Java

Object, classes, interfaces and packages

Presented by Bartosz Sakowicz

Creating Objects

Each **statement** has three parts:

1.Declaration: When you create an object, you do not have to declare a variable to refer to it. However, a variable declaration often appears on the same line as the code to create an object.

2.Instantiation: new is a Java operator that creates the new object (allocates space for it).

3.Initialization: The new operator is followed by a call to a constructor. For example, Point(23, 94) is a call to Point's only constructor. The constructor initializes the new object.

Creating Objects(2)

1) Declaration

type name

Declarations do not create new objects. The code Point origin_one does not create a new Point object; it just declares a variable, named origin_one, that will be used to refer to a Point object. The reference is empty until assigned. An empty reference is known as a *null reference*.

To create an object you must instantiate it with the **new** operator.

Creating Objects(3)

2) Instantiating an object

- The **new** operator instantiates a class by allocating memory for a new object. The **new** operator requires a single, postfix argument: a call to a constructor. The name of the constructor provides the name of the class to instantiate. The constructor initializes the new object.
- The **new** operator returns a reference to the object it created. Often, this reference is assigned to a variable of the appropriate type. If the reference is not assigned to a variable, the object is unreachable after the statement in which the **new** operator appears finishes executing.

Creating Objects(3)

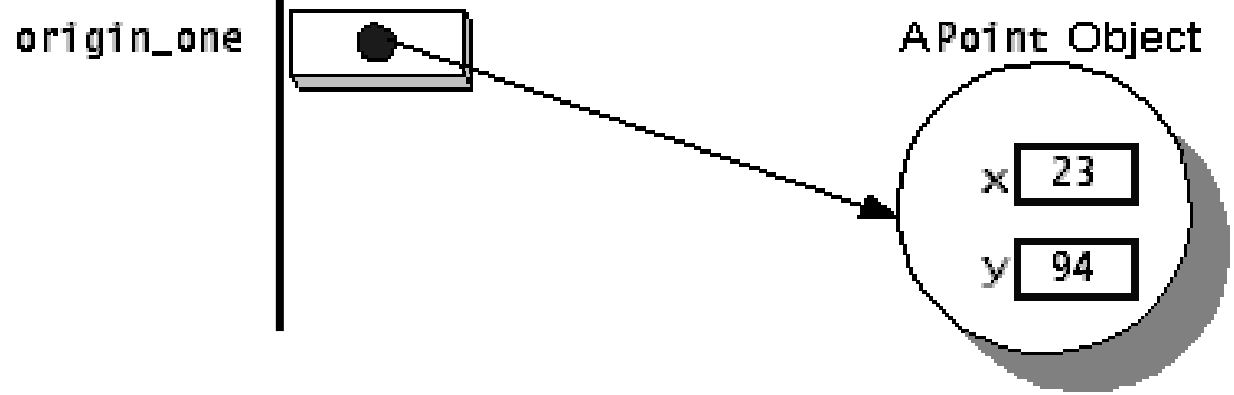
3) Intializing an object

Example:

```
public class Point {
    public int x = 0;
    public int y = 0;
    public Point(int x, int y) {
        this.x = x;
        this.y = y;
    }
}
```

Point origin_one =

new Point(23, 94);



Variables and Methods

Referencing an Object's Variables:

objectReference.variableName

Calling an Object's Methods

objectReference.methodName(argumentList);

or

objectReference.methodName();

The Garbage Collector

- In some object oriented languages (ex. C++) is necessary to keep the track of all used objects and destroy them when they are no longer needed. This process is error prone.
- The Java runtime environment deletes objects when it determines that they are no longer being used. This process is called *garbage collection*.
- An object is eligible for garbage collection when there are no more references to that object. References that are held in a variable are usually dropped when the variable goes out of scope. Or, you can explicitly drop an object reference by setting the variable to the special value null. Remember that a program can have multiple references to the same object; all references to an object must be dropped before the object is eligible for garbage collection.

The Garbage Collector(2)

- Garbage collector periodically frees the memory used by objects that are no longer referenced.
- The garbage collector does its job automatically
- In some situations, you may want to run the garbage collection explicitly by calling the gc method in the System class.
- Before an object gets garbage-collected, the garbage collector gives the object an opportunity to clean up after itself through a call to the object's *finalize* method. This process is known as *finalization*.

Finalization

- The *finalize* method is a member of the **Object class, which is the top of the Java platform's class hierarchy and a superclass of all classes.**
- A class can override the finalize method to perform any finalization necessary for objects of that type.
- If you override finalize, your implementation of the method should call *super.finalize* as the last thing it does.

Creating Objects (4)

Question:

What's wrong with the following program?

```
public class SomethingIsWrong {
    public static void main(String[] args) {
        Rectangle myRect;
        myRect.width = 40;
        myRect.height = 50;
        System.out.println("myRect's area is " + myRect.area());
    }
}
```

=new Rectangle();

Answer:

The Rectangle Object is never created. This code will cause a compiler warning or **NullPointerException** during runtime.

Creating Objects (5)

Excercise:

Given the following class write some code that creates an instance of the class, initializes its member variable, and then displays the value of it.

```
public class NumberHolder { public int anInt; }
```

Answer:

```
public class NumberHolderDisplay {

        public static void main(String[] args) {

                NumberHolder aNH = new NumberHolder();

                aNH.anInt = 1;

                System.out.println(aNH.anInt);}}
```

Characters and Strings

The Java platform contains three classes that you can use when working with character data:

- **Character** -- A class whose instances can hold a single character value. This class also defines handy methods that can manipulate or inspect single-character data.
- **String** -- A class for working with immutable (unchanging) data composed of multiple characters.
- **StringBuffer** -- A class for storing and manipulating mutable data composed of multiple characters.

Characters

- An object of **Character** type contains a single character value.
- You use a **Character** object instead of a primitive char variable when an object is required-for example, when passing a character value into a method that changes the value or when placing a character value into a data structure, such as a vector, that requires objects.

Characters(2)

Constructors and methods provided by the Character class:

Character(char)

The Character class's only constructor, which creates a Character object containing the value provided by the argument. Once a Character object has been created, the value it contains cannot be changed.

compareTo(Character)

An instance method that compares the values held by two character objects: the object on which the method is called and the argument to the method. This method returns an integer indicating whether the value in the current object is greater than, equal to, or less than the value held by the argument. A letter is greater than another letter if its numeric value is greater.

Characters(3)

Constructors and methods provided by the Character class:

equals(Object)

An instance method that compares the value held by the current object with the value held by another. Returns true if the values held by both objects are equal.

toString()

An instance method that converts the object to a string. The resulting string is one character in length and contains the value held by the character object.

charValue()

An instance method that returns the value held by the character object as a primitive char value.

isUpperCase(char)

A class method that determines whether a primitive char value is uppercase.

Strings and StringBuffers

Creating Strings and StringBuffers:

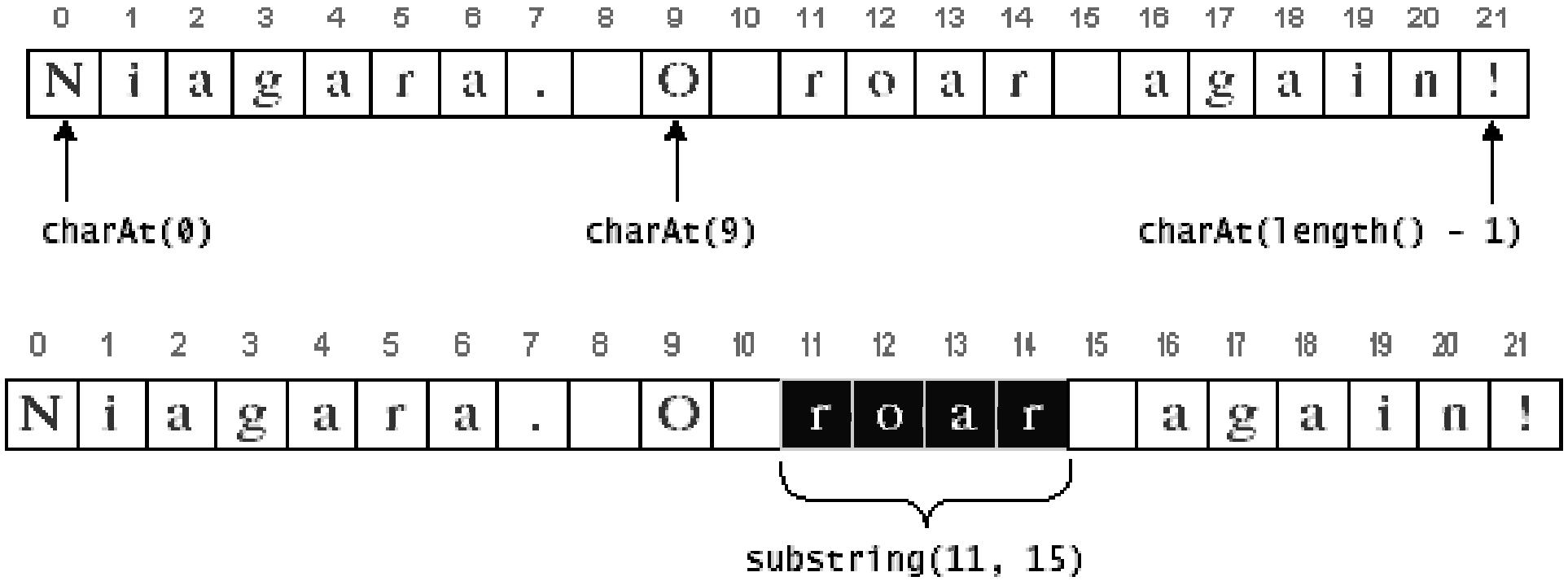
```
char[] helloArray = { 'h', 'e', 'l', 'l', 'o' };
String helloString = new String(helloArray);
int len = helloString.length();
StringBuffer dest = new StringBuffer(len);
```

