

Object-Oriented Design

Chapter

6

5TH EDITION

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java

Software Solutions

Foundations of Program Design

10/12/17

-more classes
-assignment#4 due tues



Object-Oriented Design

the location for die didnt change - they were the same even though there was a roll.

- **Now we can extend our discussion of the design of classes and objects**
- **Chapter 6 focuses on:**
 - **software development activities**
 - **determining the classes and objects that are needed for a program**
 - **the relationships that can exist among classes**
 - **the static modifier**
 - **writing interfaces**
 - **the design of enumerated type classes**
 - **method design and method overloading**
 - **GUI design and layout managers**

Outline



Software Development Activities

Identifying Classes and Objects

Static Variables and Methods

Class Relationships

Interfaces

Enumerated Types Revisited

Method Design

Testing

GUI Design and Layout

Program Development

- **The creation of software involves four basic activities:**
 - **establishing the requirements**
 - **creating a design**
 - **implementing the code**
 - **testing the implementation**
- **These activities are not strictly linear – they overlap and interact**

Requirements

- ***Software requirements* specify the tasks that a program must accomplish**
 - **what to do, not how to do it**
- **Often an initial set of requirements is provided, but they should be critiqued and expanded**
- **It is difficult to establish detailed, unambiguous, and complete requirements**
- **Careful attention to the requirements can save significant time and expense in the overall project**

Design

- ***A software design* specifies how a program will accomplish its requirements**
- **That is, a software design determines:**
 - **how the solution can be broken down into manageable pieces**
 - **what each piece will do**
- **An object-oriented design determines which classes and objects are needed, and specifies how they will interact**
- **Low level design details include how individual methods will accomplish their tasks**

Implementation

- ***Implementation* is the process of translating a design into source code**
- **Novice programmers often think that writing code is the heart of software development, but actually it should be the least creative step**
- **Almost all important decisions are made during requirements and design stages**
- **Implementation should focus on coding details, including style guidelines and documentation**

Testing

test based coding

- ***Testing*** attempts to ensure that the program will solve the intended problem under all the constraints specified in the requirements
- A program should be thoroughly tested with the goal of finding errors
- ***Debugging*** is the process of determining the cause of a problem and fixing it
- We revisit the details of the testing process later in this chapter

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Identifying Classes and Objects

- **The core activity of object-oriented design is determining the classes and objects that will make up the solution**
- **The classes may be part of a class library, reused from a previous project, or newly written**
- **One way to identify potential classes is to identify the objects discussed in the requirements**
- **Objects are generally nouns, and the services that an object provides are generally verbs**

Identifying Classes and Objects

- A partial requirements document:

The **user** must be allowed to specify each **product** by its primary **characteristics**, including its **name** and **product number**. If the **bar code** does not match the **product**, then an **error** should be generated to the **message window** and entered into the **error log**. The **summary report** of all **transactions** must be structured as specified in section 7.A.

Of course, not all nouns will correspond to a class or object in the final solution

Identifying Classes and Objects

- **Remember that a class represents a group (classification) of objects with the same behaviors**
- **Generally, classes that represent objects should be given names that are singular nouns**
- **Examples: Coin, Student, Message**
- **A class represents the concept of one such object**
- **We are free to instantiate as many of each object as needed**

create classes that are singular

Identifying Classes and Objects

dont make methods that dont fit on one screen

- **Sometimes it is challenging to decide whether something should be represented as a class**
- **For example, should an employee's address be represented as a set of instance variables or as an Address object**
- **The more you examine the problem and its details the more clear these issues become**
- **When a class becomes too complex, it often should be decomposed into multiple smaller classes to distribute the responsibilities**

Identifying Classes and Objects

- **We want to define classes with the proper amount of detail**
- **For example, it may be unnecessary to create separate classes for each type of appliance in a house**
- **It may be sufficient to define a more general `Appliance` class with appropriate instance data**
- **It all depends on the details of the problem being solved**

Identifying Classes and Objects

- Part of identifying the classes we need is the process of *assigning responsibilities* to each class
- Every activity that a program must accomplish must be represented by one or more methods in one or more classes
- We generally use verbs for the names of methods
- In early stages it is not necessary to determine every method of every class – begin with primary responsibilities and evolve the design

