Chapter 4: Writing Classes

Presentation slides for

Java Software Solutions

for AP* Computer Science

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Writing Classes

- We've been using predefined classes. Now we will learn to write our own classes to define objects

- Chapter 4 focuses on:
  - class definitions
  - encapsulation and Java modifiers
  - method declaration, invocation, and parameter passing
  - method overloading
  - method decomposition
  - graphics-based objects

Objects

- An object has:
  - *state* - descriptive characteristics
  - *behaviors* - what it can do (or what can be done to it)
- For example, consider a coin that can be flipped so that it's face shows either "heads" or "tails"
- The state of the coin is its current face (heads or tails)
- The behavior of the coin is that it can be flipped
- Note that the behavior of the coin might change its state

Classes

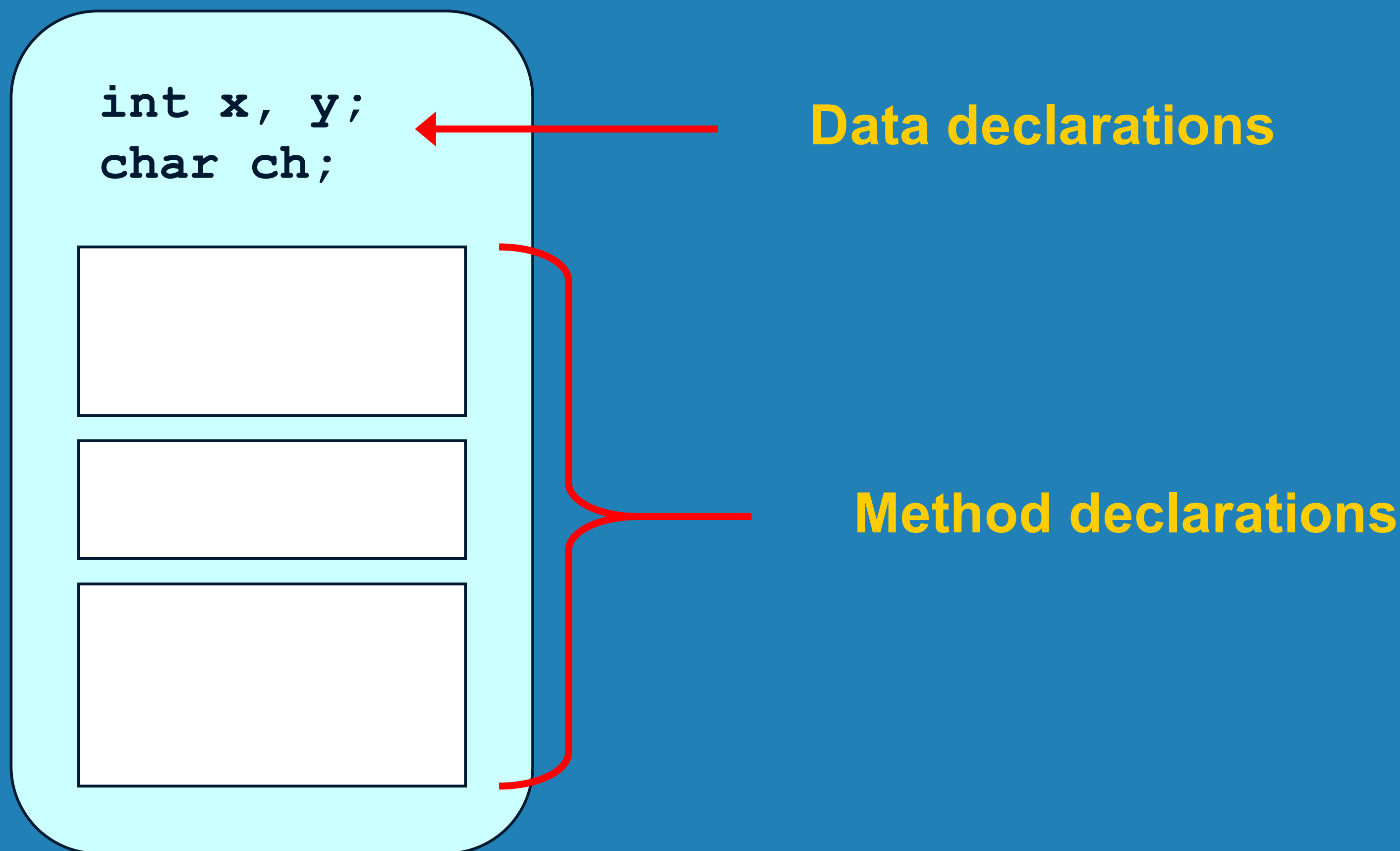
- A *class* is a blueprint of an object
- It is the model or pattern from which objects are created
- For example, the `String` class is used to define `String` objects
- Each `String` object contains specific characters (its state)
- Each `String` object can perform services (behaviors) such as `toUpperCase`

