

# CPS122 Lecture: Identifying Objects and Classes

last revised December 4, 2017

## *Objectives:*

1. To show how to identify the major objects/classes for a problem

## *Materials:*

1. Quick-Check questions and answers for ch. 4
2. ATM System example on the web.
3. AddressBook use cases - handout

## **I. Introduction**

A. Today, we are continuing to talk about analysis, where the goal is to *understand* a problem. Actually, there are two kinds of things we need to think about at this point.

1. Application analysis is concerned with understanding the requirements of a particular problem.
  - a) The development of use cases, as we discussed last time, falls into this category. We seek to understand how someone will use our software.
  - b) The specification of initial functional tests likewise falls into this category. Spelling out such tests helps us to better understand what must take place.
2. Domain analysis is concerned with understanding the particular application domain of which a specific problem is a part.

For example, if you were developing a system involved with student registration for courses, the domain you would need to be familiar with includes concepts like students, courses, course offerings, sections, enrollments etc.; as well as the relationships between them.

To illustrate this, what is the difference between a course offering and a section?

ASK

Why is this difference important?

ASK

When a student registers for a multiple section course, whether there is room depends on the specific section; each section has its own roster; and the specific professor is responsible for assigning the student's final grade.

- a) In an OO approach to problem solving, we use the same concepts (objects and classes) for analyzing a domain as we will later use for developing a solution to a problem in that domain.
- b) This stands in sharp contrast with the traditional structured approach, which uses quite different approaches for understanding a domain and for developing a solution to a particular problem in the domain.

B. At the heart of any problem-solving approach is the idea of decomposition - breaking a large problem up into smaller pieces.

1. An old joke: "How do you eat an elephant?"

ASK

One bite at a time

2. Problems of any significant size require the effort of more than one person - in fact, major software projects may involve thousands. One wants to decompose a problem into modules that are as independent as possible, so that different people can work on them without getting in each other's way. The technical term for this is that we want to minimize coupling - i.e. the degree to which one module depends on another.

Example: Some books are collections of articles by different authors - that is, the books are decomposed into chapters, with each having its own author. This works reasonably well.

Suppose, instead, that the book were decomposed by pages, with one author responsible for page 1, 5, 9, 13..., a second responsible for page 2, 6, 10, 14 ... etc. Obviously, this would result in chaos!

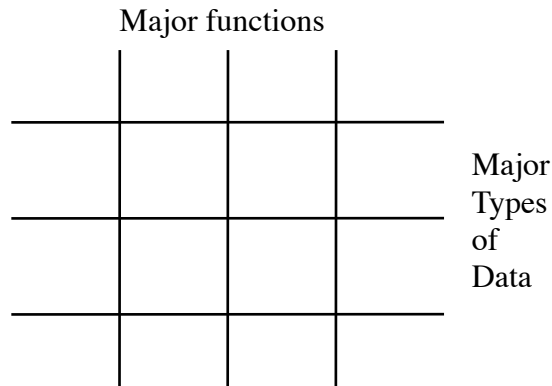
3. While any approach to solving a large problem necessarily involves decomposition, an object-oriented approach to software development diverges dramatically from the structured approach in terms of how it approaches this.

- a) Any software system can be viewed in two ways - one can focus on the data that is being manipulated, or the functionality that manipulates the data.

Example: consider software used for student registration. The data being manipulated includes information about individual students, information about individual courses, and information about enrollment in courses - what students are in what course. The functionality includes things like enrolling a student in a course, dropping a student from a course, printing student schedules, printing course lists, etc.

- b) As today's chapter in the book discussed, the older structured approach decomposes the system according to its functionality - e.g. major pieces in the decomposition would be “enroll student”, “drop student”, “print schedule”, “print course list”, etc. The object oriented approach decomposes the system according to its data - e.g. the major pieces in the decomposition would be “student” and “course”, related by an “enrolled in” relationship.

This can be depicted as follows - it's like the “warp and woof” of cloth:



c) Thus, a key part of solving any problem is identifying the classes that naturally model its domain.

## II. Go Over Quick Check Questions

### III. Exercises to do in groups of 4

A. Exercise 4.1

B. Exercise 4.5

### IV. Class Identification Based on Domain Analysis

A. It is often possible to develop a model of the general domain of which a particular problem is a part in terms of objects and classes. The objects and classes thus identified will necessarily be part of any system that solves problems in that domain.

B. Recall from the reading that it is important to consider not only the individual objects, but also how the objects relate to one another.

What are the three ways?

ASK

1. Association: objects of the two classes have some sort of relationship and can communicate with one another.
2. Aggregation: a stronger relationship in which there is an “ownership” or whole-part relationship between the objects (as opposed to association where the two objects can be thought of as peers).

