Java certification success, Part 1: SCJP

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Section 1. Before you start

About this tutorial

This tutorial is a guide to help you become a Sun certified Java programmer. It is organized in the same way as the Sun Certified Java Programmer (SCJP) 1.4 exam and provides a detailed overview of all of the exam's main objectives. Throughout the tutorial, simple examples are provided to illustrate the important concepts covered in the exam.

At the end of each section, exercises are provided to test your knowledge of the main concepts covered in that section. At the end of the tutorial, useful resources, such as recommended books, articles, tutorials, training, and specifications for the exam, are also listed.

If you are a programmer interested in enhancing your skills and your resume, this tutorial is for you. The tutorial assumes you have familiarity with the Java programming language.

About the SCJP 1.4 exam

The SCJP 1.4 exam is the first in a series of Java certification exams offered by Sun Microsystems, and for many programmers it is the first step to becoming established as a competent Java developer.

The exam tests the knowledge of Java fundamentals and requires in-depth knowledge of the syntax and semantics of the language. Even experienced Java programmers can benefit from preparing for the SCJP exam. You get to learn very subtle and useful tips you might not have been aware of, even after many years of Java programming.

About the author

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Section 2. Declarations and access control

Arrays

Arrays are dynamically created objects in Java code. An array can hold a number of variables of the same type. The variables can be primitives or object references; an array can even contain other arrays.

Declaring array variables

When we declare an array variable, the code creates a variable that can hold the reference to an array object. It does not create the array object or allocate space for array elements. It is illegal to specify the size of an array during declaration. The square brackets may appear as part of the type at the beginning of the declaration or as part of the array identifier:

```
int[] i;          // array of int
byte b[];         // array of byte
Object[] o,       // array of Object
short s[][];      // array of arrays of short
```

Constructing arrays

You can use the `new` operator to construct an array. The size of the array and type of elements it will hold have to be included. In the case of multidimensional arrays, you may specify the size only for the first dimension:

```
int [] marks = new int[100];
String[][] s = new String[3][];
```

Initializing arrays

An array initializer is written as a comma-separated list of expressions, enclosed within curly braces:

```
String s[] = { new String("apple"),new String("mango") };
int i[][] = { {1, 2}, {3,4} };
```

An array can also be initialized using a loop:

```
int i[] = new int[5];
for(int j = 0; j < i.length;j++)
{
  i[j] = j;
}
```

Accessing array elements

Arrays are indexed beginning with 0 and ending with `n-1`, where *n* is the array size. To get the array size, use the array instance variable called `length`. If you attempt to access an index value outside the range 0 to `n-1`, an `ArrayIndexOutOfBoundsException` is thrown.

Declaring classes, variables, and methods

Now let's look at ways we can modify classes, methods, and variables. There are two kinds of modifiers -- access modifiers and non-access modifiers. The access modifiers allow us to restrict access or provide more access to our code.

Class modifiers

The access modifiers available are `public`, `private`, and `protected`. However, a top-level class can have only public and default access levels. If no access modifier is specified, the class will have default access. Only classes within the same package can see a class with default access. When a class is declared as public, all the classes from other packages can access it.

Let's see the effect of some non-access modifiers on classes. The `final` keyword (see Java keywords and identifiers on page 21 for more on keywords) does not allow the class to be extended. An `abstract` class cannot be instantiated, but can be extended by subclasses:

```
public final class Apple {..}
class GreenApple extends Apple {}    // Not allowed, compile time error
```