Classes

- The `String` class was provided for us by the Java standard class library
- But we can also write our own classes that define specific objects that we need
- For example, suppose we want to write a program that simulates the flipping of a coin
- We can write a `Coin` class to represent a coin object

Classes

- A class contains data declarations and method declarations



The Coin Class

- In our `Coin` class we could define the following data:
  - `face`, an integer that represents the current face
  - `HEADS` and `TAILS`, integer constants that represent the two possible states
- We might also define the following methods:
  - a `Coin` constructor, to initialize the object
  - a `flip` method, to flip the coin
  - a `isHeads` method, to determine if the current face is heads
  - a `toString` method, to return a string description for printing

The Coin Class

- See CountFlips.java (page 193)
- See Coin.java (page 194)
- Note that the `CountFlips` program did not use the `toString` method
- A program will not necessarily use every service provided by an object
- Once the `Coin` class has been defined, we can use it again in other programs as needed

Data Scope

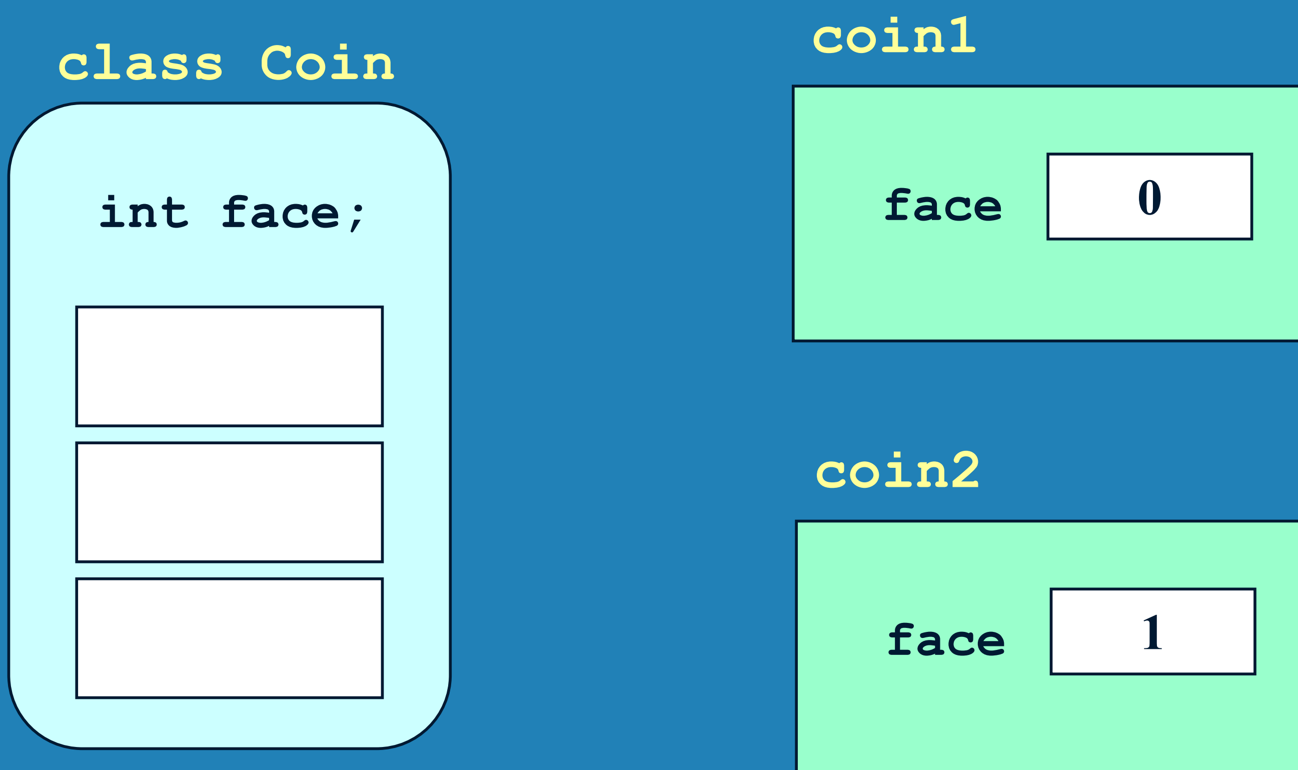
- The *scope* of data is the area in a program in which that data can be used (referenced)
- Data declared at the class level can be used by all methods in that class
- Data declared within a method can be used only in that method
- Data declared within a method is called *local data*

