Object-Oriented Thinking (Part 1)

Introduction to Programming and Computational Problem Solving - 2

CSE 8B

Lecture 8

Announcements

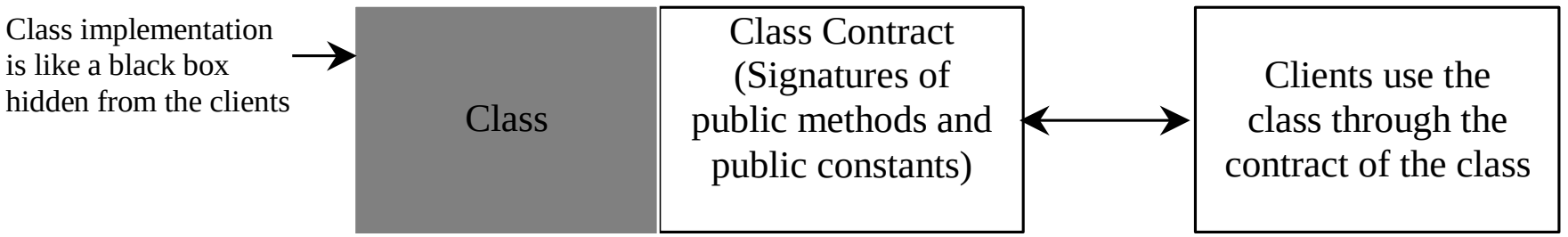
- Assignment 3 is due today, 11:59 PM
- Quiz 3 is Oct 22
- Assignment 4 will be released today
  - Due Oct 27, 11:59 PM
- Educational research study
  - Oct 22, weekly survey
- Reading
  - Liang
    - Chapter 10

Object-oriented thinking

- The advantages of object-oriented programming over procedural programming
- Classes provide more flexibility and modularity for building reusable software
- How to solve problems using the object-oriented paradigm
- Class design

Class abstraction and encapsulation

- *Class abstraction* means to separate class implementation from the use of the class
- The creator of the class provides a description of the class and lets the user know how the class can be used
  - The *class contract*
- The user of the class does not need to know how the class is implemented
- The detail of implementation is encapsulated and hidden from the user
  - *Class encapsultion*
  - A class is called an *abstract data type* (ADT)



Class abstraction and encapsulation

- For example, a class for a loan

Loan	
-annualInterestRate: double	The annual interest rate of the loan (default: 2.5).
-numberOfYears: int	The number of years for the loan (default: 1)
-loanAmount: double	The loan amount (default: 1000).
-loanDate: Date	The date this loan was created.
+Loan()	Constructs a default Loan object.
+Loan(annualInterestRate: double, numberOfYears: int, loanAmount: double)	Constructs a loan with specified interest rate, years, and loan amount.
+getAnnualInterestRate(): double	Returns the annual interest rate of this loan.
+getNumberOfYears(): int	Returns the number of the years of this loan.
+getLoanAmount(): double	Returns the amount of this loan.
+getLoanDate(): Date	Returns the date of the creation of this loan.
+setAnnualInterestRate(annualInterestRate: double): void	Sets a new annual interest rate to this loan.
+setNumberOfYears(numberOfYears: int): void	Sets a new number of years to this loan.
+setLoanAmount(loanAmount: double): void	Sets a new amount to this loan.
+getMonthlyPayment(): double	Returns the monthly payment of this loan.
+getTotalPayment(): double	Returns the total payment of this loan.

The creator of the class provides a description of the class and lets the user know how the class can be used

The *class contract*

Class abstraction and encapsulation

- A class is designed for use by many different users (or customers or clients)
- To be useful in a wide range of applications, a class should provide a variety of ways for customization through properties, and constructors and methods that, together, are **minimal and complete**

Thinking in objects

- Procedural programming focuses on designing methods
- Object-oriented programming
  - Couples data and methods together into objects
  - Focuses on designing objects and operations on objects
- Object-orientated programming combines the power of procedural programming with an additional component that integrates data with operations into objects

Procedural programming vs object-oriented programming

- Procedural programming
  - Data and operations on data are separate
  - Requires passing data to methods
- Object-oriented programming
  - Data and operations on data are in an object
  - Organizes programs like the real world
    - All objects are associated with both attributes and activities
  - Using objects improves software reusability and makes programs easier to both develop and maintain

Class relationships

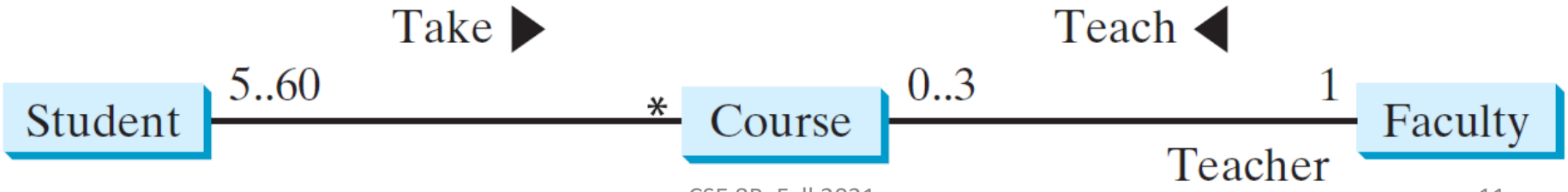
- To design classes, one must understand the relationships among classes
  - Association
  - Aggregation
  - Composition
  - Inheritance (covered next week)