- **Reasonable memory allocation** - good first guess

Strings and StringBuffers(2)

Getting characters and substrings from String and StringBuffer:

String aString = "Niagara. O roar again!";
char aChar = aString.charAt(9);
String roar = aString.substring(11,15);



Strings Accessor Methods

indexOf(int character)
lastIndexOf(int character)

Return the index of the first (last) occurrence of the specified character.

indexOf(int *character*, int *from*)
lastIndexOf(int *character*, int *from*)

Return the index of the first (last) occurrence of the specified character, searching forward (backward) from the specified index.

Strings Accessor Methods(2)

indexOf(String string)
lastIndexOf(String string)

Return the index of the first (last) occurrence of the specified String.

indexOf(String string, int from)
lastIndexOf(String string, int from)

Return the index of the first (last) occurrence of the specified String, searching forward (backward) from the specified index.

StringBuffers Accessor Methods

Question:

What is the difference between:
StringBuffer.length()
and
StringBuffer.capacity() ?

Answer:

StringBuffer.length() - returns amount of space used

StringBuffer.capacity() - returns the amount of space currently allocated for the StringBuffer,

Strings conversions

Sometimes is necessary to convert an object to a String because there are methods that accept only String values.

Example:

```
class ReverseString {
    public static String reverseIt(String source) {
        int i, len = source.length();
        StringBuffer dest = new StringBuffer(len);

        for (i = (len - 1); i >= 0; i--) {
            dest.append(source.charAt(i));
        }
        return dest.toString();
    }
}
```

Strings conversions(2)

All classes inherit toString from the Object class

Many classes in the java.lang package override this method to provide an implementation that is meaningful to that class.

The valueOf Method

You can use **valueOf** to convert variables of different types to Strings. Example:

*System.out.println(**String.valueOf**(Math.PI));*

Converting Strings to numbers

The "type wrapper" classes (Integer, Double, Float, and Long) provide a class method named valueOf that converts a String to an object of that type. Example:

String piStr = "3.14159";
Float pi = Float.valueOf(piStr);

Strings - cont.

Literal Strings

In Java, you specify *literal strings* between double quotes:

"Hello World!"

So, possible is:

int len = "Hello World!".length();

Question:

What is the difference between:

String s = "Hello World!";

and

String s = new String("Hello World!");

Answer:

Efficiency. In the second example there are two objects created.

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Concatenation and + operator

In the Java programming language, you can use **+** to concatenate Strings together:

```
String cat = "cat";
System.out.println("con" + cat + "enation");
```

Question:

Is the above efficient?

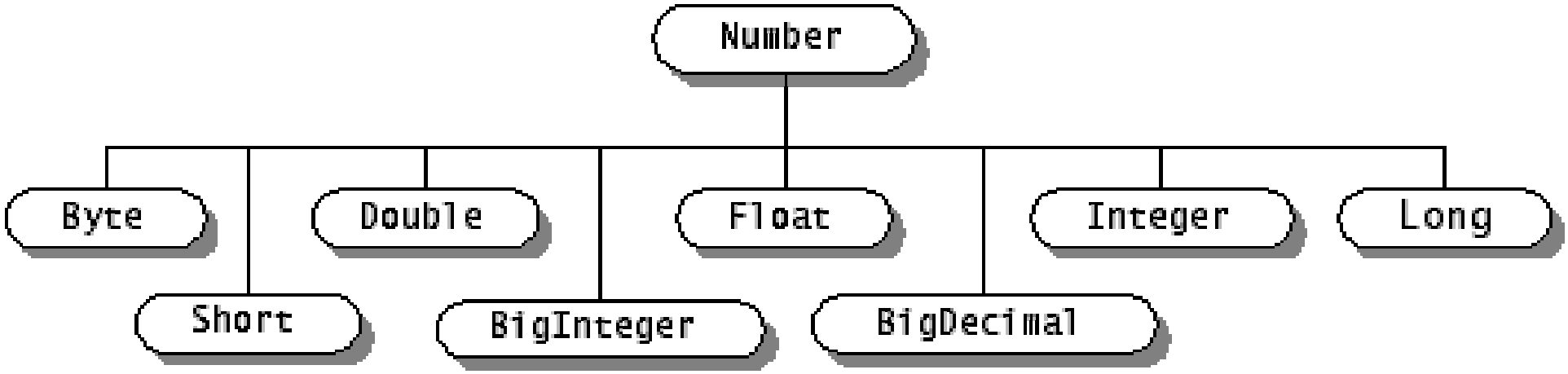
Answer:

Yes, it is. The second line is compiled to:

```
System.out.println(new StringBuffer().append("con").
append(cat).append("enation").toString());
```

Numbers

Java.lang.Number class and its subclasses:



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The wrapper classes

Number classes:

- Number
- Byte
- Double
- Float
- Integer
- Long
- Short
- BigDecimal (java.Math)
- BigInteger (java.Math)

Wrappers for other data types:

- Boolean
- Character
- Void

The Integer class overview

Field Overview

static int ***MAX_VALUE***
A constant holding the maximum value an int can have, $2^{31}-1$.

static int ***MIN_VALUE***
A constant holding the minimum value an int can have, -2^{31}.

Constructor Overview

Integer*(int value)*
Constructs a newly allocated Integer object that represents the specified int value.

Integer*(String s)*
Constructs a newly allocated Integer object that represents the int value indicated by the String parameter.

The Integer class ...(2)

Method Overview

byte ***byteValue****()*
Returns the value of this Integer as a byte.

int ***intValue****()*
Returns the value of this Integer as an int.

static int ***parseInt****(String s)*
Parses the string argument as a signed decimal integer. static
String ***toBinaryString****(int i)*
Returns a string representation of the integer argument as an unsigned integer in base 2.

String ***toString****()*
Returns a String object representing this Integer's value. static
Integer ***valueOf****(String s)*
Returns an Integer object holding the value of the specified String.

Numbers(2)

By invoking the methods provided by the **NumberFormat** class, you can format numbers, currencies, and percentages according to **Locale**. Example:

```
Double amount = new Double(345987.246);
NumberFormat numberFormatter;
String amountOut;
numberFormatter =
NumberFormat.getNumberInstance(currentLocale);
amountOut = numberFormatter.format(amount);
System.out.println(amountOut + " " +
                   currentLocale.toString());
```

The output shows how the format of the same number varies with Locale:

```
345 987,246   fr_FR
345.987,246   de_DE
345,987.246   en_US
```

Currencies and Percentages

To have currency or percentage format, you need to change following line:

NumberFormat.getCurrencyInstance(currentLocale); or

NumberFormat.getPercentInstance(currentLocale);

The output for currencies with different Locale:

9 876 543,21 F	fr_FR
9.876.543,21 DM	de_DE
$9,876,543.21	en_US

Of course NumberFormat class is unaware of exchange rates!

Customizing Formats

You specify the formatting properties of **DecimalFormat class** with a **pattern String**. The pattern determines what the formatted number looks like.