In describing an aggregation, one will typically use phrases like “has a” or “is a part of”(Note: there is a strong form of aggregation called composition or containment which we will discuss later)

3. Inheritance/generalization: a relationship between CLASSES, **not** INDIVIDUAL OBJECTS.

a) We will say a lot more about this later.

b) This is the relationship implied by phrases like “is a”.

Examples: the relationship between classes like "Student" and "Person" - but not the relationship between classes like "Person" and "Arm". (The latter would be aggregation)

4. Some things to note about these.

a) It is vital to note the difference between association/aggregation on the one hand, and generalization on the other. The key distinction is rooted in a concept known as *the law of substitution*: we can legitimately say that class A is a generalization of class B if and only if wherever an A is required, A B can be used.

b) While there is a very sharp distinction between generalization, on the one hand, and association or aggregation on the other, the distinction between association and aggregation is not always as clear; sometimes, a reasonable case can be made for either.

c) “What is the difference between aggregation and composition?”

The essence is that the relationship is exclusive: the part belongs to exactly one whole, and cannot exist apart from the whole, and the parts live and die with the whole

Example: Course Roster, Student is an aggregation but cannot be regarded as a composition, because students are, in general, enrolled in multiple courses, and a student can exist even if not enrolled in any courses.

Example: Book, Chapter: Composition is reasonable in this case - unless one wants to allow a Chapter to have a separate existence (as might be the case with certain kinds of reprinting)

d) Do the following as think-pair-share

Person, Student: Generalization (satisfies law of substitution - it is meaningful to say “a Student is a Person”)

Course Roster, Student Aggregation (it is meaningful to say “a Course Roster is made of Students”)

Course, Student Probably simple Association - maybe Aggregation.

Book, Chapter Composition - it is meaningful to say “A chapter is part of a book”

C. At this point, we are interested in identifying classes which are part of the problem domain. Later, we will extend this to include classes that are part of the solution domain for a specific problem.

D. Exercises in Groups of 4

1. Exercise 4.3

2. Let’s develop an OO model of the domain underlying the “Wheels” system in the book.

a) What are the key concepts?

ASK

(1) An individual bicycle

(2) A specialist bicycle (e.g. racer, mountain bike ...)

(3) A customer

b) How are these concepts related to one another?

ASK

(1) A specialist bicycle is a kind of bicycle - Generalization - it is meaningful to say "a specialist bicycle is a bicycle"

(2) A given bicycle can be hired by a given customer.

Association - it is not meaningful to say "a bicycle is a customer or vice versa; it is not meaningful to say "a bicycle is a part of a customer or vice versa".

In the case of association, one can also consider multiplicity

(a) Any given bicycle can only be hired by one customer at a time.

(b) But a given customer can hire multiple bikes at a given time (e.g. a family)

Thus, this association is 1 : many from customer to bicycle (more on this later)

(3) A customer can have reservations for one or more bicycles at some time in the future.

Probably association

Note that a bicycle can be reserved for multiple customers (at different times), so the association is many : many.

## V. Class Identification Based on Noun Extraction

Another approach to identifying classes that is sometimes simplistic, but yet is often useful, is called noun extraction. The basic idea is this: read over the system requirements/use case flows of events, and note the nouns that appear.

A. Some of the nouns that appear - especially the ones that appear frequently - will turn out to refer to objects that need to be represented by classes in the final system.

B. Other nouns will turn out to be other things, including:

1. Attributes of objects, rather than objects in their own right. An important skill to develop is being able to distinguish the two. Recall that objects have three essential characteristics:

*ASK*

- a) Identity.
- b) State (often complex - i.e. involving more than a simple value).
- c) Behavior

Examples: ASK for Wheels examples of attributes that are not objects in their own right, and why

things like customer name, bicycle rental rate, date due, etc. are attributes

2. Actors or other objects that are outside the scope of the system.

Example: ASK for Wheels examples

Receptionist



Note that since we don't have to build models of these, they do not need to be represented by classes inside the system.

C. Finally, sometimes there may be a generalization-specialization relationship between nouns - implying an inheritance relationship between the corresponding classes.

D. Exercise in Groups of 4: Apply noun-extraction to use cases for AddressBook system.

## **VI. Class Identification is not Once-for-All**

It is important to recognize that identifying classes is not something we do once and then never change. As the design process proceeds, we should be prepared to:

A. Add additional classes that we discover the need for

B. Reconfigure classes identified previously as we develop a clearer sense of what their responsibilities will be.

C. The classes identified during analysis will often carry forward into the implementation of the system - with others added as well to support the implementation per se. (A 5:1 expansion is not uncommon.)

1. The classes discovered by analyzing the problem domain are called analysis classes.
2. The classes used to actually implement the system are called design classes or implementation classes.
3. One of the advantages of the "seamless development" aspect of OO is that the analysis classes generally form an important subset of the classes actually used to implement the system.