Module 9 - Objects and Classes

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General Notes

ZyBooks

Objects: Introduction

- An **object** is a grouping of data (variables) and operations that can be performed on that data (methods).
    - The physical world is made up of material items like wood, metal, plastic, fabric, etc. To keep the world understandable, people deal with higher-level objects, like chairs, tables, and TV's. Those objects are groupings of the lower-level items.

High-level Object Examples

Object	Methods	Fields
Chair	• Put stuff in	• Green fabric • Wood
Couch	• Sit • Lie down	• Red fabric • Wood
Drawer	• Put stuff in • Take stuff out	• Metal bar • Wood
Restaurant	• Set main info • Add cuisine • Add review • Print all	• Name • Cuisines • Phone • Reviews
Hotel	• Set main info • Add amenity • Add review • Print all	• Name • Amenities • Phone • Reviews

Abstraction / Information Hiding

Abstraction means to have a user interact with an item at a high-level, with lower-level internal details hidden from the user (aka **information hiding** or **encapsulation**).

- Ex: An oven supports an abstraction of a food compartment and a knob to control heat. An oven's user need not interact with internal parts of an oven.

Objects strongly support abstraction, hiding entire groups of methods and variables, exposing only certain methods to a user.

An **abstract data type (ADT)** is a data type whose creation and update are constrained to specific well-defined operations.

- A class can be used to implement an ADT.

Using a Class

- A class is a blueprint for creating objects.

Some **class - object** pairs:

Coin - penny → **Coin** is the class/blueprint.

- **penny** is an object of type **Coin**.

Student - Bart Simpson → **Student** is the class/blueprint.

- **Bart Simpson** is an object of type **Student**

When creating a class, think about what data an object needs to know about, and what an object needs to do.

Classes Intro: Public Member Methods

The **class** construct defines a new type that can group data and methods to form an object. A class' **public member methods** indicate all operations a class user can perform on the object.

Using a Class

Creating an object consists of two steps:

1. Declaring a reference variable of the class type
2. Assigning the variable with an explicitly allocated instance of the class type.

- A **reference variable** can refer to an instance of a class.
- The **new** operator explicitly allocates an object of the specified class type.

- The `.` operator, known as the **member access operator**, is used to invoke a method on an object.

Defining a Class

When defining a class, attributes of the class are called **private fields** or **instance variables**.

- **private fields:** variables that member methods can access but class users cannot.
  - The `private` access modifier precedes each private field declaration.

A programmer defining a class first names the class, declares private fields, and defines public member methods. A class' fields and methods are collectively called **class members**.

The programmer defines the details of each member method, sometimes called the class' **implementation**.

A **method definition** provides an access modifier, return type, name, parameters, and the method's statements. A member method can access all private fields.

Class definitions typically follow this structure:

```
Class Name
-----------------------------------------------
private fields/instance variables - can be seen/used throughout the class definition
-----------------------------------------------
public methods
-----------------------------------------------
```

Example: RunnerInfo Class

RunnerInfo.java

```
class RunnerInfo {
  private int timeRun;
  private double distRun;

  public void setTime(int timeRunSecs) {     // Time run in seconds
    timeRun = timeRunSecs;                   // timeRun refers to the field
  }

  public void setDist(double distRunMiles) {  // Distance run in miles
    distRun = distRunMiles;
  }

  public double getSpeedMph() {              // Speed in miles/hour
    return distRun / (timeRun / 3600.0);     // miles / (secs / (secs / hour))
  }
}
```

RaceResults.java

```
public class RaceResults {
  public static void main(String[] args) {
    RunnerInfo runner1 = new RunnerInfo();        // User-created object of class type
RunnerInfo
    RunnerInfo runner2 = new RunnerInfo(); // A second object

    runner1.setTime(360);
    runner1.setDist(1.2);
    runner2.setTime(200);
    runner2.setDist(0.5);

    System.out.println("Runner1's speed in MPH: " + runner1.getSpeedMph());
    System.out.println("Runner2's speed in MPH: " + runner2.getSpeedMph());
  }
}
```

Output

```
Runner1's speed in MPH: 12
Runner2's speed in MPH: 9
```

Mutators, Accessors, and Private Helpers

Mutators and Accessors

A class' public methods are commonly classified as either mutators or accessors.