For a full description of the pattern syntax, see:

http://java.sun.com/docs/books/tutorial/java/data/numberpattern.html

Example:

```
DecimalFormat myFormatter = new DecimalFormat(pattern);
String output = myFormatter.format(value);
System.out.println(value + " " + pattern + " " + output);
```

Patterns examples:

###,###.###

000000.000

$###,###.###

Local- sensitive formatting

If you want a **DecimalFormat object for a nondefault Locale**, you instantiate a NumberFormat and then cast it to DecimalFormat. **Example:**

```
NumberFormat nf =
NumberFormat.getNumberInstance(loc);
DecimalFormat df = (DecimalFormat)nf;
df.applyPattern(pattern);
String output = df.format(value);
System.out.println(pattern + " " + output + " " +
loc.toString());
```

The output varies with Locale:

```
###,###.###   123,456.789  en_US
###,###.###   123.456,789  de_DE
###,###.###   123 456,789  fr_FR
```

Altering the formating symbols

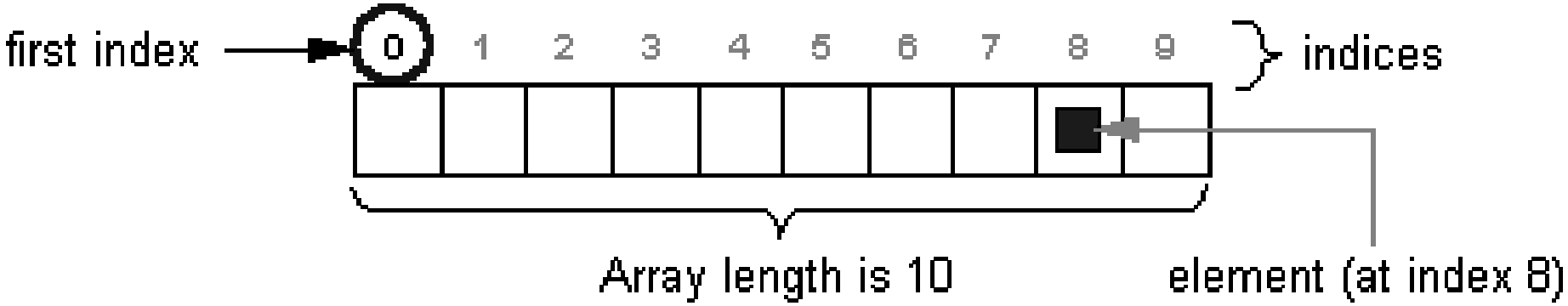
You can use the **DecimalFormatSymbols class** to change the symbols that appear in the formatted numbers produced by the format method. The unusual format is the result of the calls to the **setDecimalSeparator, setGroupingSeparator,** and **setGroupingSize methods.** Example:

```
DecimalFormatSymbols unusualSymbols =
    new DecimalFormatSymbols(currentLocale);
unusualSymbols.setDecimalSeparator('|');
unusualSymbols.setGroupingSeparator('^');
String strange = "#,##0.###";
DecimalFormat weirdFormatter =
            new DecimalFormat(strange, unusualSymbols);
weirdFormatter.setGroupingSize(4);
String bizarre = weirdFormatter.format(12345.678);
System.out.println(bizarre);
```

The output = ? **=1^2345|678**

Arrays

An array is a structure that holds multiple values of the same type. The length of an array is established when the array is created (at runtime).



To store data of different types in a single structure which could dynamically change, use a **Collection** implementation, such as Vector, instead of an array.

Arrays (2)

Example on using arrays:

```
public class ArrayDemo {
    public static void main(String[] args) {
        int[] anArray;            // declare an array of integers
        anArray = new int[10];// create an array of integers
        // assign a value to each array element and print
        for (int i = 0; i < anArray.length; i++) {
            anArray[i] = i;
            System.out.print(anArray[i] + " ");
        }
    }
}
```

Array initializers example:

```
boolean[] answers = { true, false, true, true, false };
```

Arrays of Objects

Question:

What is wrong with following code:

```
String[] anArray = new String[5];
for (int i = 0; i < anArray.length; i++) {
        System.out.println(anArray[i].toLowerCase());
}
```

Answer:

After first line of code is executed, the array called anArray exists and has enough room to hold 5 string objects. However, the array doesn't contain any strings yet. **It is empty**. The program must explicitly create strings and put them in the array. The code will cause **NullPointerException**.

Arrays of Arrays

Example:

```
public class ArrayOfArraysDemo {
    public static void main(String[] args) {
        String[][] letters =
        {
                { "a", "b", "c", "d", "e" },
                { "f", "g", "h", "i" },
                { "j", "k", "l", "m", "n", "o", "p" },
                { "q", "r", "s", "t", "u", "v" }
        };
        for (int i = 0; i < letters.length; i++) {
            for (int j = 1; j < letters[i].length; j++) {
                System.out.print(letters[i][j] + " ");        } } }}
```

Notice that the sub-arrays are all of different lengths. The names of the sub-arrays are letters[0], letters[1], and so on.

Arrays of Arrays (2)

As with arrays of objects, you must explicitly create the sub-arrays within an array. So if you don't use an initializer, you need to write code like the following:

```
public class ArrayOfArraysDemo2 {
    public static void main(String[] args) {
        int[][] aMatrix = new int[4][];

          //populate matrix
        for (int i = 0; i < aMatrix.length; i++) {
            aMatrix[i] = new int[5]; //create sub-array
            for (int j = 0; j < aMatrix[i].length; j++) {
                aMatrix[i][j] = i + j;
            }}}}
```

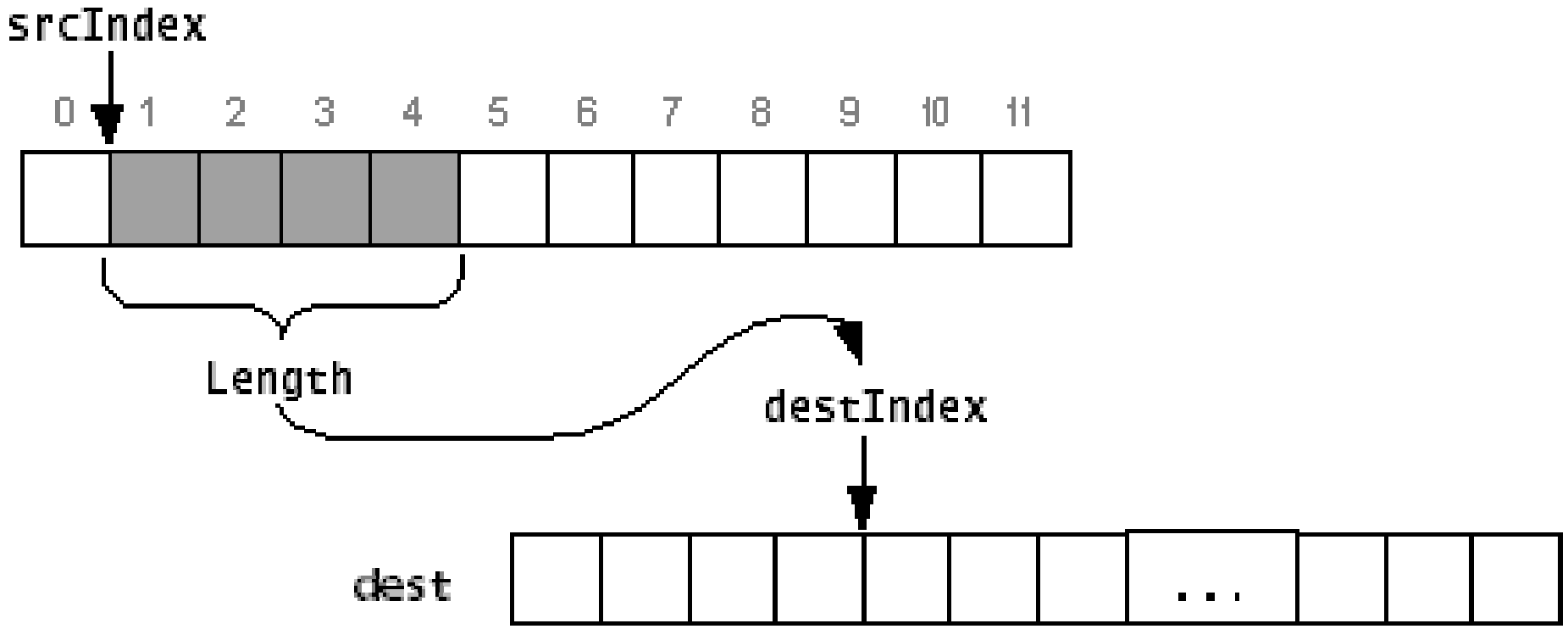
The copying Arrays

The arraycopy method requires five arguments:

*public static void **arraycopy**(Object source,i nt srcIndex,*

Object dest, int destIndex, int length)

Diagram illustrates how the copy takes place:



Arrays (3)

Questions:

1. What is wrong with following code and how to repair it?

2. What kind of message you will get and when?

```
public class WhatHappens {
        public static void main(String[] args) {
                StringBuffer[] stringBuffers = new StringBuffer[10];
                for (int i = 0; i < stringBuffers.length; i ++) {
                stringBuffers[i].append("StringBuffer at index " + i);
} } }
```