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Identifying Classes and Objects



Static Variables and Methods

static is a type of memory

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Static Class Members

- Recall that a static method is one that can be invoked through its class name
- For example, the methods of the `Math` class are **static**:

methods and classes can be defined as static -it doesn't belong to the object - it belongs to the class
they are loaded before code is executed

```
result = Math.sqrt(25)
```

- Variables can be static as well
- Determining if a method or variable should be static is an important design decision

The static Modifier

- We declare static methods and variables using the `static` modifier
- It associates the method or variable with the class rather than with an object of that class
- Static methods are sometimes called *class methods* and static variables are sometimes called *class variables*
- Let's carefully consider the implications of each

Static Variables

- **Normally, each object has its own data space, but if a variable is declared as static, only one copy of the variable exists**

```
private static float price;
```

- **Memory space for a static variable is created when the class is first referenced**
- **All objects instantiated from the class share its static variables**
- **Changing the value of a static variable in one object changes it for all others**

Static Methods

```
class Helper
{
    public static int cube (int num)
    {
        return num * num * num;
    }
}
```

Because it is declared as static, the method can be invoked as

class method
`value = Helper.cube(5);`

Static Class Members

break 10/12/17

- The order of the modifiers can be interchanged, but by convention visibility modifiers come first
- Recall that the `main` method is static – it is invoked by the Java interpreter without creating an object
- Static methods cannot reference instance variables because instance variables don't exist until an object exists

phrase is a local variable - each object has its own
count is static, so it is maintained in the class

- However, a static method can reference static variables or local variables

memory
auto
primitive and object memory
stored here
obj [cloud 8]

dynamic

->

[c8] Slogan: Phrase
Slogan: count ----->

static
SloganCounter: main
Slogan: count

Static Class Members

- **Static methods and static variables often work together**
- **The following example keeps track of how many Slogan objects have been created using a static variable, and makes that information available using a static method**
- **See [SloganCounter.java](#) (page 299)**
- **See [Slogan.java](#) (page 300)**

variable

	local	instance	static
scope	method	object	class
lifetime	method	object	program

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end 10/12/17

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GUI Design and Layout will not be tested on GUI design and layout

Class Relationships

- **Classes in a software system can have various types of relationships to each other**
- **Three of the most common relationships:**
 - **Dependency: A *uses* B**
 - **Aggregation: A *has-a* B**
 - **Inheritance: A *is-a* B**
- **Let's discuss dependency and aggregation further**
- **Inheritance is discussed in detail in Chapter 8**

Dependency

- ***A dependency exists when one class relies on another in some way, usually by invoking the methods of the other***
- **We've seen dependencies in many previous examples**
- **We don't want numerous or complex dependencies among classes**
- **Nor do we want complex classes that don't depend on others**
- **A good design strikes the right balance**

Dependency

- **Some dependencies occur between objects of the same class**
- **A method of the class may accept an object of the same class as a parameter**
- **For example, the `concat` method of the `String` class takes as a parameter another `String` object**

```
str3 = str1.concat(str2) ;
```

- **This drives home the idea that the service is being requested from a particular object**

Dependency

- The following example defines a class called `Rational` to represent a rational number
- A rational number is a value that can be represented as the ratio of two integers
- Some methods of the `Rational` class accept another `Rational` object as a parameter
- See [RationalTester.java](#) (page 302)
- See [RationalNumber.java](#) (page 304)

