Java classes

Savitch, ch 5

Outline

- Objects, classes, and object-oriented programming
  - relationship between classes and objects
  - abstraction
- Anatomy of a class
  - instance variables
  - instance methods
  - constructors

Objects and classes

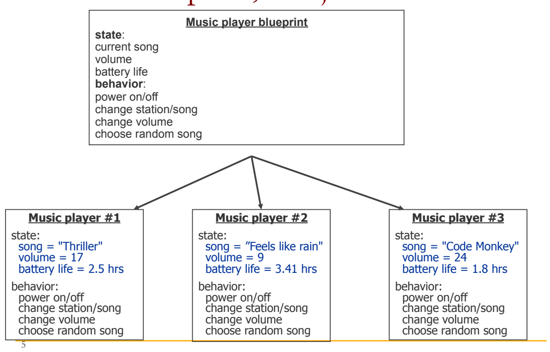
- **object**: An entity that combines state and behavior.
  - **object-oriented programming (OOP)**: Writing programs that perform most of their behavior as interactions between objects.
- **class**:
  1. A program/module.   or:
  2. **A blueprint/template for creating an object.**
  - classes you have used so far:
    `String`, `Scanner`, `File`
- We will write classes to define new types of objects.

Abstraction

- **abstraction**: A distancing between ideas and details.
  - Objects in Java provide abstraction:
    We can use them without knowing how they work.

- You use abstraction every day.
  Example: Your portable music player.
  - You understand its external behavior (buttons, screen, etc.)
  - You don't understand its inner details (and you don't need to).

Class = blueprint, Object = instance



5

How often would you expect to get snake eyes?

If you're unsure on how to compute the probability then you write a program that simulates the process

Snake Eyes

```
public class SnakeEyes {
  public static void main(String [] args){
     int ROLLS = 100000;
     int count = 0;
     Die die1 = new Die();
     Die die2 = new Die();
     for (int i = 0; i < ROLLS; i++){
         if (die1.roll() == 1 && die2.roll() == 1){
            count++;
         }
     }
     System.out.println("snake eyes probability: " +
   (float)count / ROLLS);
  }
}
```

Need to write the Die class!

Die object

- State (data) of a `Die` object:

Instance variable	Description
`numFaces`	the number of faces for a die
`faceValue`	the current value produced by rolling the die

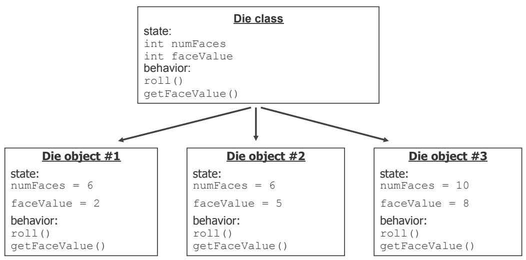
- Behavior (methods) of a `Die` object:

Method name	Description
`roll()`	roll the die (and return the value rolled)
`getFaceValue()`	retrieve the value of the last roll

8

The Die class

- The class (blueprint) knows how to create objects.




```
Die die1 = new Die();
```

9

Object state: instance variables

10

Die class

- The following code creates a new class named `Die`.

```
public class Die {
    int numFaces;
    int faceValue;
}
```

declared outside of any method

  - Save this code into a file named `Die.java`.
- Each `Die` object contains two pieces of data:
  - an `int` named `numFaces`,
  - an `int` named `faceValue`
- No behavior (yet).