Instance Data

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

Instance Data

- See FlipRace.java (page 197)



Encapsulation

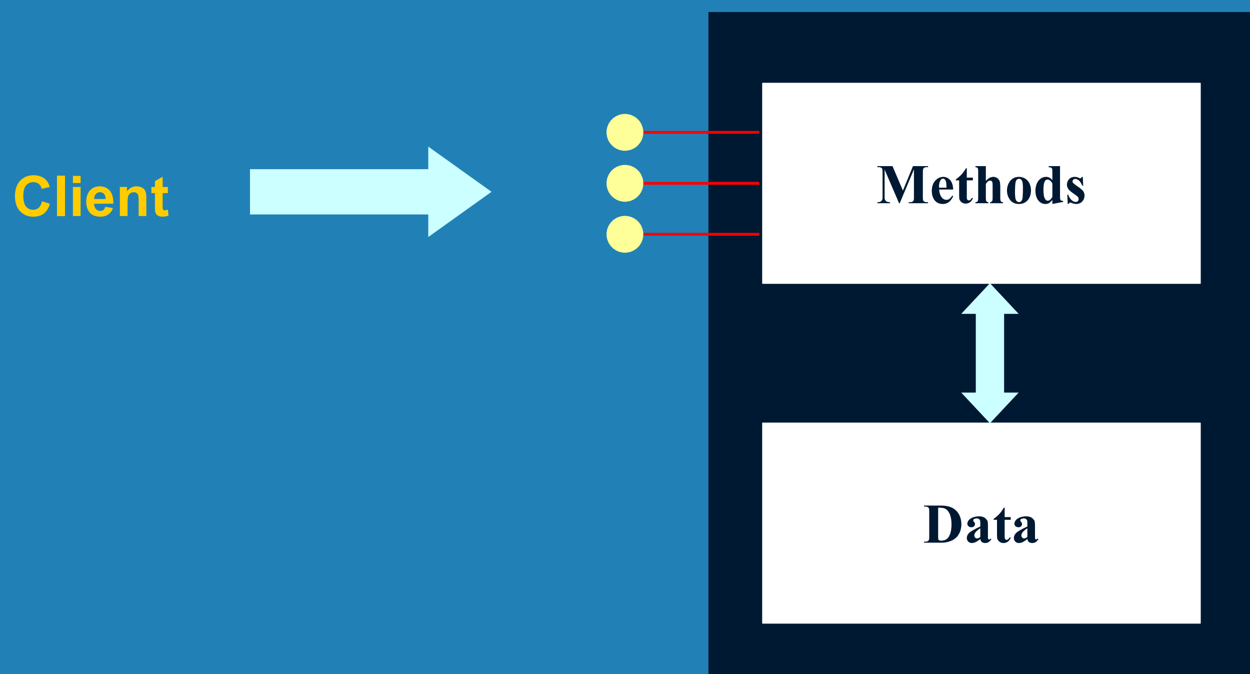
- We can take one of two views of an object:
  - internal - the variables the object holds and the methods that make the object useful
  - external - the services that an object provides and how the object interacts
- From the external view, an object is an *encapsulated* entity, providing a set of specific services
- These services define the *interface* to the object
- Recall from Chapter 2 that an object is an *abstraction*, hiding details from the rest of the system

Encapsulation

- An object should be *self-governing*
- Any changes to the object's state (its variables) should be made only by that object's methods
- We should make it difficult, if not impossible, to access an object’s variables other than via its methods
- The user, or *client*, of an object can request its services, but it should not have to be aware of how those services are accomplished

Encapsulation

- An encapsulated object can be thought of as a *black box*
- Its inner workings are hidden to the client, which invokes only the interface methods



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 value
- We've used the modifier `final` to define a constant
- We will study two visibility modifiers: `public` and `private`

Visibility Modifiers

- Members of a class that are declared with *public visibility* can be accessed from anywhere
- Public variables violate encapsulation
- Members of a class that are declared with *private visibility* can only be accessed from inside the class
- Members declared without a visibility modifier have *default visibility* and can be accessed by any class in the same package