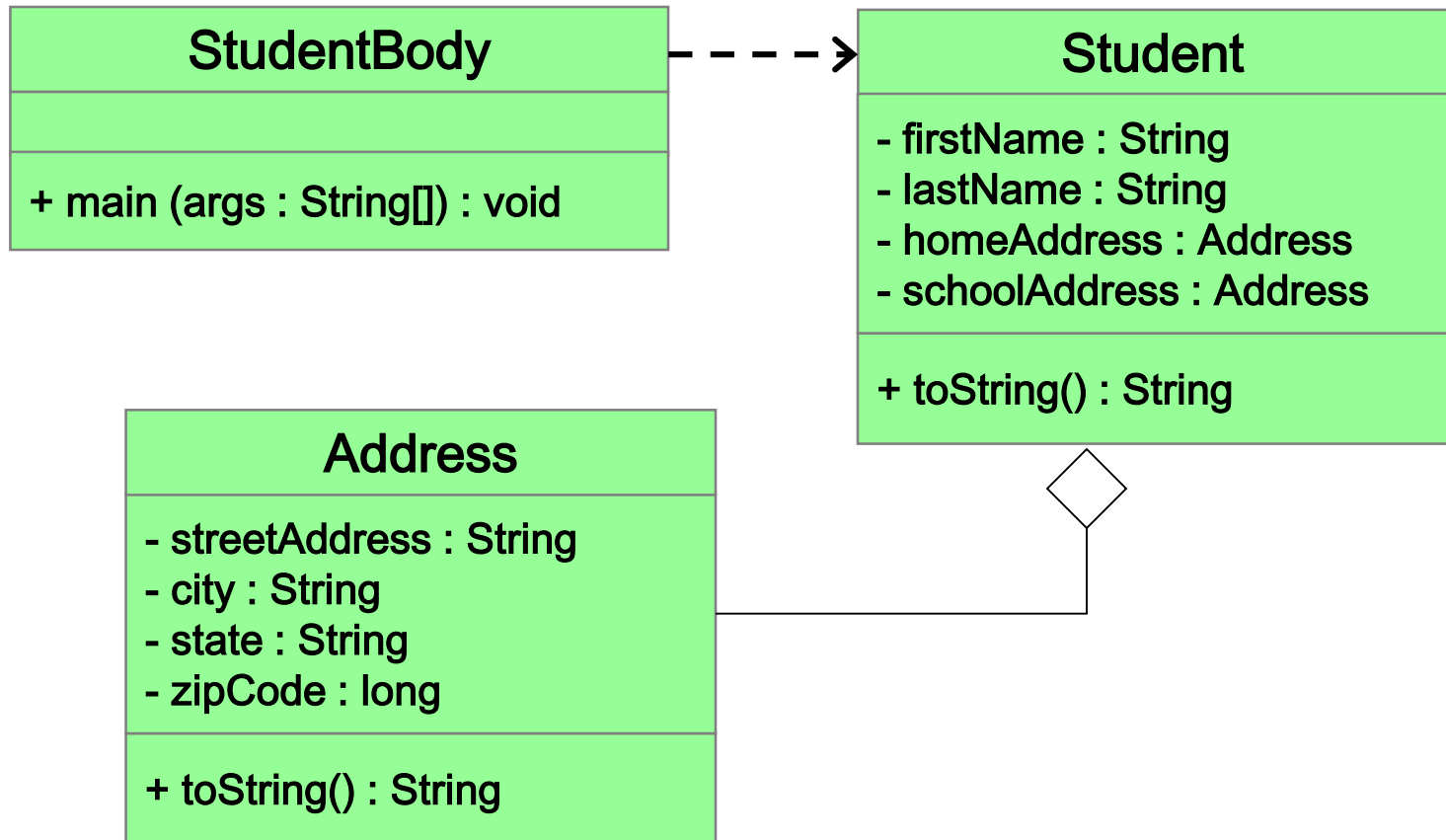
Aggregation

- An *aggregate* is an object that is made up of other objects
- Therefore aggregation is a *has-a* relationship
 - A car *has a* chassis
- In software, an aggregate object contains references to other objects as instance data
- The aggregate object is defined in part by the objects that make it up
- This is a special kind of dependency – the aggregate usually relies on the objects that compose it

Aggregation

- In the following example, a `Student` object is composed, in part, of `Address` objects
- A student has an address (in fact each student has two addresses)
- See [StudentBody.java](#) (page 309)
- See [Student.java](#) (page 311)
- See [Address.java](#) (page 312)
- An aggregation association is shown in a UML class diagram using an open diamond at the aggregate end

Aggregation in UML



The this Reference

- The `this` reference allows an object to refer to itself
- That is, the `this` reference, used inside a method, refers to the object through which the method is being executed
- Suppose the `this` reference is used in a method called `tryMe`, which is invoked as follows:

```
obj1.tryMe();
```

```
obj2.tryMe();
```

- In the first invocation, the `this` reference refers to `obj1`; in the second it refers to `obj2`