11

Instance variables

- **instance variable**: A variable inside an object that holds part of its state.
  - Each object has *its own copy*.
- Declaring an instance variable:

  <type> <name> ;

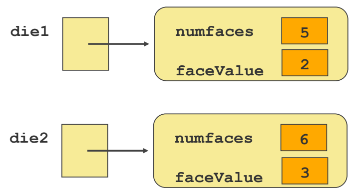
```
public class Die {
    int numFaces;
    int faceValue;
}
```

12

Instance variables

Each `Die` object maintains its own `numfaces` and `faceValue` variable, and thus its own state

```
Die die1 = new Die();
Die die2 = new Die();
```



Accessing instance variables

- Code in other classes can access your object's instance variables.
  - Accessing an instance variable: dot operator

    <variable name>* . *<instance variable>
  - Modifying an instance variable:

    ***<variable name>* . *<instance variable>* = *<value>* ;**
- Examples:

```
System.out.println("you rolled " + die.faceValue);
die.faceValue = 20;
```

14

Client code

- `Die.java` can be made executable by giving it a main …
  - We will almost always do this…. WHY?
  - To test the class Die before it is used by other classes
- or can be used by other programs stored in separate `.java` files.
  - **client code**: Code that uses a class

Roll.java (client code)

```
main(String[] args) {
    Die die1 = new Die();
    die1.numFaces = 6;
    die1.faceValue = 5;

    Die die2 = new Die();
    die2.numFaces = 10;
    die2.faceValue = 3;
    ...
}
```

Die.java

```
public class Die {
    int numFaces;
    int faceValue;
}
```

15

Object behavior: methods

16

Instance methods

- Classes combine state and behavior.
- **instance variables:** define state
- **instance methods**: define behavior for each object of a class. Are the way objects communicate with each other and with users
- instance method declaration, general syntax:

```
public <type> <name> ( <parameter(s)> ) {
     <statement(s)> ;
}
```

17

Rolling the dice: instance methods

```
public class Die {
   int numFaces;
   int faceValue;
   public int roll (){
      faceValue = (int)(Math.random() * numFaces) + 1;
      return faceValue;
   }
}
    Die die1 = new Die();
    die1.numFaces = 6;
    int value1 = die1.roll();
    Die die2 = new Die();
    die2.numFaces = 10;
    int value2 = die2.roll();
```

Think of each `Die` object as having its own copy of the `roll` method, which operates on that object's state

Object initialization: constructors

20

Initializing objects

- When we create a new object, we can assign values to all, or some of, its instance variables:

```
Die die2 = new Die();
Die die1 = new Die(6);
```

How do we make that happen?

21

Die constructor

```
public class Die {
    int numFaces;
    int faceValue;

    public Die (int faces) {
        numFaces = faces;
        faceValue = 1;
    }

    public int roll (){
        faceValue = (int)(Math.random()*numFaces) + 1;
        return faceValue;
    }
}
```

```
Die die1 = new Die(6);
```

Constructors

- **constructor**: creates and initializes a new object

```
public <type> ( <parameter(s)> ) {
    <statement(s)> ;
}
```

  - For a constructor the <type> is the **name of the class**
  - A constructor runs when the client uses the `new` keyword.
  - A constructor implicitly returns the newly created and initialized object.
  - If a class has no constructor, Java gives it a *default constructor* with no parameters that sets all the object's fields to 0 or null.
    - we did this in Recap.java

23

Multiple constructors are possible

```
public class Die {
    int numFaces;
    int faceValue;

    public Die () {
        numFaces = 6;
        faceValue = 1;
    }

    public Die (int faces) {
        numFaces = faces;
        faceValue = 1;
    }
}
```

```
Die die1 = new Die(5);
Die die2 = new Die();
```

The Student class

- Let's write a class called **Student** with the following state and behavior:

Student

state:

```
String name
String id
int[] grades
```

behavior:

```
Constructor - takes id and name
numGrades - returns the number of grades
addGrade - adds a grade
getAverage - computes the average grade
```

Encapsulation

Encapsulation

- **encapsulation**:
  Hiding implementation details of an object from clients.
- Encapsulation provides *abstraction*;
  we can use objects without knowing how they work.
  The object has:
  - an external view (its behavior)
  - an internal view (the state and methods that accomplish the behavior)

Implementing encapsulation

- Instance variables can be declared *private* to indicate that no code outside their own class can access or change them.
  - Declaring a private instance variable:
    private *<type> <name>* ;
  - Examples:

```
private int faceValue;
private String name;
```

- Once instance variables are private, client code cannot access them:

```
Roll.java:11: faceValue has private access in Die
System.out.println("faceValue is " + die.faceValue);
                                        ^
```


Instance variables, encapsulation and access

- In our previous implementation of the Die class we used the public access modifier:

```
public class Die {
   public int numFaces;
   public int faceValue;
}
```

- We can encapsulate the instance variables using private:

```
public class Die {
   private int numFaces;
   private int faceValue;
}
```

But how does a client class now get to these?