- A **mutator** method may modify ("mutate") a class' fields.
- An **accessor** method accesses fields but may not modify a class' fields.

Commonly, a field has two associated methods: a mutator for setting the value, and an accessor for getting the value, known as a setter and getter method, respectively, and typically with names starting with set or get.

- Other mutators and accessors may exist that aren't associated with just one field, such as the `print()` method below.

Private Helper Methods

A programmer commonly creates private methods, known as **private helper methods**, to help public methods carry out tasks.

```
public class MyClass {
  private int numA;

  private int methodX() {
    ...
  }

  public void method1() {


  }
}
```

Initialization and Constructors

A good practice is to initialize all variables when declared. This section deals with initializing the fields of a class when a variable of the class type is allocated.

Field Initialization

It is possible to initialize fields in the field declaration, but **it is not advised to do so. Instead, use a class constructor to initialize fields.**

Constructors

- A **constructor** is a special class member method that is called when an object of that class type is created.
  - It can be used to initialize all fields.
- The constructor has the same name as the class and no return type (not even void).

A programmer specifies the constructor that should be called when creating an object:

```
Restaurant favLunchPlace = new Restaurant();
```

- Creates a new `Restaurant` object and calls the constructor `Restaurant()`.
- If a class does not have a programmer-defined constructor, then the Java compiler implicitly defines a default constructor with no arguments.
  - The Java compiler also initializes all fields to their default values.

Restaurant.java

```java
public class Restaurant {
  private String name;
  private int rating;

  public Restaurant() {  // Constructor with no arguments
    name = "NoName";    // Default name: NoName indicates name was not set
    rating = -1;        // Default rating: -1 indicates rating was not set
  }

  public void setName(String restaurantName) {
    name = restaurantName;
  }

  public void setRating(int userRating) {
    rating = userRating;
  }

  public void print() {
    System.out.println(name + " -- " + rating);
  }
}
```

RestaurantFavorites.java

```java
public class RestaurantFavorites {
  public static void main(String[] args) {
    Restaurant favLunchPlace = new Restaurant(); // Calls the constructor

    favLunchPlace.print();

    favLunchPlace.setName("Central Deli");
    favLunchPlace.setRating(4);
    favLunchPlace.print();
  }
}
```

Output

```
NoName -- -1
Central Deli -- 4
```

Exploring Further

- Constructors

  from Oracle's Java tutorials
- Initializing Fields

  from Oracle's Java tutorials

Choosing Classes to Create

- Creating a program may start by a programmer deciding what "things" exist, and what each thing contains and does.

Unified Modeling Language (UML) Example

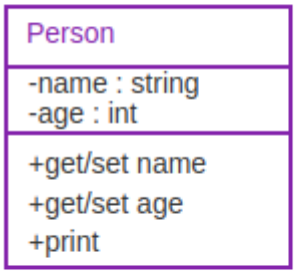
My program

Will have a soccer team

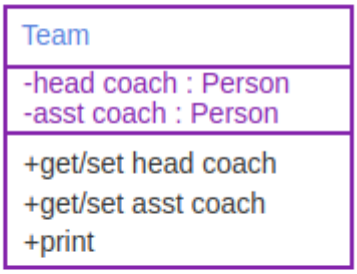
The team will have a head coach, assistant coach, list of players, name, etc.

Each coach and player will have a name, age, phone, etc.

I need a class for a "person" (coaches, players)



And for a "team"



More to come (list of players, name, etc.)

The programmer then sketches a Team class. Private items are head coach and asst coach, both of Person type. Public items are getters/setters and print.

- Top section is the class name
- Middle section are private fields / instance variables.
- Bottom section shows all the methods, or tasks/behaviors that objects need to be able to do.
  - They are usually public.
- The hyphen (`-`) indicates a private item
- The plus (`+`) indicates a public item

Defining `main()` in a Programmer-defined Class

- The `main()` method can be defined within a programmer-defined class and create objects of that class type.
- `main()` is a static method that is independent of class objects.
- `main()` can access other static methods and static fields of the class, but cannot directly access non-static methods or fields.
- A programmer must create objects within `main()` to call non-static methods on those objects.
- Non-static fields and methods are also called instance variables and instance methods.

```java
public class BasicCar {

  // Total miles driven by the car
  private int milesDriven;

  // Constructor assigns initial values to instance variables
  public BasicCar() {
    milesDriven = 0;
  }

  // Drive the requested miles
  public void drive(int tripMiles) {
    milesDriven = milesDriven + tripMiles;
  }

  // Return total number of miles driven
  public int checkOdometer() {
    return milesDriven;
  }

  // Main() creates objects of type BasicCar and
  // calls methods to operate on the objects
  public static void main(String [] args) {
    BasicCar redCorvette = new BasicCar();
    BasicCar fordMustang = new BasicCar();

    redCorvette.drive(100);
    fordMustang.drive(75);
    fordMustang.drive(300);
    fordMustang.drive(50);
  }
}
```