The this reference

- The `this` reference can be used to distinguish the instance variables of a class from corresponding method parameters with the same names
- The constructor of the `Account` class (from Chapter 4) could have been written as follows:

```
public Account (String name, long acctNumber,  
                double balance)  
{  
    this.name = name;  
    this.acctNumber = acctNumber;  
    this.balance = balance;  
}
```


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Interfaces

- A Java *interface* is a collection of abstract methods and constants
- An *abstract method* is a method header without a method body
- An abstract method can be declared using the modifier `abstract`, but because all methods in an interface are abstract, usually it is left off
- An interface is used to establish a set of methods that a class will implement

Interfaces

interface is a reserved word



```
public interface Doable
{
    public void doThis();
    public int doThat();
    public void doThis2 (float value, char ch);
    public boolean doTheOther (int num);
}
```

**None of the methods in
an interface are given
a definition (body)**



**A semicolon immediately
follows each method header**

Interfaces

- **An interface cannot be instantiated**
- **Methods in an interface have public visibility by default**
- **A class formally implements an interface by:**
 - **stating so in the class header**
 - **providing implementations for each abstract method in the interface**
- **If a class asserts that it implements an interface, it must define all methods in the interface**

Interfaces


```
public class CanDo implements Doable
{
    public void doThis ()
    {
        // whatever
    }

    public void doThat ()
    {
        // whatever
    }

    // etc.
}
```



**implements is a
reserved word**



**Each method listed
in Doable is
given a definition**

Interfaces

- A class that implements an interface can implement other methods as well
- See [Complexity.java](#) (page 315)
- See [Question.java](#) (page 316)
- See [MiniQuiz.java](#) (page 318)
- In addition to (or instead of) abstract methods, an interface can contain constants
- When a class implements an interface, it gains access to all its constants

Interfaces

- A class can implement multiple interfaces
- The interfaces are listed in the `implements` clause
- The class must implement all methods in all interfaces listed in the header

```
class ManyThings implements interface1, interface2
{
    // all methods of both interfaces
}
```

Interfaces

- The Java standard class library contains many helpful interfaces
- The `Comparable` interface contains one abstract method called `compareTo`, which is used to compare two objects
- We discussed the `compareTo` method of the `String` class in Chapter 5
- The `String` class implements `Comparable`, giving us the ability to put strings in lexicographic order

The Comparable Interface

- Any class can implement `Comparable` to provide a mechanism for comparing objects of that type

```
if (obj1.compareTo(obj2) < 0)
    System.out.println ("obj1 is less than obj2");
```
- The value returned from `compareTo` should be negative if `obj1` is less than `obj2`, 0 if they are equal, and positive if `obj1` is greater than `obj2`
- When a programmer designs a class that implements the `Comparable` interface, it should follow this intent

The Comparable Interface

- It's up to the programmer to determine what makes one object less than another
- For example, you may define the `compareTo` method of an `Employee` class to order employees by name (alphabetically) or by employee number
- The implementation of the method can be as straightforward or as complex as needed for the situation

The Iterator Interface

- As we discussed in Chapter 5, an iterator is an object that provides a means of processing a collection of objects one at a time
- An iterator is created formally by implementing the `Iterator` interface, which contains three methods
- The `hasNext` method returns a boolean result – true if there are items left to process
- The `next` method returns the next object in the iteration
- The `remove` method removes the object most recently returned by the `next` method

The Iterator Interface

- By implementing the `Iterator` interface, a class formally establishes that objects of that type are iterators
- The programmer must decide how best to implement the iterator functions
- Once established, the for-each version of the `for` loop can be used to process the items in the iterator

Interfaces

- You could write a class that implements certain methods (such as `compareTo`) without formally implementing the interface (`Comparable`)
- However, formally establishing the relationship between a class and an interface allows Java to deal with an object in certain ways
- Interfaces are a key aspect of object-oriented design in Java
- We discuss this idea further in Chapter 9

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Enumerated Types

- In Chapter 3 we introduced enumerated types, which define a new data type and list all possible values of that type

```
enum Season {winter, spring, summer, fall}
```

- Once established, the new type can be used to declare variables

```
Season time;
```

- The only values this variable can be assigned are the ones established in the `enum` definition