Accessors and mutators

- We provide accessor methods to examine their values:

```
public int getFaceValue() {
    return faceValue;
}
```

  - This gives clients read-only access to the object's fields.
  - Client code will look like this:

```
System.out.println("faceValue is " + die.getFaceValue());
```

- **If required**, we can also provide mutator methods:

```
public void setFaceValue(int value) {
    faceValue = value;
}
```

Often not needed. Do we need a mutator method in this case?

30

Benefits of encapsulation

- Protects an object from unwanted access by clients.
  - Example: If we write a program to manage users' bank accounts, we don't want a malicious client program to be able to arbitrarily change a `BankAccount` object's balance.
- Allows you to change the class implementation later.
- As a general rule, all instance data should be modified only by the object, i.e. **instance variables should be declared private**

31

Access Protection: Summary

Access protection has three main benefits:

- It allows you to enforce constraints on an object's state.
- It provides a simpler client interface. Client programmers don't need to know everything that's in the class, only the public parts.
- It separates interface from implementation, allowing them to vary independently.

General guidelines

As a rule of thumb:

- Classes are public.
- Instance variables are private.
- Constructors are public.
- Getter and setter/mutator methods are public
- Other methods must be decided on a case-by-case basis.

Printing Objects

- We would like to be able to print a Java object like this:

```
Student student = new Student(…);
System.out.println("student: " + student);
```

- Would like this to provide output that is more useful than what Java provides by default.
  - Need to provide a toString() method

The `toString()` method

- tells Java how to represent an object as a `String`
- called when an object is printed or concatenated to a `String`:

```
Point p = new Point(7, 2);
System.out.println("p: " + p);
```

  - Same as:

```
System.out.println("p: " + p.toString());
```

- Every class has a `toString()`, even if it isn't in your code.
  - The default is the class's name and a hex (base-16) hash-code:

```
Point@9e8c34
```

`toString()` implementation

```
public String toString() {
    code that returns a suitable String;
}
```

- Example: toString() method for our Student class:

```
public String toString(){
  return "name: " + name+ "\n"
    + "id: " + id + "\n"
    + "average: " + getAverage();
}
```

Variable shadowing

- A method parameter can have the same name as one of the instance variables:

```
public class Point {
  private int x;
  private int y;
      …
  // this is legal
  public void setLocation(int x, int y) {
    // when using x and y you get the parameters
  }
```

  - Instance variables `x` and `y` are *shadowed* by parameters with the same names.

Avoiding variable shadowing

```
public class Point {
    private int x;
    private int y;
    ...
    public void setLocation(int x_value, int y_value) {
        x = x_value;
        y = y_value;
    }
}
```

Avoiding shadowing using `this`

```
public class Point {
    private int x;
    private int y;
    ...
    public void setLocation(int x, int y) {
        this.x = x;
        this.y = y;
    }
}
```

- Inside the `setLocation` method,
  - When `this.x` is seen, the *instance variable* `x` is used.
  - When `x` is seen, the *parameter* `x` is used.