Unit Testing (Classes)

Testbenches

- A **testbench** is a program whose job is to thoroughly test another program (or portion) via a series of input/output checks known as **test cases**.
- **Unit testing** means to create and run a testbench for a specific item (or *unit*) like a method or a class.

Features of a Good Testbench

- **Automatic checks**
  - Ex: Values are compared, as in `testData.GetNum1() != 100`. For conciseness, only fails are printed.
- **Independent test cases**
  - Ex: The test case for `GetAverage()` assigns new values, vs. relying on earlier values.
- **100% code coverage**
  - Every line of code is executed. A good testbench would have more test cases than below.
- **Includes not just typical values but also border cases**
  - Unusual or extreme test case values like 0, negative numbers, or large numbers.

Class to test: StatsInfo.java

```java
public class StatsInfo {

  // Note: This class intentionally has errors

  private int num1;
  private int num2;

  public void setNum1(int numVal) {
    num1 = numVal;
  }

  public void setNum2(int numVal) {
    num2 = numVal;
  }

  public int getNum1() {
    return num1;
  }

  public int getNum2() {
    return num1;
  }

  public int getAverage() {
    return num1 + num2 / 2;
  }
}
```

Testbench: StatsInfoTest.java

```
public class StatsInfoTest {
  public static void main(String[] args) {
    StatsInfo testData = new StatsInfo();

    // Typical testbench tests more thoroughly

    System.out.println("Beginning tests.");

    // Check set/get num1
    testData.setNum1(100);
    if (testData.getNum1() != 100) {
      System.out.println("   FAILED set/get num1");
    }

    // Check set/get num2
    testData.setNum2(50);
    if (testData.getNum2() != 50) {
      System.out.println("   FAILED set/get num2");
    }

    // Check getAverage()
    testData.setNum1(10);
    testData.setNum2(20);
    if (testData.getAverage() != 15) {
      System.out.println("   FAILED GetAverage for 10, 20");
    }

    testData.setNum1(-10);
    testData.setNum2(0);
    if (testData.getAverage() != -5) {
      System.out.println("   FAILED GetAverage for -10, 0");
    }

    System.out.println("Tests complete.");
  }
}
```

Output

```
Beginning tests.
  FAILED set/get num2
  FAILED GetAverage for 10, 20
  FAILED GetAverage for -10, 0
Tests complete.
```

Regression Testing

Regression testing means to retest an item like a class anytime that item is changed

- If previously-passed test cases fail, the item has "regressed".

A testbench should be maintained along with the item, to always be usable for regression testing.

Testbenches may be complex, with thousands of test cases. Various tools support testing, and companies employ test engineers who only test other programmers' items.

- A large percent, like 50% or more, of commercial software development time may go into testing.

Erroneous Unit Tests

An erroneous unit test may fail even if the code being tested is correct.

- A common error is for a programmer to assume that a failing unit test means that the code being tested has a bug. Such an assumption may lead the programmer to spend time trying to "fix" code that is already correct.
- Good practice is to inspect the code of a failing unit test before making changes to the code being tested.

Exploring Further

JUnit testing framework for Java

Constructor Overloading

Methods are overloaded when **both** of the following are true:

- ☐ They have the same method
- ☐ They have different parameter list (either of these two):
  - Different number of parameters
  - The parameter datatypes must be distinguishable

```
public class Restaurant {
  ...

  // Default constructor
  public Restaurant() {
    name = "NoName";
    rating = -1;
  }

  // Another constructor
  public Restaurant(String initName, int initRating) {
    name = initName;
    rating = initRating;
  }
}
```

If a programmer defines any constructor, the compiler does not implicitly define a default constructor, so good practice is for the programmer to also explicitly define a default constructor so that an object creation like new `MyClass()` remains supported.