Enumerated Types

- An enumerated type definition is a special kind of class
- The values of the enumerated type are objects of that type
- For example, `fall` is an object of type `Season`
- That's why the following assignment is valid

```
time = Season.fall;
```


Enumerated Types

- An enumerated type definition can be more interesting than a simple list of values
- Because they are like classes, we can add additional instance data and methods
- We can define an `enum` constructor as well
- Each value listed for the enumerated type calls the constructor
- See [Season.java](#) (page 322)
- See [SeasonTester.java](#) (page 323)

Enumerated Types

- Every enumerated type contains a static method called `values` that returns a list of all possible values for that type
- The list returned from `values` is an iterator, so a `for` loop can be used to process them easily
- An enumerated type cannot be instantiated outside of its own definition
- A carefully designed enumerated type provides a versatile and type-safe mechanism for managing data

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Method Design

- **As we've discussed, high-level design issues include:**
 - identifying primary classes and objects
 - assigning primary responsibilities
- **After establishing high-level design issues, its important to address low-level issues such as the design of key methods**
- **For some methods, careful planning is needed to make sure they contribute to an efficient and elegant system design**

Method Design

- An *algorithm* is a step-by-step process for solving a problem
- Examples: a recipe, travel directions
- Every method implements an algorithm that determines how the method accomplishes its goals
- An algorithm may be expressed in *pseudocode*, a mixture of code statements and English that communicate the steps to take

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 public service method of an object may call one or more private support methods to help it accomplish its goal**
- **Support methods might call other support methods if appropriate**

Method Decomposition

- Let's look at an example that requires method decomposition – translating English into Pig Latin
- Pig Latin is a language in which each word is modified by moving the initial sound of the word to the end and adding "ay"
- Words that begin with vowels have the "yay" sound added on the end