Visibility Modifiers

- Methods that provide the object's services are usually 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

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

Driver Programs

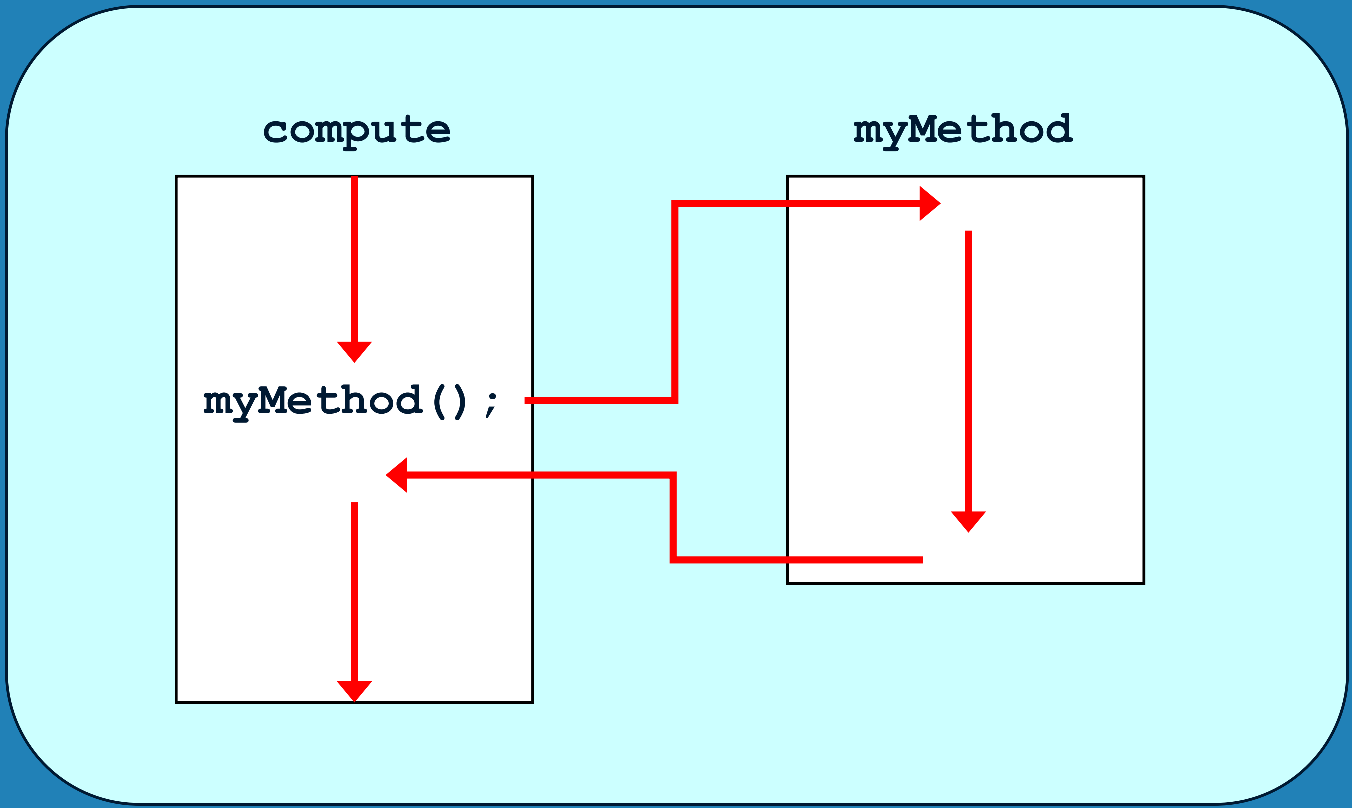
- A *driver progam* drives the use of other, more interesting parts of a program
- Driver programs are often used to test other parts of the software
- The `Banking` class contains a `main` method that drives the use of the `Account` class, exercising its services
- See Banking.java (page 202)
- See Account.java (page 204)

Method Declarations

- A *method declaration* specifies the code that will be executed when the method is invoked (or called)
- When a method is invoked, the flow of control jumps to the method and executes its code
- When complete, the flow returns to the place where the method was called and continues
- The invocation may or may not return a value, depending on how the method is defined