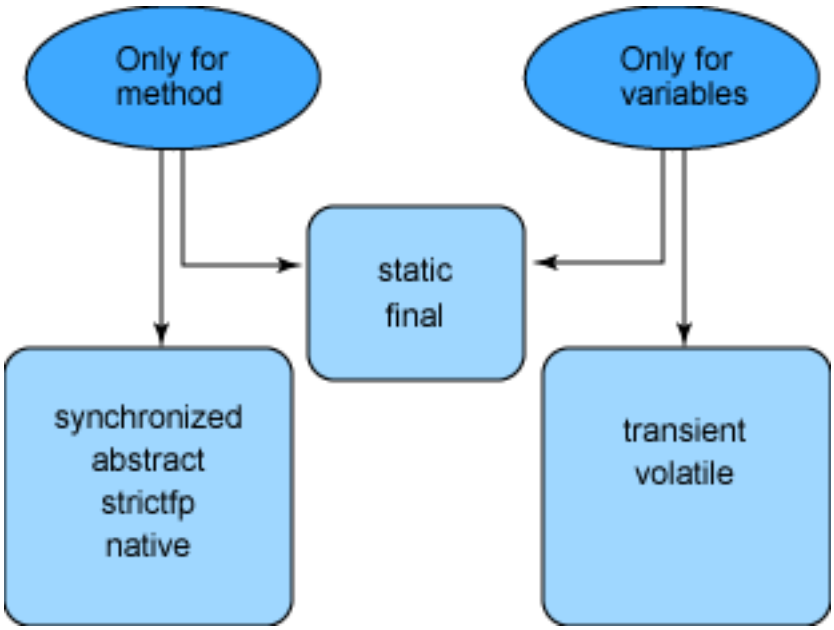
Method and variable modifiers

All the access modifiers can be used for members of a class. The private members can only be accessed from inside the class. The protected members can only be accessed by classes in the same package or subclasses of the class. The public members can be accessed by any other class.

If there is no access modifier specified, these members will have default access and only other classes in the same package can access them.

Now let's explore other modifiers that can be applied to member declarations. Some of them can be applied only to methods while some can be applied only to variables, as illustrated in the figure below:

Figure 1. Modifiers for methods and variables



A `synchronized` method can be accessed by only one thread at a time. `Transient` variables cannot be serialized. An `abstract` method does not have an implementation; it has to be implemented by the first concrete subclass of the containing class. The class containing at least one `abstract` method has to be declared as `abstract`. However, an `abstract` class need not have any `abstract` methods in it:

```
public abstract class MyAbstractClass
{
  public abstract void test();
}
```

The `native` modifier indicates that the method is not written in the Java language, but in a native language. The `strictfp` keyword (see Java keywords and identifiers on page 21 for more information on keywords), which is used only for methods and classes, forces floating points to adhere to IEE754 standard. A variable may be declared `volatile`, in which case a thread must reconcile its working copy of the field with the master copy every time it accesses the variable.

`Static` variables are shared by all instances of the class. `Static` methods and variables can be used without having any instances of that class at all:

```
class StaticTest
{
  static int i = 0;
  static void getVar()
    {
      i++;
      System.out.println(i);
    }
}

class Test
{
  public static void main(String args[])
```

```
    {
      StaticTest.getVar();
    }
}
```

Constructors

A constructor is used when creating an object from a class. The constructor name must match the name of the class and must not have a return type. They can be overloaded, but they are not inherited by subclasses.

Invoking constructors

A constructor can be invoked only from other constructors. To invoke a constructor in the same class, invoke the `this()` function with matching arguments. To invoke a constructor in the superclass, invoke the `super()` function with matching arguments. When a subclass object is created, all the superclass constructors are invoked in the order starting from the top of the hierarchy.

Default constructors

The compiler creates the default constructor if you have not provided any other constructor in the class. It does not take any arguments. The default constructor calls the no-argument constructor of the superclass. It has the same access modifier as the class.

However, the compiler will not provide the default constructor if you have written at least one constructor in the class. For example, the following class has a constructor with two arguments defined in it. Here the compiler will give an error if we try to instantiate the class without passing any arguments because the default constructor is not available:

```
class Dot
{
  int x, y;
  Dot(int x, int y)
  {
    this.x = x;
    this.y = y;
  }
}
```

If you invoke the default constructor of your class and the superclass does not have a constructor without any arguments, your code will not compile. The reason is that the subclass default constructor makes an implicit call to the no-argument constructor of its superclass. For instance:

```
class Dot
{
  int x, y;
  Dot(int x, int y)
  {
    this.x = x;
    this.y = y;
  }
}
```

```
class MyDot extends Dot { }
class Test
{
  public static void main(String args[])
  {
    MyDot dot=new MyDot();
  }
}
```

Summary

In this section, we covered the important concepts that are included in the first objective. We discussed the valid ways to declare and construct single and multi-dimensional arrays. When you understand the effect of modifiers in methods and classes, make sure you know the legal combinations of modifiers. For example, you cannot declare a `final` method as `abstract`. We also learned about constructors. Remember that the compiler provides the default no-argument constructor only when you don't write any constructors.

Exercise

Question:

What will be the result of an attempt to compile and run the following program?

```
class Box
{
  int b,w;
  void Box(int b,int w)
  {
    this.b = b;
    this.w = w;
  }
}

public class MyBox extends Box
{
  MyBox()
  {
    super(10,15);
    System.out.println(b + "," + w);
  }
  static public void main(String args[])
  {
    MyBox box = new MyBox();
  }
}
```

Choices:

- A. Does not compile; main method is not declared correctly
- B. Prints 10,15
- C. Prints 0,0
- D. None of the above

Correct choice:

- D

Explanation:

The program does not compile because there is no matching constructor in the base class for the `super(10,15)` call from the subclass constructor. `void Box(int b, int w)` is not a constructor, because a return type is given. If it had been a constructor, the variables `w` and h would have been initialized to 10 and 15. The program would have compiled correctly and printed 10,15. There is no error in the declaration of the `main()` method; `static` and `public` can appear in any order.