book → ookbay

table → abletay

item → itemyay

chair → airchay

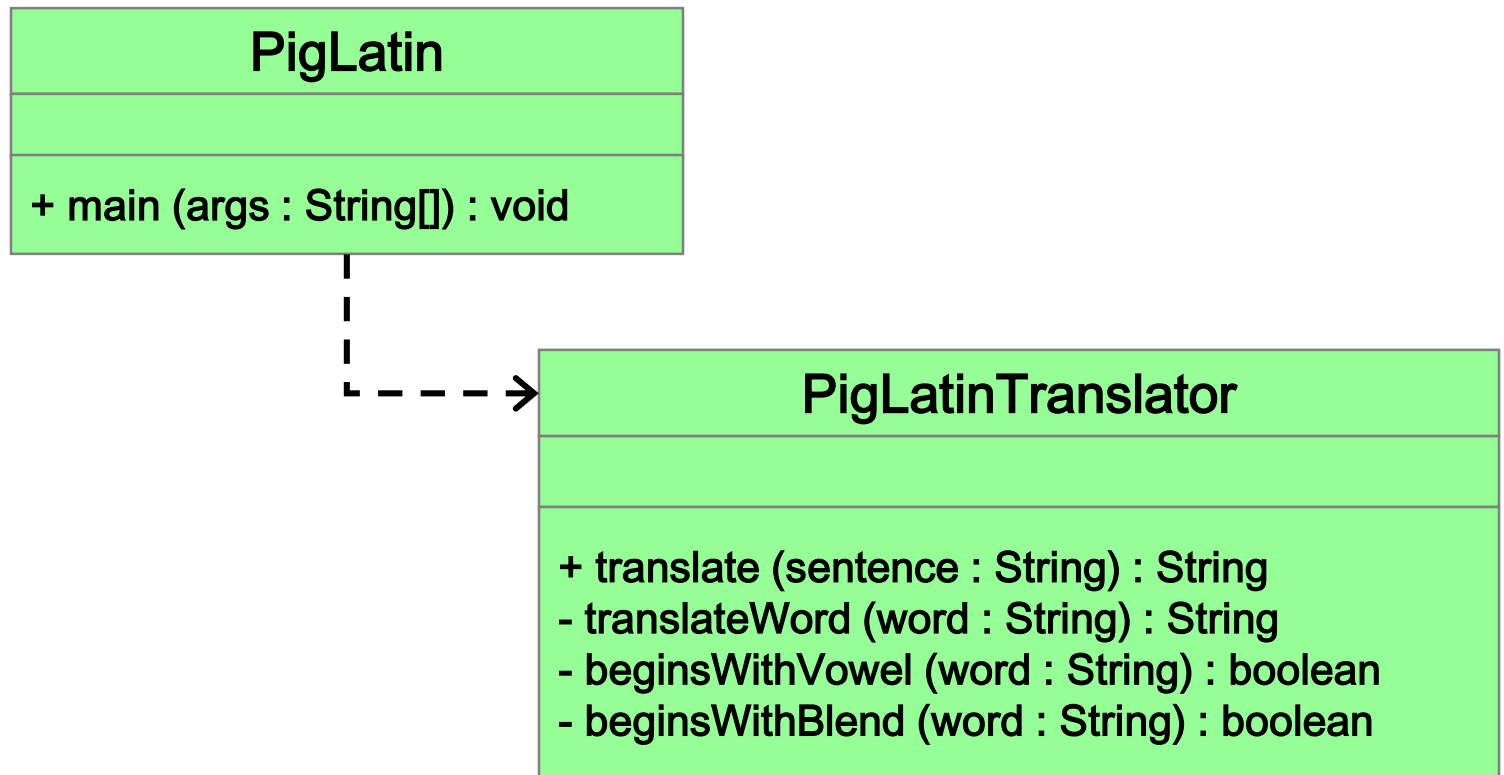
Method Decomposition

- **The primary objective (translating a sentence) is too complicated for one method to accomplish**
- **Therefore we look for natural ways to decompose the solution into pieces**
- **Translating a sentence can be decomposed into the process of translating each word**
- **The process of translating a word can be separated into translating words that:**
 - **begin with vowels**
 - **begin with consonant blends (sh, cr, th, etc.)**
 - **begin with single consonants**

Method Decomposition

- See [PigLatin.java](#) (page 325)
- See [PigLatinTranslator.java](#) (page 327)
- In a UML class diagram, the visibility of a variable or method can be shown using special characters
- Public members are preceded by a plus sign
- Private members are preceded by a minus sign

Class Diagram for Pig Latin



Objects as Parameters

- Another important issue related to method design involves parameter passing
- Parameters in a Java method are *passed by value*
- A copy of the actual parameter (the value passed in) is stored into the formal parameter (in the method header)
- Therefore passing parameters is similar to an assignment statement
- When an object is passed to a method, the actual parameter and the formal parameter become aliases of each other

Passing Objects to Methods

- What a method does with a parameter may or may not have a permanent effect (outside the method)
- See [ParameterTester.java](#) (page 331)
- See [ParameterModifier.java](#) (page 333)
- See [Num.java](#) (page 334)
- Note the difference between changing the internal state of an object versus changing which object a reference points to

Method Overloading

- ***Method overloading*** is the process of giving a single method name multiple definitions
- If a method is overloaded, the method name is not sufficient to determine which method is being called
- The ***signature*** of each overloaded method must be unique
- The signature includes the number, type, and order of the parameters

Method Overloading

- The compiler determines which method is being invoked by analyzing the parameters

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

Invocation

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

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



Method Overloading

- 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

- The return type of the method is not part of the signature
- That is, overloaded methods cannot differ only by their return type
- Constructors can be overloaded
- Overloaded constructors provide multiple ways to initialize a new object

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Testing

- **Testing can mean many different things**
- **It certainly includes running a completed program with various inputs**
- **It also includes any evaluation performed by human or computer to assess quality**
- **Some evaluations should occur before coding even begins**
- **The earlier we find an problem, the easier and cheaper it is to fix**

Testing

- **The goal of testing is to find errors**
- **As we find and fix errors, we raise our confidence that a program will perform as intended**
- **We can never really be sure that all errors have been eliminated**
- **So when do we stop testing?**
 - **Conceptual answer: Never**
 - **Snide answer: When we run out of time**
 - **Better answer: When we are willing to risk that an undiscovered error still exists**

Reviews

- A *review* is a meeting in which several people examine a design document or section of code
- It is a common and effective form of human-based testing
- Presenting a design or code to others:
 - makes us think more carefully about it
 - provides an outside perspective
- Reviews are sometimes called *inspections* or *walkthroughs*