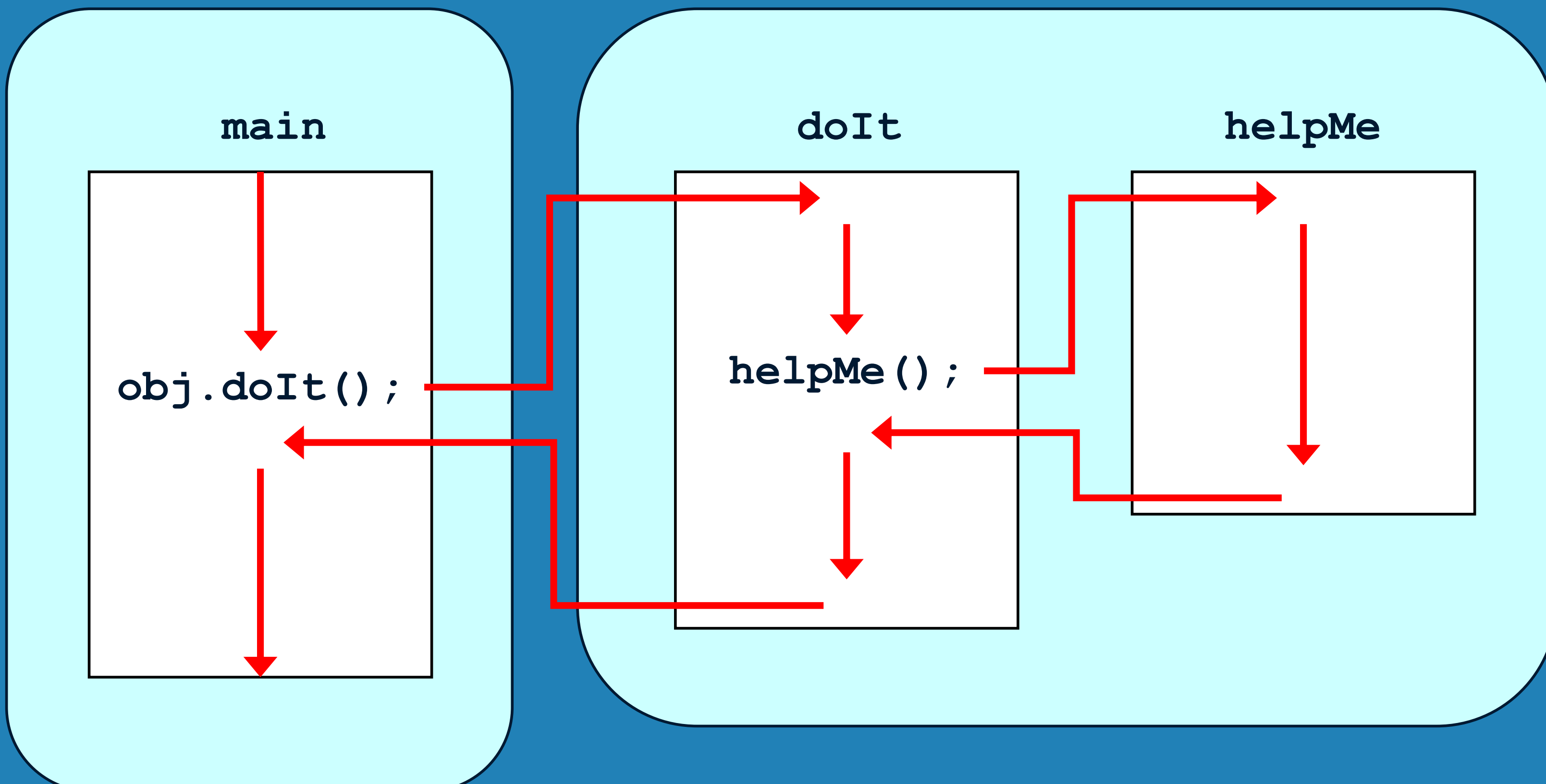
Method Control Flow

- The called method can be within the same class, in which case only the method name is needed



Method Control Flow

- The called method can be part of another class or object



Method Header

- A method declaration begins with a *method header*

```
char calc (int num1, int num2, String message)
```

method name

parameter list

return type

The parameter list specifies the type and name of each parameter

The name of a parameter in the method declaration is called a *formal argument*

Method Body

- The method header is followed by the *method body*

```
char calc (int num1, int num2, String message)
{
   int sum = num1 + num2;
   char result = message.charAt (sum);

   return result;
}
```

The return expression must be consistent with the return type

`sum` and `result` are local data

They are created each time the method is called, and are destroyed when it finishes executing