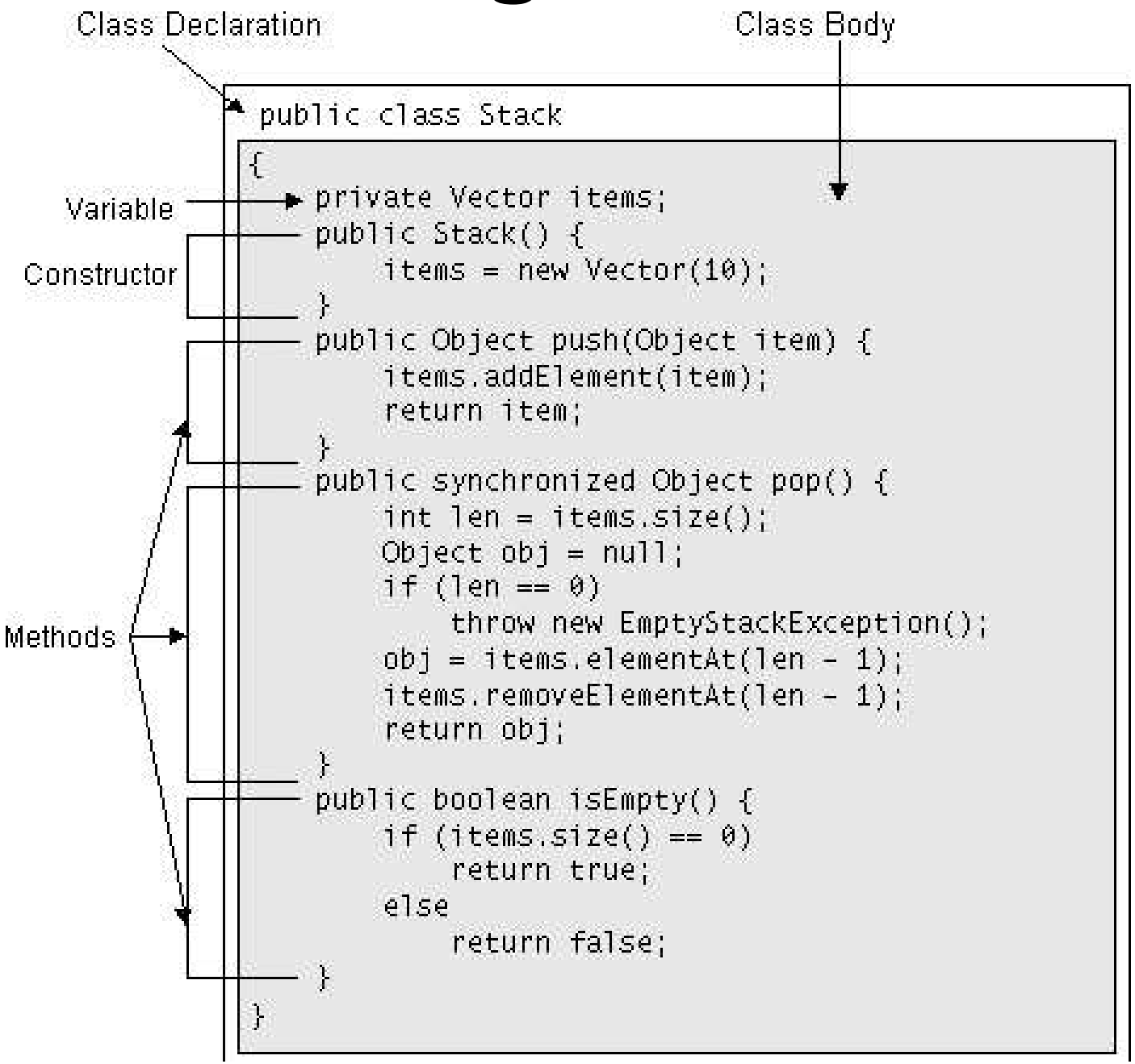
Answers:

1. Before appending to buffer following line is missing:

stringBuffers[i] = new StringBuffer();

2. NullPointerException during runtime.

Creating classes



The class declaration

`public`	Class is publicly accessible.
`abstract`	Class cannot be instantiated.
`final`	Class cannot be subclassed.
`class NameOfClass`	***Name of the Class.***
`extends` *`Super`*	Superclass of the class.
`implements` *`Interfaces`*	Interfaces implemented by the class.

`{`
`    `*`ClassBody`*
`}`	

If you do not explicitly declare the optional items, the Java compiler assumes certain defaults: a nonpublic, nonabstract, nonfinal subclass of Object that implements no interfaces.

Constructors

All Java classes have **constructors** that are used to initialize a new object of that type. A constructor has the same name as the class. **A constructor is not a method**. **Examples**:

```
public Stack() {
items = new Vector(10);
}
public Stack(int initialSize) {
 items = new Vector(initialSize);
}
```

The compiler differentiates these constructors based on the number of parameters in the list and their types. Based on the number and type of the arguments that you pass into the constructor, the compiler can determine which constructor to use:

new Stack();

new Stack(5);

Constructors (2)

```
class AnimationThread extends Thread {
    int framesPerSecond;
    int numImages;
    Image[] images;
    AnimationThread(int fps, int num) {

        super("AnimationThread");
        this.framesPerSecond = fps;
        this.numImages = num;
        this.images = new Image[numImages];
        for (int i = 0; i <= numImages; i++) {
                        // Load all the images.
 }}}
```

Constructors (3)

super("AnimationThread");

- This line invokes a constructor provided by the superclass of AnimationThread, namely, Thread.
- This particular Thread constructor takes a String that sets the name of Thread.
- Often a constructor wants to take advantage of initialization code written in a class's superclass.
- Some classes must call their superclass constructor in order for the object to work properly.
- **If present, the superclass constructor must be the first statement in the subclass's constructor**: An object should perform the higher-level initialization first.

Constructors (4)

Access specifiers in the constructors' declaration:

private

No other class can instantiate your class. Your class may contain public class methods (sometimes called factory methods), and those methods can construct an object and return it, but no other classes can.

protected

Only subclasses of the class and classes in the same package can create instances of it.

public

Any class can create an instance of your class.

no specifier gives package access

Only classes within the same package as your class can construct an instance of it.

Declaring Member Variables

accessLevel	Indicates the access level for this member.
`static`	Declares a class member.
`final`	Indicates that it is constant.
`transient`	This variable is transient.
`volatile`	This variable is volatile.
type name	The type and name of the variable.

transient

The transient marker is not fully specified by *The Java Language Specification* but is used in object serialization to mark member variables that should not be serialized.

volatile

The volatile keyword is used to prevent the compiler from performing certain optimizations on a member.

Method Declaration

accessLevel	Access level for this method.
static	This is a class method.
abstract	This method is not implemented.
final	Method cannot be overridden.
native	Method implemented in another language.
synchronized	Method requires a monitor to run.
returnType methodName	The return type and method name.
(*paramList*)	The list of arguments.
throws *exceptions*	The exceptions thrown by this method.

native

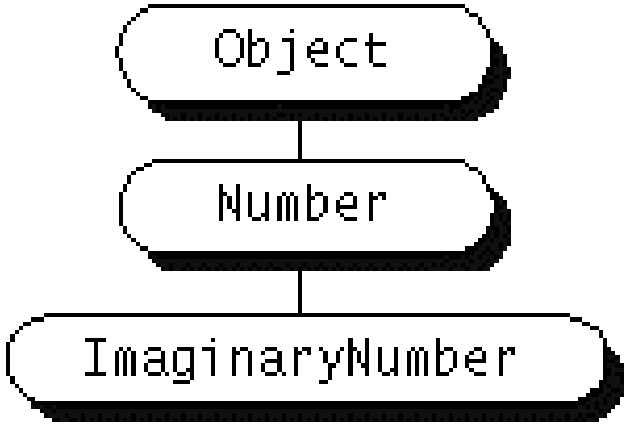
Methods implemented in a language other than Java are called native methods and are declared as such using the native keyword.

synchronized

Concurrently running threads often invoke methods that operate on the same data. These methods may be declared synchronized.

Returning a value

Suppose you have a class hierarchy illustrated here:



And a method declared

to return a Number:

public Number returnANumber() { . . .}

Question:

What object can be returned from the method?

Answer:

The returnANumber method can return an ImaginaryNumber but not an Object. ImaginaryNumber "is a" Number because it's a subclass of Number. However, an Object is not necessarily a Number--it could be a String or some other type. **You also can use interface names as return types. In this case, the object returned must implement the specified interface.**

A Method's name

Java supports method name overloading so that multiple methods can share the same name. **Example**:

```
class DataRenderer {
        void draw(String s) { . . . }
        void draw(int i) { . . . }
        void draw(float f) { . . . }
 }
```

Question:

Is it correct add another method:
***void draw(String t){...}* to above example?**

Answer:

No, because compiler cannot differentiate them and it will cause an compiler error.

Passing information into a method

•In Java, you can pass an argument of any **valid Java data type** into a method. This includes **primitive data types** such as doubles, floats, integers and **reference data types** such as objects and arrays.

•**You cannot pass methods into Java methods**. But you can pass an object into a method and then invoke the object's methods.

Hiding variables:

```
class Circle {
        int x, y, radius;
        public Circle(int x, int y, int radius) {
                this.x = x;
                this.y = y;
                this.radius = radius;          } }
```

Pass by value

In Java methods, arguments are **passed by value**. When invoked, the method receives the value of the variable passed in. When the argument is of primitive type, pass-by-value means that the method cannot change its value. When the argument is of reference type, pass-by-value means that the method cannot change the object reference, but can invoke the object's methods and modify the accessible variables within the object.

Question:

What is the final value of variable *b*:

int r = -1, g = -1, b = -1;
pen.getRGBColor(r, g, b);
b=?