Test Cases

- **A *test case* is a set of input and user actions, coupled with the expected results**
- **Often test cases are organized formally into *test suites* which are stored and reused as needed**
- **For medium and large systems, testing must be a carefully managed process**
- **Many organizations have a separate Quality Assurance (QA) department to lead testing efforts**

Defect and Regression Testing

- ***Defect testing*** is the execution of test cases to uncover errors
- The act of fixing an error may introduce new errors
- After fixing a set of errors we should perform ***regression testing*** – running previous test suites to ensure new errors haven't been introduced
- It is not possible to create test cases for all possible input and user actions
- Therefore we should design tests to maximize their ability to find problems

Black-Box Testing

- In ***black-box testing***, test cases are developed without considering the internal logic
- They are based on the input and expected output
- Input can be organized into ***equivalence categories***
- Two input values in the same equivalence category would produce similar results
- Therefore a good test suite will cover all equivalence categories and focus on the boundaries between categories

White-Box Testing

- ***White-box testing* focuses on the internal structure of the code**
- **The goal is to ensure that every path through the code is tested**
- **Paths through the code are governed by any conditional or looping statements in a program**
- **A good testing effort will include both black-box and white-box tests**

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GUI Design and Layout

GUI Design

- **We must remember that the goal of software is to help the user solve the problem**
- **To that end, the GUI designer should:**
 - **Know the user**
 - **Prevent user errors**
 - **Optimize user abilities**
 - **Be consistent**
- **Let's discuss each of these in more detail**

Know the User

- **Knowing the user implies an understanding of:**
 - **the user's true needs**
 - **the user's common activities**
 - **the user's level of expertise in the problem domain and in computer processing**
- **We should also realize these issues may differ for different users**
- **Remember, to the user, the interface is the program**

Prevent User Errors

- **Whenever possible, we should design user interfaces that minimize possible user mistakes**
- **We should choose the best GUI components for each task**
- **For example, in a situation where there are only a few valid options, using a menu or radio buttons would be better than an open text field**
- **Error messages should guide the user appropriately**

Optimize User Abilities

- **Not all users are alike – some may be more familiar with the system than others**
- **Knowledgeable users are sometimes called *power users***
- **We should provide multiple ways to accomplish a task whenever reasonable**
 - "wizards" to walk a user through a process
 - short cuts for power users
- **Help facilities should be available but not intrusive**

Be Consistent

- **Consistency is important – users get used to things appearing and working in certain ways**
- **Colors should be used consistently to indicate similar types of information or processing**
- **Screen layout should be consistent from one part of a system to another**
- **For example, error messages should appear in consistent locations**

Layout Managers

- A *layout manager* is an object that determines the way that components are arranged in a container
- There are several predefined layout managers defined in the Java standard class library:

Flow Layout

Border Layout

Card Layout

Grid Layout

GridBag Layout

Box Layout

Overlay Layout

Defined in the AWT

Defined in Swing

Layout Managers

- **Every container has a default layout manager, but we can explicitly set the layout manager as well**
- **Each layout manager has its own particular rules governing how the components will be arranged**
- **Some layout managers pay attention to a component's preferred size or alignment, while others do not**
- **A layout manager attempts to adjust the layout as components are added and as containers are resized**

Layout Managers

- We can use the `setLayout` method of a container to change its layout manager

```
JPanel panel = new JPanel();  
panel.setLayout(new BorderLayout());
```