Section 3. Flow control, assertions, and exception handling

Flow control statements

The flow control statements allow you to conditionally execute statements, to repeatedly execute a block of statements, or to just change the sequential flow of control.

`if/else` statement

The `if/else` statement is used for decision-making -- that is, it decides which course of action needs to be taken. The syntax is:

```
if(boolean expression)
{
  // do this if the expression is true
}
else
{
  // do this if the expression is false
}
```

The `else` part in the `if/else` statement is optional. The curly braces are optional if the body is limited to a single statement. (Note that we cannot use numeric values to represent true and false as we do in C/C++.) For instance:

```
if (x == 5) {}      // compiles, executes body if x is equal to 5
if (x = 0) {}       // does not compile, because expression is non-boolean
if (x = true) {}    // compiles, but the body is always executed
```

In the case of nested `if/else` statements, each `else` clause belongs to the closest preceding `if` statement that does not have an `else`.

`switch` statement

The `switch` statement is also used for decision-making, based on an integer expression. The argument passed to the `switch` and `case` statements should be `int`, `short`, `char`, or `byte`. The argument passed to the `case` statement should be a literal or a `final` variable. If no case matches, the `default` statement (which is optional) is executed.

When a `break` statement is encountered, the control moves out of the `switch` statement. If no `break` statement is given, all the `case` statements are executed until a break is encountered or the `switch` statement ends. For instance:

```
int x = 1;
switch(x)
{
  case 1: System.out.println("one");
  case 2:         System.out.println("two");
}
// both one and two are printed
```

Notice the position of the `default` statement. Though the `default` statement is usually

placed at the end of all the case options, it is not mandatory as you can see in the example below:

```
int i = 1;
switch(i)
{
  default:
    System.out.println("Default");
    break;
  case 0:
    System.out.println("Zero");
    break;
  case 1:
    System.out.println("One");
    break;
}
```

Note that the control comes to the `default` statement only if none of the cases match. However, it is a good practice to have the `default` statement at the end itself.

Loop statements

The three types of Java looping constructs are `while`, `do-while`, and `for`.

`while` loop

The syntax of the `while` loop is:

```
while(boolean expression) {}
```

The body of the `while` loop is executed only if the expression is true, so it may not be executed even once:

```
while(false){}    // body never executed

while(1) {}       // code will not compile, not a boolean
```

`do-while` loop

The syntax of the `do-while` loop is:

```
do { } while(boolean expression);
```

The body of the `do-while` loop is executed at least once because the test expression is evaluated only after executing the loop body. Also, don't forget the ending semicolon after the `while` expression.

`for` loop

The syntax of the `for` loop is:

```
for(expr1; expr2; expr3)
{
  // body
```

```
}
```

`expr1` is for initialization, `expr2` is the conditional test, and `expr3` is the iteration expression. Any of these three sections can be omitted and the syntax will still be legal:

```
for( ; ; ) {}  // an endless loop
```

There can be more than one initialization expression and more than one iteration expression, but only one test expression.

break and continue

The `break` statement is used to exit from a `loop` or `switch` statement, while the `continue` statement is used to skip just the current iteration and continue with the next.

In the case of nested loops, the `break` statement exits from the innermost loop only. If a `break` keyword (see Java keywords and identifiers on page 21 for more information on keywords) is combined with a label, a `break` statement will exit out of the labeled loop:

```
outer: for (int i = 0; i < 10; i++)
  {
    while(y > 0)
    {
      break outer;
    }
  }
// breaks from the for loop if y > 0
```

Assertions

An assertion is a statement containing a boolean expression that is assumed to be true when the statement is executed. The system reports an `AssertionError` if the expression evaluates to false. It is used for debugging purposes:

```
assert(a > 0); // throws an AssertionError if a <= 0
```

Assertions can be in two forms:

```
assert Expression1 ;
assert Expression1 : Expression2 ;
```

`Expression1` should always result in a boolean value.