Answer:

b=-1

The *super* keyword

Example:

```
class ASillyClass {
        boolean aVariable;
        void aMethod() { aVariable = true; }
}
class ASillierClass extends ASillyClass {
        boolean aVariable;
        void aMethod() {
                aVariable = false;
                super.aMethod();
                System.out.println(aVariable);
                System.out.println(super.aVariable);
} }
```

Question:

What is an output?

Answer:

false

true

Local variables

Within the body of the method you can declare more variables for use within that method. These variables are **local variables** and live only while control remains within the method. Example:

```
Object findObjectInArray(Object o, Object[] arrayOfObjects) {
        int i; // local variable
        for (i = 0; i < arrayOfObjects.length; i++) {
                if (arrayOfObjects[i] == o)
                        return o;
        }
        return null;
}
```

After this method returns, i no longer exists.

Controlling Access to Members of a Class

Question:

What is wrong:

```
class Alpha {
        private int iamprivate;
        private void privateMethod() {
                System.out.println("privateMethod");
 } }
class Beta {
        void accessMethod() {
                Alpha a = new Alpha();
                a.iamprivate = 10;
                a.privateMethod();
 } }
```

Answer:

//illegal

//illegal

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Controlling Access to Members of a Class(2)

Compiler errors:

Beta.java:9: Variable iamprivate in class Alpha not accessible from class Beta.
a.iamprivate = 10;
^
1 error

Beta.java:12: ***No method matching privateMethod() found in class Alpha.***
a.privateMethod();
1 error

Conclusion: Compiler is always right. Sometimes it is difficult to understand error message.

Controlling Access to Members of a Class(3)

Question:
What is wrong?

```
class Alpha {
        private int iamprivate;
        boolean isEqualTo(Alpha anotherAlpha) {
                if (this.iamprivate == anotherAlpha.iamprivate)
                        return true;
                else
                        return false;  } }
```

Answer:

Everything is all right (!!!). Objects of the same type have access to one another's private members. This is because access restrictions apply at the class or type level rather than at the object level (this particular instance of a class).

Controlling Access to Members of a Class(4)

Protected access level specifier allows the class itself, subclasses (**with one caveat**), and all classes in the same package to access the members.

```
package Greek;
public class Alpha {
        protected int iamprotected;
        protected void protectedMethod() {
                        System.out.println("protectedMethod");   } }

package Greek;
class Gamma {
        void accessMethod() {
                Alpha a = new Alpha();
                a.iamprotected = 10; // legal
                a.protectedMethod(); // legal                    }}
```

Controlling Access to Members of a Class(5)

The caveat:

The Delta class (introduced below) can access both iamprotected and protectedMethod, but only on objects of type Delta or its subclasses. The Delta class cannot access iamprotected or protectedMethod on objects of type Alpha. Example:

```
package Latin;
import Greek.*;
class Delta extends Alpha {
        void accessMethod(Alpha a, Delta d) {
                a.iamprotected = 10; // illegal
                d.iamprotected = 10; // legal
                a.protectedMethod(); // illegal
                d.protectedMethod(); // legal
} }
```

Controlling Access to Members of a Class(6)

Public:

Any class, in any package, has access to a class's public members.

Package:

The package access level is what you get if you don't explicitly set a member's access to one of the other levels. This access level allows classes in the same package as your class to access the members

```
package Greek;
class Alpha {
        int iampackage;
         void packageMethod() {
                System.out.println("packageMethod");
 } }
```

Instance and Class members

Instance variable. Example:
class MyClass { float aFloat; }

Every time you create an instance of a class, the runtime system creates one copy of each the class's instance variables for the instance.

Class variable. Example:
*class MyClass { **static** float aFloat; }*

The runtime system allocates class variables once per class regardless of the number of instances created of that class. The system allocates memory for class variables the first time it encounters the class. All instances share the same copy of the class's class variables. You can access class variables through an instance or through the class itself.

Instance and Class members(2)

Methods:

•Instance methods operate on the current object's instance variables but also have access to the class variables.

•Class methods cannot access the instance variables declared within the class (unless they create a new object and access them through the object).

•Class methods can be invoked on the class, you don't need an instance to call a class method.

Initializing Instance and Class Members

You can use static initializers and instance initializers to provide initial values for class and instance members when you declare them in a class:

```
class BedAndBreakfast {
        static final int MAX_CAPACITY = 10;
        boolean full = false; }
```

This works well for members of primitive data type. Sometimes, it even works when creating arrays and objects. But this form of initialization has **limitations**, as follows:

1. Initializers can perform only initializations that can be expressed in an assignment statement.
2. Initializers cannot call any method that can throw a checked exception.
3. If the initializer calls a method that throws a runtime exception, then it cannot do error recovery.

Using static initialization blocks

If you have some initialization to perform that cannot be done in an initializer because of one of previous limitations, you have to put the initialization code elsewhere. **To initialize class members, put the initialization code in a static initialization block**. To initialize instance members, put the initialization code in a constructor.

```
import java.util.ResourceBundle;
class Errors {
    static ResourceBundle errorStrings;
    static {
        try {
            errorStrings = ResourceBundle.
                                getBundle("ErrorStrings");
        } catch (java.util.MissingResourceException e) {
            // error recovery code here
        }
    }
}
```

Initializing instance members

Example:

```
import java.util.ResourceBundle;

class Errors {

        ResourceBundle errorStrings;

        Errors() {

        try {

        errorStrings =
        ResourceBundle.getBundle("ErrorStrings");

        } catch (java.util.MissingResourceException e) {

        // error recovery code here          } } }
```

The code that initializes errorStrings is in a constructor for the class.

Initializing instance members(2)

Example.java.awt.Rectangle has these three constructors:

Rectangle();

Rectangle(int width, int height);

Rectangle(int x, int y, int width, int height);

Here are the possible implementations of the three Rectangle constructors:

Rectangle() { this(0,0,0,0); }

Rectangle(int width, int height) { this(0,0,width,height); }
Rectangle(int x, int y, int width, int height) {

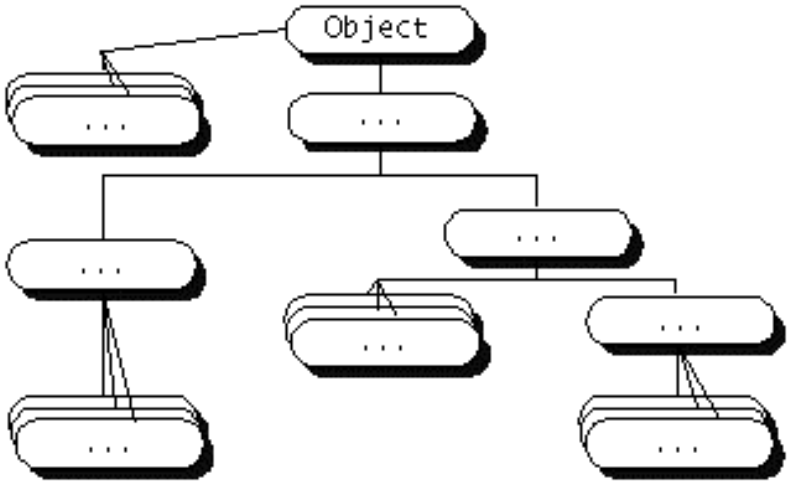
this.x = x; this.y = y;

this.width = width; this.height = height; }

Inheritance

Extends clause declares that your class is a subclass of another. You can specify **only one superclass** for your class (**Java does not support multiple class inheritance**), and even though you can omit the *extends* clause from your class declaration, your class has a superclass.

The **Object class** defines and implements behavior that every class in the Java system needs. It is the most general of all classes. Its immediate subclasses, and other classes near top of the hierarchy, implement general behavior; classes near the bottom of the hierarchy provide for more specialized behavior.



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Inheritance(2)

The members that are inherited by a subclass:

•Subclasses inherit those superclass members declared as public or protected.

•Subclasses inherit those superclass members declared with no access specifier as long as the subclass is in the same package as the superclass.

•Subclasses don't inherit a superclass's member if the subclass declares a member with the same name. **In the case of member variables, the member variable in the subclass hides the one in the superclass. In the case of methods, the method in the subclass overrides the one in the superclass.**

Hiding member variables

Lets consider the following superclass and subclass pair:

class Super { Number aNumber; }

class Subbie extends Super { Float aNumber; }

The aNumber variable in Subbie hides aNumber in Super. It is possible to access Super's aNumber from Subbie with:

super.aNumber

super is a Java language keyword that allows a method to refer to hidden variables and overridden methods of the superclass.

Overriding Methods

Object class contains the toString method, which returns a String object containing the name of the object's class and its hash code. Most, if not all, classes will want to override this method and print out something meaningful for that class.

The output of toString should be a textual representation of the object. For the Stack class, a list of the items in the stack would be appropriate

```
public class Stack {
        private Vector items;
        public String toString() {
                // list of the items in the stack
         } }
```

Overriding Methods(2)

- The return type, method name, and number and type of the parameters for the overriding method must match those in the overridden method.
- The overriding method can have a different throws clause as long as it doesn't declare any types not declared by the throws clause in the overridden method.
- The access specifier for the overriding method can allow more access than the overridden method, but not less. For example, a protected method in the superclass can be made public but not private.