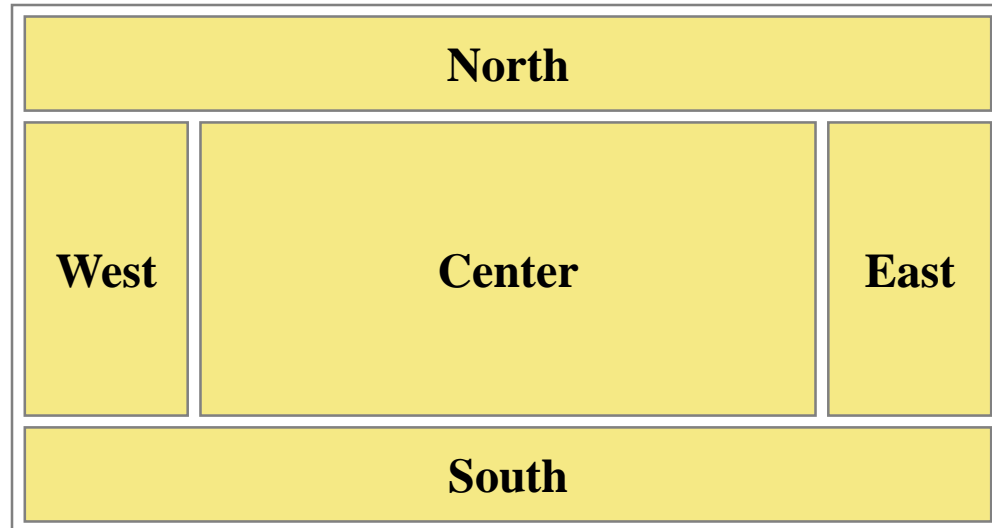
- The following example uses a *tabbed pane*, a container which permits one of several panes to be selected
- See [LayoutDemo.java](#) (page 343)
- See [IntroPanel.java](#) (page 344)

Flow Layout

- ***Flow layout*** puts as many components as possible on a row, then moves to the next row
- Rows are created as needed to accommodate all of the components
- Components are displayed in the order they are added to the container
- Each row of components is centered horizontally in the window by default, but could also be aligned left or right
- Also, the horizontal and vertical gaps between the components can be explicitly set
- See [FlowPanel.java](#) (page 346)

Border Layout

- ***A border layout* defines five areas into which components can be added**



Border Layout

- Each area displays one component (which could be a container such as a `JPanel`)
- Each of the four outer areas enlarges as needed to accommodate the component added to it
- If nothing is added to the outer areas, they take up no space and other areas expand to fill the void
- The center area expands to fill space as needed
- See [BorderPanel.java](#) (page 349)

Grid Layout

- A *grid layout* presents a container's components in a rectangular grid of rows and columns
- One component is placed in each cell of the grid, and all cells have the same size
- As components are added to the container, they fill the grid from left-to-right and top-to-bottom (by default)
- The size of each cell is determined by the overall size of the container
- See [GridPanel.java](#) (page 352)

Box Layout

- A *box layout* organizes components horizontally (in one row) or vertically (in one column)
- Components are placed top-to-bottom or left-to-right in the order in which they are added to the container
- By combining multiple containers using box layout, many different configurations can be created
- Multiple containers with box layouts are often preferred to one container that uses the more complicated gridbag layout manager

Box Layout

- ***Invisible components*** can be added to a box layout container to take up space between components
 - ***Rigid areas*** have a fixed size
 - ***Glue*** specifies where excess space should go
- A rigid area is created using the `createRigidArea` method of the `Box` class
- Glue is created using the `createHorizontalGlue` or `createVerticalGlue` methods
- See [BoxPanel.java](#) (page 355)

Borders

- A *border* can be put around any Swing component to define how the edges of the component should be drawn
- Borders can be used effectively to group components visually
- The `BorderFactory` class contains several static methods for creating border objects
- A border is applied to a component using the `setBorder` method

Borders

- ***An empty border***
 - buffers the space around the edge of a component
 - otherwise has no visual effect
- ***A line border***
 - surrounds the component with a simple line
 - the line's color and thickness can be specified
- ***An etched border***
 - creates the effect of an etched groove around a component
 - uses colors for the highlight and shadow

Borders

- ***A bevel border***
 - can be raised or lowered
 - uses colors for the outer and inner highlights and shadows
- ***A titled border***
 - places a title on or around the border
 - the title can be oriented in many ways
- ***A matte border***
 - specifies the sizes of the top, left, bottom, and right edges of the border separately
 - uses either a solid color or an image

Borders

- ***A compound border***
 - is a combination of two borders
 - one or both of the borders can be a compound border
- See [BorderDemo.java](#) (page 358)

Summary

- **Chapter 6 has focused on:**
 - **software development activities**
 - **determining the classes and objects that are needed for a program**
 - **the relationships that can exist among classes**
 - **the static modifier**
 - **writing interfaces**
 - **the design of enumerated type classes**
 - **method design and method overloading**
 - **GUI design and layout managers**