The return Statement

- The *return type* of a method indicates the type of value that the method sends back to the calling location

- A method that does not return a value has a `void` return type

- A *return statement* specifies the value that will be returned

```
return expression;
```

- Its expression must conform to the return type

Parameters

- Each time a method is called, the *actual parameters* in the invocation are copied into the formal parameters

```
ch = obj.calc (25, count, "Hello");
```

```
char calc (int num1, int num2, String message)
{
   int sum = num1 + num2;
   char result = message.charAt (sum);

   return result;
}
```

Local Data

- Local variables can be declared inside a method
- The formal parameters of a method create *automatic local variables* when the method is invoked
- When the method finishes, all local variables are destroyed (including the formal parameters)
- Keep in mind that instance variables, declared at the class level, exists as long as the object exists
- Any method in the class can refer to instance data

Constructors Revisited

- Recall that a constructor is a special method that is used to initialize a newly created object
- When writing a constructor, remember that:
  - it has the same name as the class
  - it does not return a value
  - it has no return type, not even `void`
  - it typically sets the initial values of instance variables
- The programmer does not have to define a constructor for a class

Overloading Methods

- *Method overloading* is the process of using the same method name for multiple methods
- The *signature* of each overloaded method must be unique
- The signature includes the number, type, and order of the parameters
- The compiler determines which version of the method is being invoked by analyzing the parameters
- The return type of the method is <u>not</u> part of the signature

Overloading Methods

Version 1

```
double tryMe (int x)
{
   return x + .375;
}
```

Version 2

```
double tryMe (int x, double y)
{
   return x*y;
}
```

Invocation

```
result = tryMe (25, 4.32)
```

Overloaded Methods

- The `println` method is overloaded:

```
println (String s)
println (int i)
println (double d)
```

and so on...

- The following lines invoke different versions of the `println` method:

```
System.out.println ("The total is:");
System.out.println (total);
```

Overloading Methods

- Constructors can be overloaded
- Overloaded constructors provide multiple ways to initialize a new object
- See SnakeEyes.java (page 212)
- See Die.java (page 213)

Method Decomposition

- A method should be relatively small, so that it can be understood as a single entity
- A potentially large method should be decomposed into several smaller methods as needed for clarity
- A service method of an object may call one or more support methods to accomplish its goal
- Support methods could call other support methods if appropriate

Pig Latin

- The process of translating an English sentence into Pig Latin can be decomposed into the process of translating each word
- The process of translating a word can be decomposed into the process of translating words that
  - begin with vowels
  - begin with consonant blends (sh, cr, tw, etc.)
  - begins with single consonants
- See PigLatin.java (page 215)
- See PigLatinTranslator.java (page 216)

Object Relationships

- Objects can have various types of relationships to each other
- A general *association* is sometimes referred to as a *use relationship*
- A general association indicates that one object (or class) uses or refers to another object (or class) in some way

Object Relationships

- Some use associations occur between objects of the same class
- For example, we might add two `Rational` number objects together as follows:

```
r3 = r1.add(r2);
```

- One object (`r1`) is executing the method and another (`r2`) is passed as a parameter
- See RationalNumbers.java (page 220)
- See Rational.java (page 222)

Aggregation

- An *aggregate object* is an object that contains references to other objects
- For example, an `Account` object contains a reference to a `String` object (the owner's name)
- An aggregate object represents a *has-a* relationship
- A bank account *has a* name
- Likewise, a student may have one or more addresses
- See <u>StudentBody.java</u> (page 226)
- See <u>Student.java</u> (page 227)
- See <u>Address.java</u> (page 228)

Applet Methods

- In previous examples we've used the `paint` method of the `Applet` class to draw on an applet
- The `Applet` class has several methods that are invoked automatically at certain points in an applet's life
- The `init` method, for instance, is executed only once when the applet is initially loaded
- The `start` and `stop` methods are called when the applet becomes active or inactive
- The `Applet` class also contains other methods that generally assist in applet processing

Graphical Objects

- Any object we define by writing a class can have graphical elements
- The object must simply obtain a graphics context (a `Graphics` object) in which to draw
- An applet can pass its graphics context to another object just as it can any other parameter
- See LineUp.java (page 233)
- See StickFigure.java (page 235)

Summary

- Chapter 4 has focused on:
  - class definitions
  - encapsulation and Java modifiers
  - method declaration, invocation, and parameter passing
  - method overloading
  - method decomposition
  - graphics-based objects