Overriding Methods(3)

Calling the Overridden Method

Sometimes, you don't want to completely override a method. Rather, you want to add more functionality to it. To do this, simply call the overridden method using the **super** keyword:
super.overriddenMethodName();

Methods a Subclass Cannot Override

A subclass cannot override methods that are declared **final** in the superclass Also, a subclass cannot override methods that are declared **static** in the superclass. A subclass can hide a static method in the superclass by declaring a static method in the subclass with the same signature as the static method in the superclass.

Methods a Subclass Must Override

A subclass must override methods that are declared **abstract** in the superclass, or **the subclass itself must be abstract**

Being Descendent of Object

Every class in the Java system is a descendent, direct or indirect, of the Object class. This class defines the basic state and behavior that all objects must have.

Your classes **may want** to override the following Object methods:

- clone
- equals/hashCode (must be overridden together.)
- finalize
- toString

Your class **cannot** override these Object methods (they are final):

- getClass
- notify
- notifyAll
- wait

The clone Method

•You use the **clone** method to create an object from an existing object.

•Object's implementation of this method checks to see if the object on which clone was invoked implements the **Cloneable interface**, and throws a CloneNotSupportedException if it does not. Note that **Object itself does not implement Cloneable**, so subclasses of Object that don't explicitly implement the interface are not cloneable.

•If the object on which clone was invoked does implement the Cloneable interface, Object's implementation of the clone method creates an object of the same type as the original object and initializes the new object's member variables to have the same values as the original object's corresponding member variables.

•**For some classes the default behavior of Object's clone method works just fine. Other classes need to override clone to get correct behavior.**

The clone Method (2)

Lets consider the Stack class. If Stack relies on Object's implementation of clone, then the original stack and its clone will refer to the same vector. Here then is an appropriate implementation of clone for Stack class:

```
public class Stack implements Cloneable {
        private Vector items;
        protected Object clone() {
            try {
                Stack s = (Stack)super.clone();    // clone the stack
                s.items = (Vector)items.clone();// clone the vector
                return s;                                  // return the clone
            } catch (CloneNotSupportedException e) {
                // this shouldn't happen because Stack is Cloneable
                throw new InternalError();
            }   }  }
```

The equals Method

- You **must** override the equals and hashCode methods together.
- The equals method compares two objects for equality and returns true if they are equal. The equals method provided in the Object class uses the identity function to determine if objects are equal (if the objects compared are the exact same object the method returns true).
- For some classes, two distinct objects of that type might be considered equal if they contain the same information. **Example:**

```
Integer one = new Integer(1), anotherOne = new Integer(1);
if (one.equals(anotherOne))
    System.out.println("objects are equal");
```

This program displays objects are equal even though one and anotherOne reference two distinct objects. They are considered equal because the objects compared contain the same int value.

The hashCode Method

- The value returned by hashCode is an int that maps an object into a bucket in a hash table.

- **An object must always produce the same hash code.**

- The hashing function for some classes is relatively obvious. For example, an obvious hash code for an Integer object is its integer value.

clone and hashCode - example

```
public class BingoBall  {
    public int number;
    public boolean equals(Object obj) {
        if (!(obj instanceof BingoBall))
            return false;
        return ((BingoBall)obj).number == number;
    }
    public int hashCode() {
        return number;
    }
    public String toString() {
        return new
StringBuffer().append(letter).append(number).toString();
    }
}
```

The finalize Method

- The Object class provides a method, finalize, that cleans up an object before it is garbage collected.

- The finalize method is called automatically by the system and most classes you write do not need to override it.

The toString Method

- **Object's toString method returns a String representation of the object.**
- You can use toString along with System.out.println to display a text representation of an object, such as the current thread:

System.out.println(Thread.currentThread().toString());

- **The String representation for an object depends entirely on the object.** The String representation of an Integer object is the integer value displayed as text. The String representation of a Thread object contains various attributes about the thread, such as its name and priority.
- **The toString method is very useful for debugging. It behooves you to override this method in all your classes**.

The getClass Method

• The **getClass method is a final method** that returns a runtime representation of the class of an object. This method returns a **Class object**.

• Once you have a Class object you can query it for various information about the class, such as its name, its superclass, and the names of the interfaces that it implements.

• The following method gets and displays the class name of an object:

```
void PrintClassName(Object obj) {
    System.out.println("The Object's class is " +
                       obj.getClass().getName());
}
```

The getClass Method(2)

•One handy use of a Class object is to create a new instance of a class without knowing what the class is at compile time.

• The following sample method creates a new instance of the same class as obj, which can be any class that inherits from Object (any class):

```
Object createNewInstanceOf(Object obj) {
        return obj.getClass().newInstance();
}
```

The notify, notifyAll and wait Methods

•You cannot override Object's notify and notifyAll methods and its three versions of wait. This is because they are critical for ensuring that threads are synchronized.

Final classes and methods

You can declare that your class is **final**, that is, that your class **cannot be subclassed.** There are (at least) two reasons why you might want to do this:

1. Security

One mechanism that hackers use to subvert systems is to create a subclass of a class and then substitute their class for the original. The subclass looks and feels like the original class but does vastly different things, possibly causing damage or getting into private information.

2. Design

You may also wish to declare a class as final for object-oriented design reasons. You may think that your class is "perfect" or that, conceptually, your class should have no subclasses.

Final classes and methods(2)

Example:

If you wanted to declare your (perfect) ChessAlgorithm class as final, its declaration should look like this:

final class ChessAlgorithm { . . .}

The final Methods

You might wish to make a method final if it has an implementation that should not be changed and it is critical to the consistent state of the object.Instead of making your ChessAlgorithm class final, you might want instead to make the nextMove method final:

```
class ChessAlgorithm {
    final void nextMove(ChessPiece pieceMoved,
                        BoardLocation newLocation)  {  ...  }
}
```

Abstract classes

To declare that your class is an **abstract class**, use the keyword abstract before the class keyword in your class declaration:

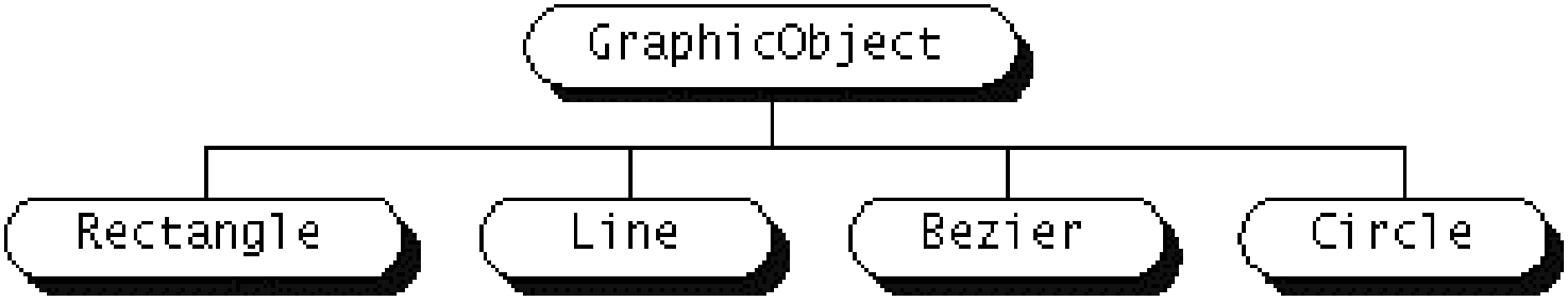
```
abstract class Number {
    . . .
}
```

If you attempt to instantiate an abstract class, the compiler displays an error similar to the following and refuses to compile your program:

```
AbstractTest.java:6: class AbstractTest is an abstract class.
It can't be instantiated.
        new AbstractTest();
        ^
1 error
```

Abstract methods

An abstract class may contain **abstract methods**.Example:



The GraphicObject class would look like this:

```
abstract class GraphicObject {
    int x, y;
        void moveTo(int newX, int newY) {  . . . }
    abstract void draw();      }
```

Each non-abstract subclass would have to provide an implementation for the draw method:

```
class Circle extends GraphicObject {
    void draw() { . . . }          }
```

Abstract classes and methods

- **An abstract class is not required to have an abstract method in it.**

- **Any class that has an abstract method in it or that does not provide an implementation for any abstract methods declared in its superclasses must be declared as an abstract class.**

Questions

```
public class ClassA {
    public void methodOne(int i) {    }
    public void methodTwo(int i) {    }
    public static void methodThree(int i) {    }
    public static void methodFour(int i) {    }
}

public class ClassB extends ClassA {
    public static void methodOne(int i) {    }
    public void methodTwo(int i) {    }
    public void methodThree(int i) {    }
    public static void methodFour(int i) {    }
}
```

Answer:

```
//compiler error
//overrides
//compiler error
//hides
```

1. **Which method overrides a method in the superclass?**
2. **Which method hides a method in the superclass?**
3. **What do the other methods do?**

A nested class

Java lets you define a class as a member of another class. Such a class is called a **nested class:**

```
class EnclosingClass{
        class ANestedClass {. . .}
}
```

• You use nested classes to reflect and enforce the relationship between two classes.

