  Abstraction makes a model more complex but can increase flexibility and reduce the number of classes.
• Group classes into packages.
  • The last step of class modeling is to group classes into packages.
  • A package is a group of elements (classes, association, generalizations and lesser packages) with common theme.

3. Domain State Model

The Following steps are performed in constructing a domain state model
  • Identifying classes with states
  • Finding states
  • Finding Events
  • Building state diagrams
  • Evaluating state diagrams

After running thro the above steps, the domain state model obtained is a shown in Figure 12.14

![Domain State Model Diagram](image)

**Figure: 12.14 Domain state model.**

4. Domain Interaction Model

• The Interaction model is seldom important for domain analysis.
• The Interaction model is an important aspect of application modeling
5. Iterating the Analysis

The iteration to the analysis should be done as follows:

- Refining the Analysis Model
- Restating the Requirements
- Analysis and Design.

6. Chapter Summary.

- The domain model captures general knowledge about the application-concepts and relationships known to experts in the domain.
- The domain model has class model and state model but seldom has an interaction model.
- A good analysis captures the essential features without introducing the implementation artifacts that prematurely restrict the design decisions.
- The result of analysis replaces the original problem statement and serves as the basis for design.

Exercise

1. For each of the following systems, identify the relative importance of the three aspects of modeling:
   1) Class modeling 2) state modeling 3) interaction modeling

   a. bridge player
   b. change making machine
   c. car cruise control
   d. electronic typewriter
   e. spelling checker
   f. telephone answering machine.

Answer:

a. bridge player. Interaction modeling, class modeling, and state modeling, in that order, are important for a bridge playing program because good algorithms are needed to yield intelligent play. The game involves a great deal of strategy. Close attention to inheritance and method design can result in significant code reuse. The interface is not complicated, so the state model is simple and could be omitted.

b. change-making machine. Interaction modeling is the most important because the machine must perform correctly. A change making machine must not make mistakes; users will be angry if they are cheated and owners of the machine do not want to lose money. The machine must reject counterfeit and foreign money, but should not reject genuine money. The state model is least important since user interaction is simple.
c. **car cruise control.** The order of importance is state modeling, class modeling, and interaction modeling. Because this is a control application you can expect the state model to be important. The interaction model is simple because there are not many classes that interact.

d. **electronic typewriter.** The class model is the most important, since there are many parts that must be carefully assembled. The interaction between the parts also must be thoroughly understood. The state model is least important.

e. **spelling checker.** The order of importance is class modeling, interaction modeling, and state modeling. Class modeling is important because of the need to store a great deal of data and to be able to access it quickly. Interaction modeling is important because an efficient algorithm is needed to check spelling quickly. The state model is simple because the user interface is simple: provide a chance to correct each misspelled word that is found.

f. **telephone answering machine.** The order of importance is state modeling, class modeling, and interaction modeling. The state diagram is non-trivial and important to the behavior of the system. The class model shows relationships between components that complement the state model. There is little computation or state diagrams to interact, so the interaction model is less important.

2. The following is the class model for the scheduler software:

[Diagram of class model]

**Figure A12.12** Class model for scheduler software
3. Ref to the Question 2. The following is a list of candidate classes. Prepare a list of classes that should be eliminated for any of the reasons listed in the chapter. Give reasons for each elimination. If there is more than one reason, give the main one.

Scheduling software, meeting user, chairperson, software, meeting entry, schedule, attendee, scheduler, room, time, everyone, attendance, acceptance status, meeting notice, invitation, meeting information, invitee, notice.

Answer:

The following tentative classes should be eliminated.

**Redundant classes.** Invitee is synonymous with user and could be a role, depending on the realization of the class model. Everyone refers to user and is redundant. Meeting notice is the same as notice; we keep notice. Attendance is also extraneous and merely refers to an attendee participating in a meeting. Meeting and meeting entry are synonymous; we keep meeting.

**Irrelevant or vague classes.** We discard scheduling software, scheduler, software, and meeting information because they are irrelevant.

**Attributes.** We model time and acceptance status as attributes. An invitation is a type of notice; we need the enumeration attribute noticeType to record whether an invitation is an invitation, reschedule, cancellation, refusal, or confirmation.

**Roles.** Chair person and attendee are association ends for user.