Association

- A general binary relationship that describes an activity between two classes
- For example
  - A student taking course is an association between the `Student` class and the `Course` class
  - A faculty member teaching a course is an association between the `Faculty` class and the `Course` class

Association

- Multiplicity
  - The number of objects of a class
- For example
  - Each student may take any number (*) of courses
  - Each course must have 5 to 60 students
  - Each course is taught by 1 faculty member
  - Each faculty member must teach 0 to 3 courses



Association

- In Java, associations can be implemented using data fields and methods
  - For example
    - A student takes a course
      `addCourse` method in `Student` class
      `addStudent` method in `Course` class
    - A faculty member teaches a course
      `addCourse` method in `Faculty` class
      `setFaculty` method in `Course` class
    - The Student class may store the courses a student is taking
      `private Course[] courseList;`
    - The Faculty class may store the courses a faculty member is teaching
      `private Course[] courseList;`
- **There are many possible ways to implement association relationships**

Aggregation

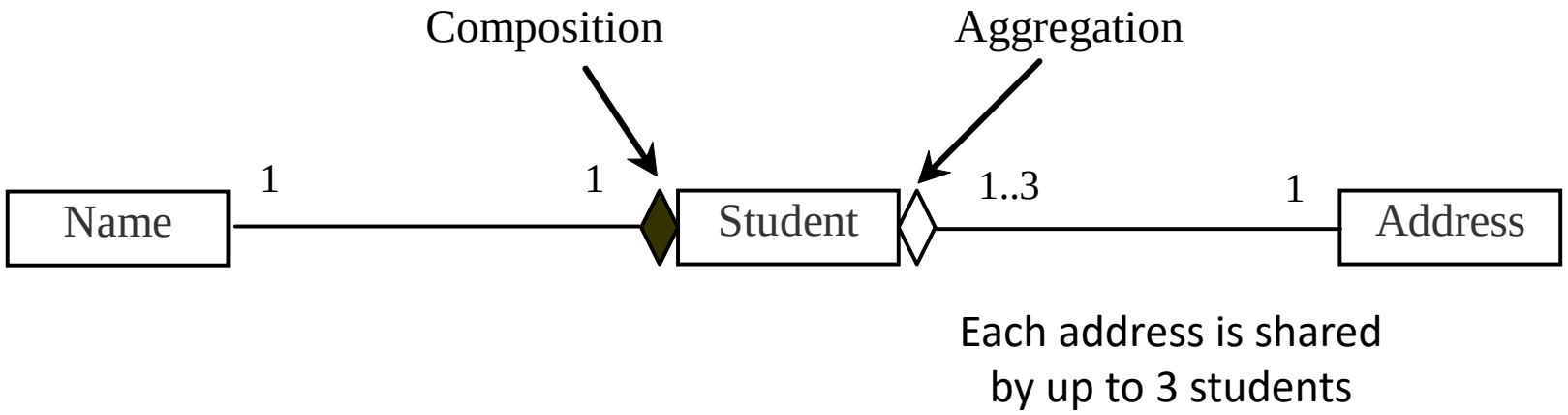
- Special form of association representing an owner-subject relationship
  - The *owner* object is called an *aggregating object* and its class is called an *aggregating class*
  - The *subject* object is called an *aggregated object* and its class is called an *aggregated class*
- Models **has-a** relationships
  - For example
    - A student **has-a** name
    - A student **has-a**n address

Composition

- Aggregation between two objects is called *composition* if the existence of the aggregated object is dependent on the aggregating object
  - Exclusive ownership of the subject
  - The subject (i.e., aggregated object) cannot (conceptually) exist on its own
    - For example
      - A book **has-a** page and when the book is destroyed, so is the page
      - A page has no meaning or purpose without the book

Aggregation and composition

- For example
  - When the student object is destroyed
    - Their name is destroyed (composition)
    - Their address is not destroyed (aggregation)



Aggregation and composition

- Usually represented as a data field in the aggregating class

```
public class Name {
  ...
}
```

Aggregated class

```
public class Student {
  private Name name;
  private Address address;

  ...
}
```

Aggregating class

```
public class Address {
  ...
}
```

Aggregated class

Aggregation between same class

- Aggregation may exist between objects of the same class
  - For example, a person may have a supervisor

```
public class Person {
  // The type for the data is the class itself
  private Person supervisor;
  ...
}
```

  - For example, a person may have multiple supervisors

```
public class Person {
  // The type for the data is the class itself
  private Person[] supervisors;
  ...
}
```

Aggregation or composition

- Warning: Since aggregation and composition relationships are represented using classes in similar ways, many texts do not differentiate them, calling both compositions