• You should define a class within another class when the nested class makes sense only in the context of its enclosing class or when it relies on the enclosing class for its function. For example, a text cursor makes sense only in the context of a particular text component.

• The nested class has unlimited access to its enclosing class's members, even if they are declared private. **Question: Why ?**
Answer: Nested class is a normal member of enclosing class.

A nested class(2)

• A nested class can be declared static (or not). A static nested class is called just that: **a static nested class.** A nonstatic nested class is called an **inner class**:

```
class EnclosingClass{
    static class AStaticNestedClass { . . . }
    class InnerClass { . . . }
}
```

•A static nested class is associated with its enclosing class.

•A static nested class cannot refer directly to instance variables or methods defined in its enclosing class-it can use them only through an object reference.

•An inner class is associated with an instance of its enclosing class and has direct access to that object's instance variables and methods.

•Inner class cannot define any static members itself.

A nested class(3)

• **Nested classes can be declared abstract or final**. The meaning of these two modifiers for nested classes is the same as for other classes.

• **The access specifiers may be used to restrict access to nested classes just as they do to other class members.**

• **Any nested class can be declared in any block of code.** A nested class declared within a method or other smaller block of code has access to any final variables in scope.

Inner class - Example

Suppose you want to add a feature to the Stack class that lets another class enumerate over the elements in the stack using the interface defined in **java.util.Enumeration**. This interface contains two method declarations:

public boolean hasMoreElements();
public Object nextElement();

The Enumeration interface defines the interface for a single loop over the elements:

```
while (hasMoreElements())
    nextElement()
```

If Stack implemented the Enumeration interface itself, you could not restart the loop and you could not enumerate the contents more than once. Also, you couldn't allow two enumerations to happen simultaneously. So Stack shouldn't implement Enumeration. Rather, a helper class should do the work for Stack.

Inner class - Example(2)

```
public class Stack {
    private Vector items;
    public Enumeration enumerator() {
        return new StackEnum();
    }
    class StackEnum implements Enumeration {
        int currentItem = items.size() - 1;
        public boolean hasMoreElements() {
            return (currentItem >= 0);
        }
        public Object nextElement() {
            if (!hasMoreElements())
                throw new NoSuchElementException();
            else
                return items.elementAt(currentItem--);
        } } }
```

Anonymous class

You can declare an inner class without naming it. Anonymous classes can make code difficult to read. You should limit their use to those classes that are very small. **Example:**

```
public class Stack {
        private Vector items;
        public Enumeration enumerator() {
            return new Enumeration() {
                int currentItem = items.size() - 1;
                public boolean hasMoreElements() {
                    return (currentItem >= 0);  }
                public Object nextElement() {
                    if (!hasMoreElements())
                        throw new NoSuchElementException();
                    else
                        return items.elementAt(currentItem--);
                } } } }
```

Nested classes - questions

a. The only users of this nested class will be instances of the enclosing class or instances of the enclosing class's subclasses.

b. Anyone can use this nested class.

c. Only instances of the declaring class need to use this nested class, and a particular instance might use it several times.

d. This tiny nested class is used just once, to create an object that implements an interface.

e. This nested class has information about its enclosing class (not about instances of the enclosing class) and is used only by its enclosing class and perhaps their subclasses.

f. Similar situation as the preceding (choice e), but not intended to be used by subclasses

1d	1. anonymous inner class
2a	2. protected inner class
3b	3. public static nested class
4e	4. protected static nested class
5f	5. private static nested class
6c	6. private inner class

Nested classes – questions(2)

```
import java.util.*;     // What is wrong ?

public class Problem {

        public static void main(String[] args) {

         final Timer timer = new Timer();

                timer.schedule(new TimerTask() {

                        public void run() {
                                System.out.println("Exiting.");

                                timer.cancel();

                        }

                }, 5000);

                System.out.println("In 5 sec exit. ");

        } }
```

Interfaces

An interface defines a protocol of behavior that can be implemented by any class anywhere in the class hierarchy. An interface defines a set of methods but does not implement them. A class that implements the interface agrees to implement all the methods defined in the interface, thereby agreeing to certain behavior.

Definition:

An interface is a named collection of method definitions (without implementations). An interface can also declare constants.

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Interfaces and abstract classes

The differences between interfaces and abstract classes:

- An interface cannot implement any methods, whereas an abstract class can.
- A class can implement many interfaces but can have only one superclass.
- An interface is not part of the class hierarchy. Unrelated classes can implement the same interface.

Using interfaces – example

Suppose that you have written a class that can watch stock prices coming over a data feed. This class allows other classes to register to be notified when the value of a particular stock changes. First, your class, which we'll call **StockMonitor**, would implement a method that lets other objects register for notification:
public class StockMonitor {

public void watchStock(StockWatcher watcher, String tickerSymbol, double delta) { ... } }

Arguments explanation:

StockWatcher is the name of an interface which declares one method: valueChanged.

String tickerSymbol - symbol of the stock to watch

double delta - amount of change that the watcher considers interesting enough to be notified of.

Using interfaces – example(2)

• The watchStock method ensures, through the data type of its first argument, **that all registered objects implement the valueChanged method**.

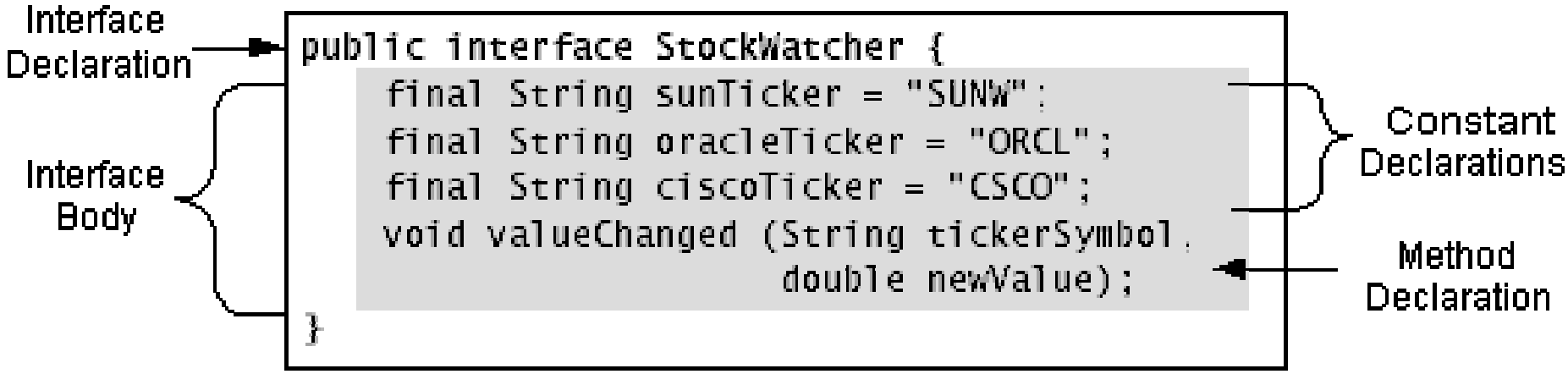
• **It makes sense to use an interface data type here because it matters only that registrants implement a particular method.**

• If StockMonitor had used a class name as the data type, that would artificially force a class relationship on its users. Because a class can have only one superclass, it would also limit what type of objects can use this service.

• **By using an interface, the registered objects class could be anything** -Applet or Thread- for instance, thus allowing any class anywhere in the class hierarchy to use this service.

Using interfaces – example(3)

Declaration of interface StockWatcher:



This interface defines three constants, which are the ticker symbols of watchable stocks. This interface also declares, but does not implement, the valueChanged method. Classes that implement this interface provide the implementation for that method.

The interface declaration

`public`	Makes this interface public.
`interface InterfaceName`	This is the name of the interface.
`Extends SuperInterfaces`	This interface's superinterfaces.

`{`
`    InterfaceBody`
`}`	

Two elements are required in an interface declaration--the interface keyword and the name of the interface.

The interface declaration(2)

- **The public access specifier indicates that the interface can be used by any class in any package.** If you do not specify that your interface is public, your interface will be accessible only to classes that are defined in the same package as the interface.

- **An interface declaration can have one other component: a list of superinterfaces.** An interface can extend other interfaces, just as a class can extend or subclass another class. However, whereas a class can extend only one other class, an interface can extend any number of interfaces. The list of superinterfaces is a comma-separated list of all the interfaces extended by the new interface.

The interface body

• The interface body contains method declarations for all the methods included in the interface. A method declaration within an interface is followed by a semicolon (;) because an interface does not provide implementations for the methods declared within it. **All methods declared in an interface are implicitly public and abstract.**

• An interface can contain constant declarations in addition to method declarations. **All constant values defined in an interface are implicitly public, static, and final.**

• Member declarations in an interface disallow the use of some declaration modifiers; **you cannot use transient, volatile, or synchronized in a member declaration in an interface**. Also, **you may not use the private and protected specifiers when declaring members of an interface.**

Implementing an Interface

An interface defines a protocol of behavior. A class that implements an interface adheres to the protocol defined by that interface.