Multiple constructors

- It is legal to have more than one constructor in a class.
  - The constructors must accept different parameters.

```
public class Point {
    private int x;
    private int y;

    public Point() {
        x = 0;
        y = 0;
    }

    public Point(int x, int y) {
        this.x = x;
        this.y = y;
    }
```

Constructors and `this`

- One constructor can call another using `this`:

```
public class Point {
    private int x;
    private int y;

    public Point() {
        this(0, 0);  //calls the (x, y) constructor
    }

    public Point(int x, int y) {
        this.x = x;
        this.y = y;
    }

    ...
}
```

Summary of `this`

- **`this`** : A reference to the current instance of a given class
- using `this`:
  - To refer to an instance variable:
    `this.`**variable**
  - To call a method:
    `this.`**method**`(`**parameters**`);`
  - To call a constructor from another constructor:
    `this(`**parameters**`);`

Example of using `this`

```
public class MyThisTest {
  private int a;
  public MyThisTest() {
    this(42);
  }
  public MyThisTest(int a) {
    this.a = a;
  }
  public void someSomething() {
    int a = 1;
    System.out.println(a);
    System.out.println(this.a);
    System.out.println(this);
  }
  public String toString() {
    return "MyThisTest a=" + a; // refers to the instance variable a
  }
}
```

The implicit parameter

- During the call `die.roll();`,
  the object referred to by `die` is the implicit parameter to the method.
- The method `int roll()` is really `int roll(Die this)`
- The call `die.roll()` is translated to `roll(die)`

44

Method overloading

- Can you write different methods that have the same name?
- Yes!

```
System.out.println("I can handle strings");
System.out.println(2 + 2);
System.out.println(3.14);
System.out.println(object);
Math.max(10, 15);        // returns integer
Math.max(10.0, 15.0);    // returns double
```

Useful when you need to perform the same operation on different kinds of data.

Method overloading

```
public int sum(int num1, int num2){
   return num1 + num2;
}
public int sum(int num1, int num2, int num3){
   return num1 + num2 + num3;
}
```

- A method's name + number, type, and order of its parameters: **method signature**
- The compiler uses a method's signature to bind a method invocation to the appropriate definition

The return value is not part of the signature

- You **cannot** overload on the basis of the return type (because it can be ignored)

  Example of invalid overloading:

```
public int convert(int value) {
  return 2 * value;
}

public double convert(int value) {

  return 2.54 * value;
}
```

Example

- Consider the class Pet

```
class Pet {
   private String name;
   private int age;
   private double weight;

…
}
```

Example (cont)

```
public Pet()
public Pet(String name, int age, double weight)
public Pet(int age)
public Pet(double weight)
```

Suppose you have a horse that weighs 750 pounds; you use:

```
Pet myHorse = new Pet(750.0);
```

but what happens if you do:

```
Pet myHorse = new Pet(750);  ?
```

Primitive Equality

- Suppose we have two integers `i` and `j`
- How does the statement `i==j` behave?
- `i==j` if `i` and `j` contain the same value

Object Equality

- Suppose we have two pet instances `pet1` and `pet2`
- How does the statement `pet1==pet2` behave?

Object Equality

- Suppose we have two pet instances `pet1` and `pet2`
- How does the statement `pet1==pet2` behave?
- `pet1==pet2` is true if ***both*** refer to the ***same*** object
- The `==` operator checks if the ***addresses*** of the two objects are equal
- May not be what we want!

52

Object Equality

- Consider the following lines of code:

String s1 = new String("Java");

String s2 = new String("Java");

Is s1==s2 True?

a) Yes b) No

.equals for the Pet class

```
public boolean equals (Object other) {
  if (!(other instanceof Pet)) {
      return false;
  }
  Pet otherPet = (Pet) other;
  return ((this.age == otherPet.age)
    &&(Math.abs(this.weight - otherPet.weight) < 1e-8)
    &&(this.name.equals(otherPet.name)));
}
```

This is not explained correctly in the book (section 5.3)!!

Naming things

- Computer programs are written to be read by humans and only incidentally by computers.
- Use names that convey meaning
- Loop indices are often a single character (i, j, k), but others should be more informative.
- Importance of a name depends on its scope: Names with a “short life” need not be as informative as those with a “long life”
- Read code and see how others do it