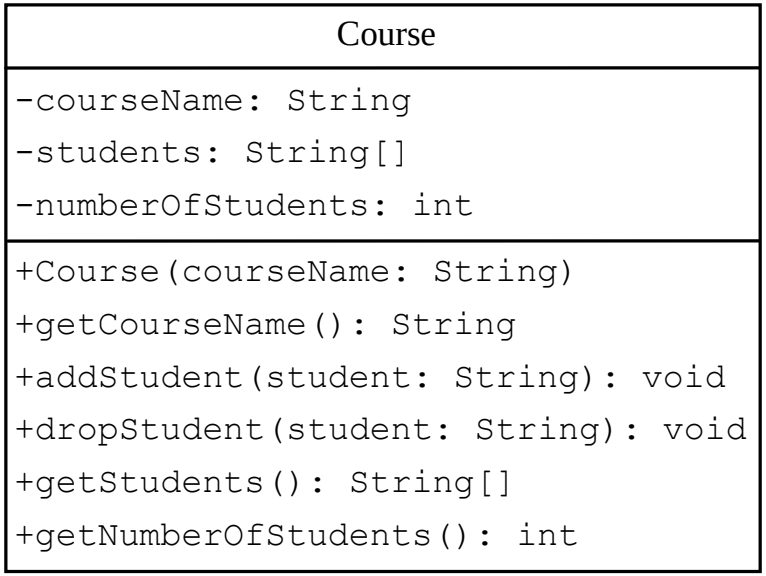
Class design and development

- For example, a class for a course

Course	
`-courseName: String`	The name of the course.
`-students: String[]`	An array to store the students for the course.
`-numberOfStudents: int`	The number of students (default: 0).
`+Course(courseName: String)`	Creates a course with the specified name.
`+getCourseName(): String`	Returns the course name.
`+addStudent(student: String): void`	Adds a new student to the course.
`+dropStudent(student: String): void`	Drops a student from the course.
`+getStudents(): String[]`	Returns the students in the course.
`+getNumberOfStudents(): int`	Returns the number of students in the course.

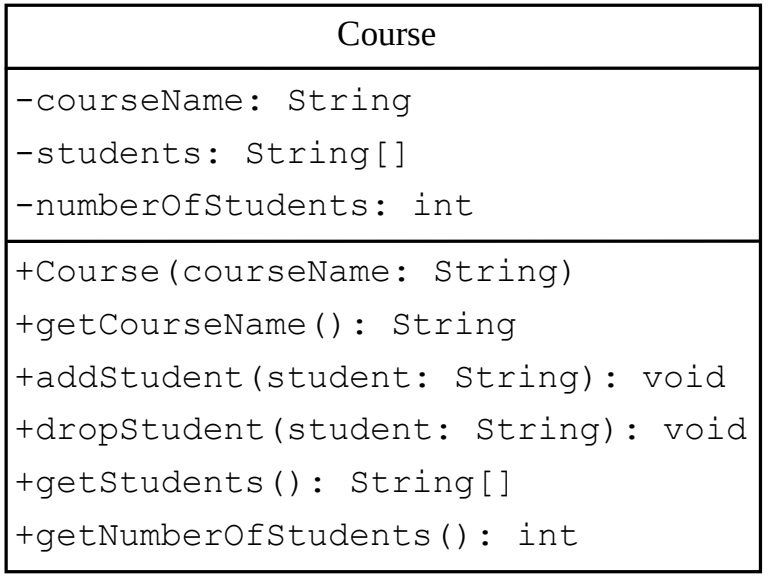
Class design and development

```
public class TestCourse {
  public static void main(String[] args) {
    Course course1 = new Course("Data Structures");
    Course course2 = new Course("Database Systems");

    course1.addStudent("Peter Jones");
    course1.addStudent("Brian Smith");
    course1.addStudent("Anne Kennedy");

    course2.addStudent("Peter Jones");
    course2.addStudent("Steve Smith");

    System.out.println("Number of students in course1: "
      + course1.getNumberOfStudents());
    String[] students = course1.getStudents();
    for (int i = 0; i < course1.getNumberOfStudents(); i++)
      System.out.print(students[i] + ", ");

    System.out.println();
    System.out.print("Number of students in course2: "
      + course2.getNumberOfStudents());
  }
}
```



Class design and development

```
public class Course {
  private String courseName;
  private String[] students = new String[4];
  private int numberOfStudents;

  public Course(String courseName) {
    this.courseName = courseName;
  }

  public void addStudent(String student) {
    students[numberOfStudents] = student;
    numberOfStudents++;
  }

  public String[] getStudents() {
    return students;
  }

  public int getNumberOfStudents() {
    return numberOfStudents;
  }

  public String getCourseName() {
    return courseName;
  }

  public void dropStudent(String student) {
    // Left as an exercise in Exercise 10.9
  }
}
```



Class design and development

- Use a UML class diagram to design the class
- Write a test program that uses the class
  - Developing a class and using a class are two separate tasks
  - It is easier to implement a class if you must use the class
- Implement the class
- Use Javadoc to document the class (contract)

Object-oriented thinking

- Classes provide more flexibility and modularity for building reusable software
- Class abstraction and encapsulation
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Next Lecture

- Object-oriented thinking
- Reading
  - Liang
    - Chapter 10