By convention: The implements clause follows the extends clause, if it exists.

Classes that implement an interface inherit the constants defined within that interface. So those classes can use simple names to refer to the constants. Any other class can use an interfaces constants with a qualified name, like this:

StockWatcher.sunTicker

Using Interface as a Type

When you define a new interface, you are defining a new reference data type. You can use interface names anywhere you can use any other data type name.

Only an instance of a class that implements the interface can be assigned to a reference variable whose type is an interface name.

Interfaces cannot grow

Suppose that you want to add some functionality to StockWatcher. For instance, suppose that you want to add a method that reports the current stock price, regardless of whether the value changed:

```
public interface StockWatcher {

...

void valueChanged(String tickerSymbol, double newValue);

void currentValue(String tickerSymbol, double newValue);

 }
```

If you make this change, all classes that implement the old StockWatcher interface will break because they dont implement the interface anymore!

Interfaces cannot grow(2)

To avoid mentioned problem you should implement interface completely from the beginning. For example, you could create a StockWatcher subinterface called StockTracker that declared the new method:

```
public interface StockTracker extends StockWatcher {

 void currentValue(String tickerSymbol, double newValue);

}
```

Now users of your code can choose to upgrade to the new interface or to stick with the old interface.

Interfaces - questions

Question:

Is the following interface valid?

public interface Marker { }

Answer:

Yes. Methods are not required. Empty interfaces can be used as types and to mark classes without requiring any particular method implementations. For an example a useful empty interface is java.io.Serializable.

Interfaces – questions(2)

Excercise:

Suppose that you have written a time server, which periodically notifies its clients of the current date and time. Write an interface that the server could use to enforce a particular protocol on its clients.

Answer:

```
public interface TimeClient {

    public void setTime(int hour, int minute, int second);

    public void setDate(int day, int month, int year);

    public void setDateAndTime(int day, int month, int year,

                               int hour, int minute, int second);     }
```

Packages

To make classes easier to find and to use, to avoid naming conflicts, and to control access, programmers bundle groups of related classes and interfaces into packages.

Definition: A package is a collection of related classes and interfaces providing access protection and namespace management.

Packages(2)

Suppose that you write a group of classes that represent a collection of graphic objects, such as circles, rectangles, lines, and points. You also write an interface, Draggable, that classes implement if they can be dragged with the mouse by the user:

//in the Graphic.java file

public abstract class Graphic { . . . }

//in the Circle.java file

public class Circle extends Graphic implements Draggable { . . . }

//in the Rectangle.java file

public class Rectangle extends Graphic implements Draggable { .}

//in the Draggable.java file public interface Draggable { . . . }

Why they should be bundled in a package?

Packages(3)

You should bundle these classes and the interface in a package for several reasons:

- You and other programmers can easily determine that these classes and interfaces are related.
- You and other programmers know where to find classes and interfaces that provide graphics-related functions.
- The names of your classes wont conflict with class names in other packages, because the package creates a new namespace.
- You can allow classes within the package to have unrestricted access to one another yet still restrict access for classes outside the package.

Creating Packages

To create a package, you put a class or an interface in it. To do this, you put a **package** statement at the top of the **source file** in which the class or the interface is defined. **Example:**

package graphics;

public class Circle extends Graphic implements Draggable { . . . }

•The Circle class is a public member of the graphics package.

•You must include a package statement at the top of every source file that defines a class or an interface that is to be a member of the graphics package.

Package Statement

- The scope of the package statement is the entire source file,
- If you put multiple classes in a single source file, only one may be public, and it must share the name of the source files base name.
- Only public package members are accessible from outside the package.
- If you do not use a package statement, your class or interface ends up in the *default package*, which is a package that has no name.
- The default package is only for small or temporary applications or when you are just beginning development. Otherwise, classes and interfaces belong in named packages.

Naming a Package

It is possible to name identically two classes unless they are in a different packages.

By convention:

Companies use their reversed Internet domain name in their package names, like this: com.company.package. Name collisions that occur within a single company need to be handled by convention within that company, perhaps by including the region or the project name after the company name, for example, com.company.region.package.

For our purposes:

All classes should be in package:

pl.lodz.p.dmcs.*particular_name*

Using Package Members

Only public package members are accessible outside the package in which they are defined. To use a public package member from outside its package, you must do one or more of the following:

- Refer to the member by its long (qualified) name
- Import the package member
- Import the members entire package

Each is appropriate for different situations.

Referring to a Package Member by Name

If you are trying to use a member from a different package and that package has not been imported, you must use the members qualified name, which includes the package name. This is the qualified name for the Rectangle class declared in the graphics package :

graphics.Rectangle

You could use this long name to create an instance of graphics.Rectangle:

graphics.Rectangle myRect = new graphics.Rectangle();

Using long names is good for one-shot uses.

Importing a Package Member

To import a specific member into the current file, put an **import** statement at the beginning of your file before any class or interface definitions but after the package statement, if there is one. **Example:**

import graphics.Circle;

Now you can refer to the Circle class by its simple name:

Circle myCircle = new Circle();

This approach works well if you use just a few members from the graphics package. But if you use many classes and interfaces from a package, you can import the entire package.

Importing an Entire Package

To import all the classes and interfaces contained in a particular package, use the import statement with the asterisk **(*)** wildcard character:

import graphics.*;

The asterisk in the import statement can be used only to specify all the classes within a package. It cannot be used to match a subset of the classes in a package. For example, the following does not match all the classes in the graphics package that begin with A:

import graphics.A; // does not work*

Instead, it generates a compiler error. **With the import statement, you can import only a single package member or an entire package.**

Packages imported automatically

The Java runtime system automatically imports three entire packages:

- **The default package** (the package with no name)
- **The java.lang package**
- **The current package**

Disambiguating a name

If by some chance a member in one package shares the same name with a member in another package and both packages are imported, you must refer to each member by its qualified name. For example, the previous example defined a class named *Rectangle* in the *graphics* package. The *java.awt package* also contains a *Rectangle* class. If both **graphics** and **java.awt** have been imported, the following is ambiguous:

Rectangle rect;

In such a situation, you have to be more specific and use the members qualified name to indicate exactly which Rectangle class you want:

graphics.Rectangle rect;

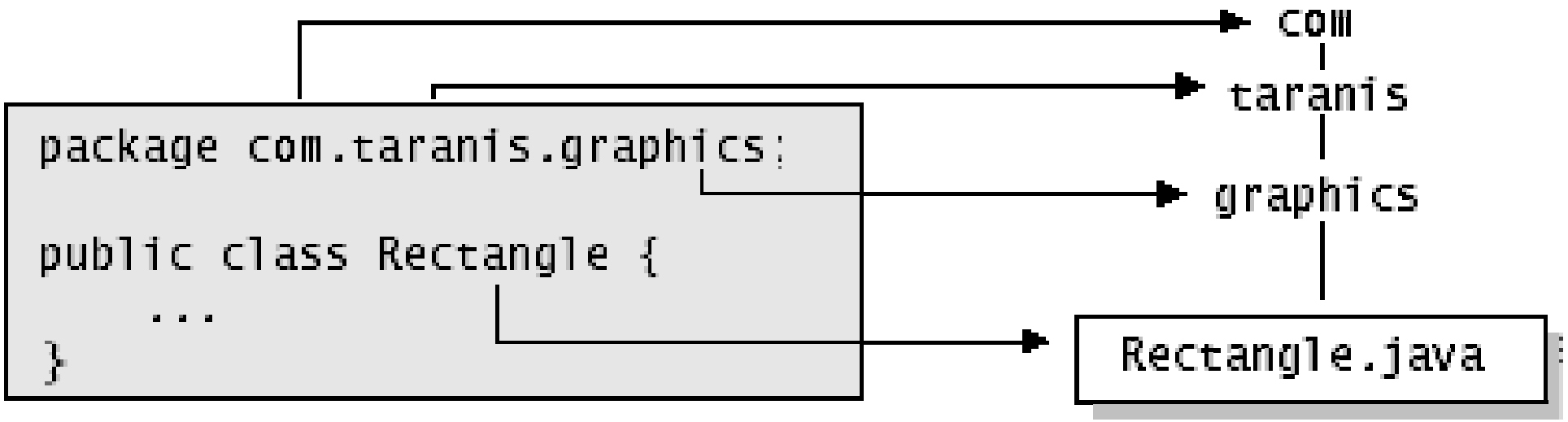
Managing files

The qualified name of the package member and the path name to the file are parallel:

class name graphics.Rectangle

pathname to file graphics/Rectangle.java

Each component of the package name corresponds to a subdirectory.



Managing files(2)

When you compile a source file, the compiler creates a different output file for each class and interface defined in it. The base name of the output file is the name of the class or the interface, and its extension is .class: