Encapsulation

September 12, 2007

ComS 207: Programming I (in Java)
Iowa State University, FALL 2007
Instructor: Alexander Stoytchev

Administrative Stuff

- HW3 is due on Friday
- No new HW will be out this week
- Next Tuesday we will have Midterm 1:
  - Sep 18 @ 6:30 – 7:45pm.
- Location: Curtiss Hall 127 (classroom)
- On Monday we will have a review session
- No class on Friday (Sep 21, 2007)

Quick review of last lecture

Writing Classes

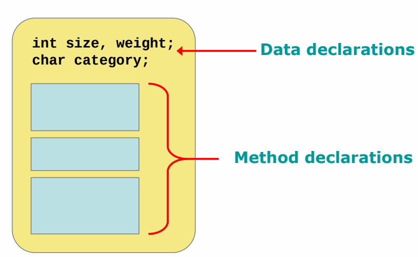
- The programs we've written in previous examples have used classes defined in the Java standard class library
- Now we will begin to design programs that rely on classes that we write ourselves
- The class that contains the `main` method is just the starting point of a program
- True object-oriented programming is based on defining classes that represent objects with well-defined characteristics and functionality

Classes and Objects

- Recall from our overview of objects in Chapter 1 that an object has *state* and *behavior*
- Consider a six-sided die (singular of dice)
  - It's state can be defined as which face is showing
  - It's primary behavior is that it can be rolled
- We can represent a die in software by designing a class called `Die` that models this state and behavior
  - The class serves as the blueprint for a die object
- We can then instantiate as many die objects as we need for any particular program

Classes

- A class can contain data declarations and method declarations



Classes

- The values of the data define the state of an object created from the class
- The functionality of the methods define the behaviors of the object
- For our `Die` class, we might declare an integer that represents the current value showing on the face
- One of the methods would "roll" the die by setting that value to a random number between one and six

Classes

- We'll want to design the `Die` class with other data and methods to make it a versatile and reusable resource
- Any given program will not necessarily use all aspects of a given class
- See RollingDice.java (page 157)
- See Die.java (page 158)

The Die Class

- The `Die` class contains two data values
  - a constant `MAX` that represents the maximum face value
  - an integer `faceValue` that represents the current face value
- The `roll` method uses the `random` method of the `Math` class to determine a new face value
- There are also methods to explicitly set and retrieve the current face value at any time

The toString Method

- All classes that represent objects should define a `toString` method
- The `toString` method returns a character string that represents the object in some way
- It is called automatically when an object is concatenated to a string or when it is passed to the `println` method
- System.out.println ("Die One: " + die1 + ", Die Two: " + die2);

Constructors

- As mentioned previously, a *constructor* is a special method that is used to set up an object when it is initially created
- A constructor has the same name as the class
- The `Die` constructor is used to set the initial face value of each new die object to one
- We examine constructors in more detail later in this chapter

Data Scope

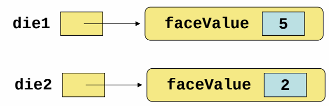
- The *scope* of data is the area in a program in which that data can be referenced (used)
- Data declared at the class level can be referenced by all methods in that class
- Data declared within a method can be used only in that method
- Data declared within a method is called *local data*
- In the `Die` class, the variable `result` is declared inside the `toString` method -- it is local to that method and cannot be referenced anywhere else

Instance Data

- The `faceValue` variable in the `Die` class is called *instance data* because each instance (object) that is created has its own version of it
- A class declares the type of the data, but it does not reserve any memory space for it
- Every time a `Die` object is created, a new `faceValue` variable is created as well
- The objects of a class share the method definitions, but each object has its own data space
- That's the only way two objects can have different states

Instance Data

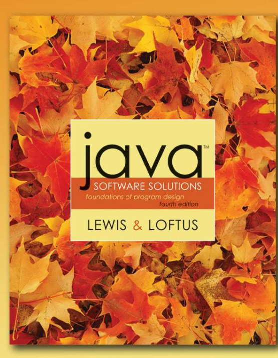
- We can depict the two `Die` objects from the `RollingDice` program as follows:



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

Chapter 4

Section 4.3



Encapsulation

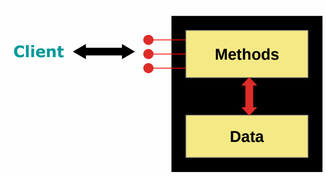
- We can take one of two views of an object:
  - internal - the details of the variables and methods of the class that defines it
  - external - the services that an object provides and how the object interacts with the rest of the system
- From the external view, an object is an *encapsulated* entity, providing a set of specific services
- These services define the *interface* to the object

Encapsulation

- One object (called the *client*) may use another object for the services it provides
- The client of an object may request its services (call its methods), but it should not have to be aware of how those services are accomplished
- Any changes to the object's state (its variables) should be made by that object's methods
- We should make it difficult, if not impossible, for a client to access an object's variables directly
- That is, an object should be *self-governing*

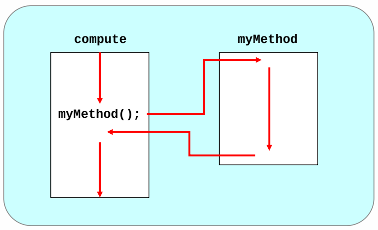
Encapsulation

- An encapsulated object can be thought of as a *black box* -- its inner workings are hidden from the client
- The client invokes the interface methods of the object, which manages the instance data



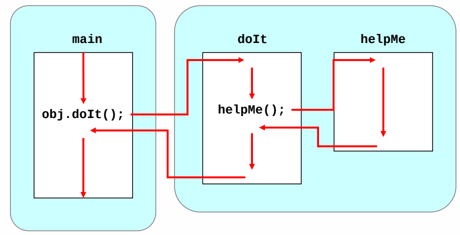
Method Control Flow

- If the called method is in the same class, only the method name is needed



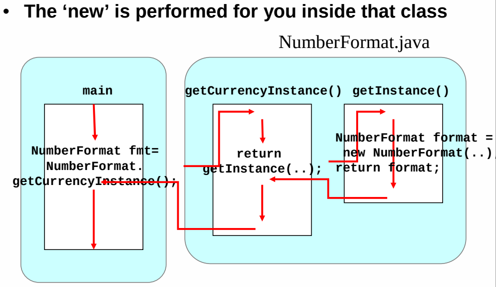
Method Control Flow

- The called method is often part of another class or object



Why we don't have to use 'new' with the NumberFormat class?

- The 'new' is performed for you inside that class

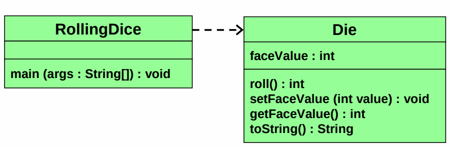


UML Diagrams

- UML stands for the *Unified Modeling Language*
- *UML diagrams* show relationships among classes and objects
- A UML *class diagram* consists of one or more classes, each with sections for the class name, attributes (data), and operations (methods)
- Lines between classes represent *associations*
- A dotted arrow shows that one class *uses* the other (calls its methods)

UML Class Diagrams

- A UML class diagram for the `RollingDice` program:



Visibility Modifiers

- In Java, we accomplish encapsulation through the appropriate use of *visibility modifiers*
- A *modifier* is a Java reserved word that specifies particular characteristics of a method or data
- We've used the `final` modifier to define constants
- Java has three visibility modifiers: `public`, `protected`, and `private`
- The `protected` modifier involves inheritance, which we will discuss later

Visibility Modifiers

	`public`	`private`
Variables	Violate encapsulation	Enforce encapsulation
Methods	Provide services to clients	Support other methods in the class

Visibility Modifiers

- Members of a class that are declared with *public visibility* can be referenced anywhere
- Members of a class that are declared with *private visibility* can be referenced only within that class
- Members declared without a visibility modifier have *default visibility* and can be referenced by any class in the same package
- An overview of all Java modifiers is presented in Appendix E

Visibility Modifiers

- Public variables violate encapsulation because they allow the client to “reach in” and modify the values directly
- Therefore instance variables should not be declared with public visibility
- It is acceptable to give a constant public visibility, which allows it to be used outside of the class
- Public constants do not violate encapsulation because, although the client can access it, its value cannot be changed

Visibility Modifiers

- Methods that provide the object's services are declared with public visibility so that they can be invoked by clients
- Public methods are also called *service methods*
- A method created simply to assist a service method is called a *support method*
- Since a support method is not intended to be called by a client, it should not be declared with public visibility

Visibility Modifiers

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Accessors and Mutators

- Because instance data is private, a class usually provides services to access and modify data values
- An *accessor method* returns the current value of a variable
- A *mutator method* changes the value of a variable
- The names of accessor and mutator methods take the form `getX` and `setX`, respectively, where `X` is the name of the value
- They are sometimes called “getters” and “setters”

Mutator Restrictions

- The use of mutators gives the class designer the ability to restrict a client's options to modify an object's state
- A mutator is often designed so that the values of variables can be set only within particular limits
- For example, the `setFaceValue` mutator of the `Die` class should have restricted the value to the valid range (1 to `MAX`)
- We'll see in Chapter 5 how such restrictions can be implemented

Run examples from the book

THE END