`Expression2` can be anything that results in a value. The value is used to generate a `String` message that displays more debugging information. For instance:

```
class AssertionTest
{
  int a ;
  public void func()
  {
```

```
    assert (a < 0): "a is positive" ;
    // Remaining code
  }
}
```

In the above code, the assertion expression is true if a is negative. If a is positive, an `AssertionError` is thrown with the message "a is positive."

Assertions are disabled by default. To compile with assertions enabled, you need to use the `source 1.4` flag:

```
javac -source 1.4 Test.java
```

To enable assertions at runtime, use the `-enableassertions` or `-ea` flags.

For selective disabling of assertions at runtime, use the `-da` or `-disableassertions` flags.

For enabling assertions in the system classes, use the `-esa` or `-dsa` flags. Assertions can also be enabled or disabled on a package basis.

Appropriate and inappropriate use of assertions

You can place an assertion at any location that you don't expect to be reached normally. Assertions can be used to validate the parameters passed to a private method. However, assertions should not be used to validate parameters passed to public methods because a public method must check its arguments regardless of whether assertions are enabled or not. However, you can test postconditions with assertions in both public and non-public methods. Also, assertions should not change the state of a program in any manner.

See Resources on page 48 for more information on assertions.

Exception handling

Exceptions are Java objects; exception classes are derived from `java.lang.Throwable`.

An exception is thrown to denote an abnormal occurrence like accessing an array index that exceeds the size of the array. Exceptions can be checked or unchecked. Subclasses of `RuntimeException` and `Error` are called *unchecked exceptions*. All other classes, which inherit from `Exception`, are *checked exceptions*. Any method that might throw a checked exception must either declare the exception using the `throws` keyword (see Java keywords and identifiers on page 21 for more information on keywords) or handle the exception using a `try/catch` block.

`try/catch` block

The code that might throw an exception is enclosed in the `try` block. One or more `catch` clauses can be provided to handle different exception types:

```
try
{
  // code that might throw exceptions
```

```
}
catch(Exception e)
{
  //code to handle the exception
}
```

The more specific exception type should be caught first. For instance, we have to order the `catch` blocks from specific to most general, otherwise a compile-time error occurs.

For example, assume that `MyException` inherits from `Exception`:

```
try
{
  throw new MyException();
}
catch(Exception e)
{
  System.out.println("Exception");
}
catch(MyException e)
{
  System.out.println("MyException");
}
```

Here the compiler complains that the `catch` clause for `MyException` is unreachable because all exceptions thrown will be caught by the first general `catch` clause.

`finally` block

The `finally` block can also be provided to perform any cleanup operation. If an exception is thrown, any matching `catch` clauses are executed, then control comes to the `finally` block, if one is provided. The syntax of the `finally` block is as follows:

```
try
{
  // code that throws exceptions
}
catch(Exception e)
{
  // handle exception
}
finally
{
  // cleanup code
}
```

The `finally` block is executed even if no exception is thrown. The only case in which this does not happen is when `System.exit()` is invoked by the `try` or `catch` blocks. A `try` block should have either a `catch` block or a `finally` block, but it's not required to have both.

Declaring and throwing exceptions

To throw an exception explicitly from the code, use the `throw` keyword.

The checked exceptions that a method can throw must be declared using the `throws` keyword (see Java keywords and identifiers on page 21 for more information on keywords).

For instance:

```
void f() throws MyException
{
  if(x > y) throw new MyException(); // MyException is a subclass of Exception
}
```

Summary

In this section, we saw the proper usage of flow control statements like `if/else` and `while` loops. Make sure that the arguments passed to these statements are legal. Note the difference between `break` and `continue` statements. We discussed assertions and the ways to disable and enable them. Be clear about when assertions should be used and when using them is inappropriate. We also learned about checked/unchecked exceptions and how to handle or raise exceptions in the code. Remember that the `finally` block would be reached in most occasions except in some special cases.

Exercise

Question:

What will be printed out if you attempt to compile and run the following code?

```
int i = 3;
switch (i)
{
  default:
    System.out.println("default");
  case 0:
    System.out.println("zero");
  case 1:
    System.out.println("one");
    break;
  case 2:
   System.out.println("two");
}
```

Choices:

- A. default
- B. default, zero, one
- C. Compiler error
- D. No output displayed

Correct choice:

- B

Explanation:

Although it is normally placed last, the `default` statement does not have to be placed as the last option in the case block. Since there is no case label found matching the expression, the default label is executed and the code continues to fall through until it encounters a `break` statement.

Section 4. Garbage collection

Behavior of the garbage collector

A Java programmer does not have to worry about memory management, because it is automatically taken care of by the garbage collector. The Java virtual machine (JVM) decides when to run the garbage collector. The garbage collector is a low priority thread that runs periodically, releasing memory used by objects that are not needed anymore.

The garbage collection (GC) algorithm varies from one JVM to another. There are different algorithms being used, like reference counting or the mark and sweep algorithm. See Resources on page 48 for more information on garbage collection.

Running the garbage collector

The JVM usually runs the garbage collector when the level of available memory is low. However, the garbage collector cannot ensure that there will always be enough memory.

If there is not enough memory even after the garbage collector reclaims memory, the JVM throws an `OutOfMemoryError` exception. Note that the JVM will definitely run the garbage collector at least once before throwing this exception.

While you can *request* that the garbage collector run, it is important to note that you can never *force* this action.

Requesting that the garbage collector run

To request garbage collection, you can call either of the following methods:

```
System.gc()
Runtime.getRuntime().gc()
```

Eligibility for garbage collection

An object is eligible for garbage collection when no live thread can access it.

An object can become eligible for garbage collection in different ways:

- If the reference variable that refers to the object is set to null, the object becomes eligible for garbage collection, provided that no other reference is referring to it.
- If the reference variable that refers to the object is made to refer to some other object, the object becomes eligible for garbage collection, provided that no other reference is referring to it.
- Objects created locally in a method are eligible for garbage collection when the method returns, unless they are exported out of the method (that is, returned or thrown as an exception).

- Objects that refer to each other can still be eligible for garbage collection if no live thread can access either of them.

Consider the following example:

```
public class TestGC
{
  public static void main(String [] args)
  {
    Object o1 = new Integer(3);               // Line 1
    Object o2 = new String("Tutorial");       // Line 2
    o1 = o2;                                  // Line 3
    o2 = null;                                // Line 4
    // Rest of the code here
  }
}
```

In this example, the `Integer` object initially referred to by the reference `o1` becomes eligible for garbage collection after line 3. This is because `o1` now refers to the `String` object. Even though `o2` is now made to refer to null, the `String` object is not eligible for garbage collection because `o1` refers to it.

Finalization

Java technology allows you to use the `finalize()` method to do the necessary cleanup before the garbage collector removes the object from memory. This method is called by the garbage collector on an object when garbage collection determines that there are no more references to the object. It is defined in the `Object` class, thus it is inherited by all classes. A subclass overrides the `finalize()` method to dispose of system resources or to perform other cleanup:

```
protected void finalize() throws Throwable
```

If an uncaught exception is thrown by the `finalize()` method, the exception is ignored and finalization of that object terminates.

The `finalize()` method will be invoked only once in the lifetime of an object.

You can use an object's `finalize()` method to make it ineligible for garbage collection. Note, however, that the garbage collector will not run `finalize()` for this object again.

The `finalize()` method will always be invoked once before the object is garbage collected. However, the `finalize()` method might never be invoked for an object in its lifetime, because there is no guarantee that it will get garbage collected.

Summary

In this section, we discussed the concept of garbage collection, which is the Java language's memory management technique. We saw that garbage collection cannot be forced. We also learned the different ways in which objects become eligible for garbage collection and that

the `finalize()` method is invoked on an object before it is removed by the garbage collector.

Exercise

Question:

How many objects will be eligible for garbage collection after line 7?

```
public class TutorialGC
{
  public static void main(String [] args)
  {
    Object a = new Integer(100);  // Line1
    Object b = new Long(100);     // Line2
    Object c = new String("100"); // Line3
    a = null;                     // Line4
    a = c;                        // Line5
    c = b;                        // Line6
    b = a;                        // Line7
    // Rest of the code here
  }
}
```

Choices:

- A. 0
- B. 1
- C. 2
- D. 3
- E. Code does not compile

Correct choice:

- B

Explanation:

Among the three objects created in lines 1, 2, and 3, only the `Integer` object is eligible for garbage collection at the end of line 7. The reference variable a, which originally referred to the `Integer` object is made to refer to the `String` object in line 5. So the `Integer` object is eligible for garbage collection after line 5, since there are no variables referring to it. The variables b and c refer to the `String` and `Long` objects in lines 6 and 7, so they are not eligible for garbage collection.

Section 5. Language fundamentals

Package and class declarations

A *package* represents a group of classes. A `package` statement should be the first valid statement in the source file. If there is no `package` statement, the classes in the source file belong to the default unnamed package, or else they belong to the named package. Only one `package` statement is allowed in a source file.

In a source file, there can be only one public class, and the name of the file should match that of the class. An `import` statement allows you to use a class directly instead of referring to it using its fully qualified name. `Import` statements must come after any `package` statement and before the class declarations, as shown below:

```
package com.abc;          // package statement
import java.net.*;        // wild card import (imports all classes in the package)
import java.util.Vector;  // class import (only the given class is imported)
```

Nested class declarations

A *nested* class or *inner* class is a class defined inside another class. Nested classes can be non-static, method-local, anonymous, or static.

Non-static inner classes

A non-static inner class definition does not use the `static` keyword (see Java keywords and identifiers on page 21 for more information on keywords). It is defined within the scope of the enclosing class, as follows:

```
class MyClass
{
  class MyInner{}
}
```

To instantiate a non-static inner class, you need an instance of the outer class.

A non-static inner class has access to all the members of the outer class. From inside the outer instance code, use the inner class name alone to instantiate it:

```
MyInner myInner = new MyInner();
```

From outside the outer instance code, the inner class name must be included in the outer instance:

```
MyClass myClass = new MyClass();
MyClass.MyInner inner = myClass.new MyInner();
```

Modifiers that can be applied to non-static inner classes are `final`, `abstract`, `public`, `private`, and `protected`.

Method local inner classes

A method local inner class can be instantiated in the method where it is defined. It can also be in a constructor, a local block, a static initializer, or an instance initializer. It cannot access the local variables of the enclosing method unless they are `final`. The only modifiers for such a class are `abstract` or `final`.

Anonymous inner classes

Anonymous inner classes are inner classes that have no name. They can extend a class or implement an interface. For instance:

```
button1.addMouseListener(new MouseAdapter()
{
  public void mouseClicked(MouseEvent e)
  {
    button1_mouseClicked(e);
  }
});
```

This example shows an anonymous inner class. It is important to note that the class has been defined within a method argument.

Static nested classes

A static nested class is a static member of the enclosing class. It does not have access to the instance variables and methods of the class. For instance:

```
class MyOuter
{
  static class MyNested{}
}
class Test
{
  public static void main(String args[]){
  MyOuter.MyNested n = new MyOuter.MyNested();
  }
}
```

As this example shows, a static nested class does not need an instance of the outer class for instantiation.

Interfaces

An interface is like a public class that has only abstract and public methods. The variables declared in an interface are implicitly `public`, `static`, and `final`. For instance:

```
interface MyInterface
{
  void f();
}
class MyClass implements MyInterface
{
  public void f() {}
}
```

A concrete class implementing an interface has to implement all the methods declared in it.

Interface methods are implicitly `public` and cannot be declared `static`. All the overriding rules are applicable for the implemented methods. A class can implement more than one interface. An interface can extend any number of interfaces:

```
main() method
```

To run the class as a Java application, there must be a method called `main` that takes an array of `String` objects as arguments. The `main()` method must be `public` and `static` and should not return anything. Note that the modifiers `static` and `public` can be in any order:

```
static public void main(String[] abc)  {}   // Valid
```

Command-line arguments

The `String` array argument of the `main()` method contains the command line arguments. The length of the array will be equal to the number of command line arguments. If you try to access elements outside the range 0 to length-1, an `ArrayIndexOutOfBoundsException` is thrown. For instance:

```
class Test
{
  public static void main(String args[])
  {
    System.out.println(args[0]);
  }
}
```

When you use the `java Test Hello` command to invoke this code, the output is "Hello."

Java keywords and identifiers

Keywords are reserved words that are predefined in the language; see the table below. All the keywords are in lowercase.

abstract	boolean	break	byte	case	catch
char	class	const	continue	default	do
double	else	extends	final	finally	float
for	goto	if	implements	import	instanceof
int	interface	long	native	new	package
private	protected	public	return	short	static
strictfp	super	switch	synchronized	this	throw
throws	transient	try	void	volatile	while

Note: `assert` is a new keyword since J2SE 1.4

An identifier is composed of a sequence of characters where each character can be a letter, a digit, an underscore, or a dollar sign.

An identifier declared by the programmer cannot be a Java keyword and it cannot start with a digit. For instance:

```
number, $$abc, _xyx     // Legal Identifiers
12cc, ss-he             // Illegal identifiers
```

Ranges of primitive types

The size and range of all primitive types are listed in the table below. The positive range is one less than the negative range because zero is stored as a positive number. For the boolean datatype, there is no range; it can only be true or false.

Primitive Type	Size	Range of Values
byte	8 bits	-2^7 to 2^7-1
short	16 bits	-2^{15} to $2^{15}-1$
int	32 bits	-2^{31} to $2^{31}-1$
long	64 bits	-2^{63} to $2^{63}-1$
char	16 bits	0 to $2^{16}-1$
float	32 bits	
double	64 bits	

Literals

Integer literals can be decimal, octal, or hexadecimal.

Octal literals begin with zero and only digits 0 through 7 are allowed. For instance:

```
011
```

Hexadecimal literals begin with *0x* or *oX*, the digits allowed are 0 through 9 and *a* through *f* (or *A* through *F*). For instance:

```
0x0001;
```

All integer literals are of type `int` by default. To define them as long, we can place a suffix of *L* or *l* after the number.

For char literals, a single character is enclosed in single quotes. You can also use the prefix \u followed by four hexadecimal digits representing the 16-bit Unicode character:

```
'\u004E', 'A', 'a'
```

For float literals, we need to attach the suffix *F* or *f*. For instance:

```
float f = 23.6F;
double d = 23.6;
```

In the case of double literals, we can add *D* or *d* to the end, however this is optional.

Uninitialized variables

Static and instance variables of a class are initialized with default values for the particular datatype. Local variables are never given a default value; they have to be explicitly initialized before use. When an array is created, all its elements are initialized to their default values, even if the array is declared locally.

Summary

In this section, we saw the correct way to declare packages, classes, interfaces, and the `main()` method. We have also seen the effect of using variables without initializing them. Make sure you can identify the keywords in Java code. Be clear about the ranges of primitive types and how to use literals.

Exercise

Question:

What will be the result of compiling and running the following program with the command **java Test hello**?

```
public class Test
{
  static int i;
  static public void main(String[] args)
  {
    do
    {
      System.out.println(args[++i]);
    } while (i < args.length);
  }
}
```

Choices:

- A. Prints "hello"
- B. Prints "Test"
- C. Code does not compile
- D. Throws an ArrayIndexOutOfBoundsException

Correct choice:

- D

Explanation:

The variable `i` is automatically initialized to 0. Inside the loop, `i` is incremented by 1 first before printing the value of `args[i]`. Here the `args` array has only one element -- "hello." Attempting to access the second element causes the exception.

Section 6. Operators and assignments

Using operators

Assignment operators

You can assign a primitive variable using a literal or the result of an expression. The result of an expression involving integers (`int`, `short`, and `byte`) is always at least of type `int`. Narrowing conversions are not allowed, as they would result in the loss of precision. For instance:

```
byte b = 5;
byte c = 4;
byte d = b + c;           // does not compile because int cannot fit in a byte

float f = (float)35.67;   // implicitly double, so casting to float
float f = 35.67F;
```

A boolean cannot be assigned any type other than boolean.

If we assign an existing object reference to a reference variable, both reference variables refer to the same object. It is legal to assign a child object to a parent object, but the reverse is not allowed. You can also assign an object reference to an interface reference variable, if the object implements that interface. For instance:

```
class Base{}
public class Child extends Base
{
  public static void main(String argv[])
  {
    Child child = new Child();
    Base base = new Base();
    base = child;     // Compiles fine
    child = base;     // Will not compile
  }
}
```

`instanceof` operator

The `instanceof` operator is used to check if an object reference belongs to a certain type or not. The type can either be an interface or a superclass. For instance:

```
class A{}
class B extends A
{
  public static void main(String args[])
  {
    B b = new B();
    if(b instanceof A)
    System.out.println("b is of type A");  // "b is of type A" is printed
  }
}
```

Note that an object is of a particular interface type if any of its superclasses implement that interface.

The plus (+) operator

The plus (+) operator is typically used to add two numbers together. If the operands are String objects, the plus (+) operator is overridden to offer concatenation. For instance:

```
String s1 = "hello ";
String s2 = "World ";
System.out.println(s1 + s2); // prints "hello world"
```

If one of the operands is a String and the other is not, the Java code tries to convert the other operand to a String representation. If the operand is an object reference, then the conversion is performed by invoking its toString() method:

```
int i = 10;
String s1 = " rivers";
String s2 = i + s1;
System.out.println(s2);  // prints "10 rivers"
```

Increment and decrement operators

Two shortcut arithmetic operators are ++, which increments its operand by 1, and --, which decrements its operand by 1.

- ++ increment operator (increments value by 1)
- -- decrement operator (decrements value by 1)

These operators can appear before the operand (prefix) or after the operand (postfix). In the case of the prefix style, the value of the operand is evaluated after the increment/decrement operation. For postfix, the value of the operand is evaluated before the increment/decrement operation, as shown below:

Prefix (operator is placed before the operand):

```
int i = 10;
int j = ++i;                  // j and i are 11
System.out.println(--i);      // prints 10
```

Postfix (operator is placed after the operand):

```
int i = 10;
int j = i++;                  // j is 10, i becomes 11
System.out.println(i--);      // prints 11
```

Shift operators

Shift operators shift the bits of a number to the right or left, thus producing a new number:

- >> right shift (fills the left bit with whatever value the original sign bit held)
- << left shift (fills the right bit with zeros)
- >>> unsigned right shift (fills the left bits with zeros)

For instance:

```
8 >> 1;
Before shifting: 0000 0000 0000 0000 0000 0000 0000 1000
After shifting:          0000 0000 0000 0000 0000 0000 0000 0100
```

Note that decimal equivalent of the shifted bit pattern is 4.

Bitwise operators

Java provides four operators to perform bitwise functions on their operands:

- The & operator sets a bit to 1 if both operand's bits are 1.
- The ^ operator sets a bit to 1 if only one operand's bit is 1.
- The | operator sets a bit to 1 if at least one operand's bit is 1.
- The ~ operator reverses the value of every bit in the operand.

For instance:

```
class Test
{
  public static void main(String args[])
  {
    int x = 10 & 9;   // 1010 and 1001
    System.out.println(x);
  }  // prints 8, which is the decimal equivalent of 1000
}
```

The bitwise operators & and | can be used in boolean expressions also.

Logical operators

The four logical operators are &, &&, |, and ||.

If both operands are true, then the & and && operators return `true`.

If at least one operand is true, then the | and || operators return `true`.

The & and | operators always evaluate both operands. && and || are called *short circuit* operators because if the result of the boolean expression can be determined from the left operand, the right operand is not evaluated. For instance:

```
if ((++x > 2) || (++y > 2)) { x++; }
  //  y is incremented only if (++x > 2) is false
```

Note that || and && can be used only in logical expressions.

The equals() method

We can use the == operator to compare the values of primitive variables and determine if they are equal. However, if object reference variables are compared using the == operator, it returns `true` only if the reference variables are referring to the same object. To check for the equality of two objects, the `Object` class provides the `equals(Object obj)` method,

which can be overridden to return `true` for logically equal objects. The default implementation of the `equals()` method in the `Object` class returns `true` only if an object is compared to itself -- that is, it behaves similarly to the == operator. Classes like `String` and `Boolean` have overridden the `equals()` method, while `StringBuffer` has not. For instance:

```
String s1 = "abc";
String s2 = new String("abc");
if (s1 == s2)      // returns false
  System.out.println("Same Object Reference");
if (s1.equals(s2)) // returns true
  System.out.println("Equal Objects");    // prints "Equal Objects"
```

Passing variables into methods

If the variable passed is a primitive, only a copy of the variable is actually passed to the method. So modifying the variable within the method has no effect on the actual variable.

When you pass an object variable into a method, a copy of the reference variable is actually passed. In this case, both variables refer to the same object. If the object is modified inside the method, the change is visible in the original variable also. Though the called method can change the object referred by the variable passed, it cannot change the actual variable in the calling method. In other words, you cannot reassign the original reference variable to some other value. For instance:

```
class MyClass
{
  int a = 3;
  void setNum(int a)
  {
    this.a = a;
  }
  int getNum()
  {
    return a;
  }
}
class Test
{
  static void change(MyClass x)
  {
    x.setNum(9);
  }
  public static void main(String args[])
  {
    MyClass my = new MyClass();
    change(my);
    System.out.println(my.getNum()); // Prints 9
  }
}
```

In the above example, you can see that changing the object referred to by `x` changes the same object referred to by `my`.

Summary

In this section, we discussed the various operators and assignment rules. You should understand the difference between bitwise operators (`&` and `|`) and logical operators (`& &` and `| |`). Be clear about how equality is tested with the == operator and the significance of the `equals()` method for the objects. Also, remember that objects are passed by a copy of the reference value, while primitives are passed by a copy of the primitive's value.

Exercise

Question:

What will be the result of compiling and running the following code fragment?

```
Integer i= new Integer("10");
if (i.toString() == i.toString())
  System.out.println("Equal");
else
  System.out.println("Not Equal");
```

Choices:

- A. Compiler error
- B. Prints "Equal"
- C. Prints "Not Equal"
- D. None of the above

Correct choice:

- C

Explanation:

The `toString()` method returns the `String` equivalent of this `String` object. It creates a new object each time it is called. The == operator compares the bit patterns of the two object references and not the actual `String` contents. Thus the comparison returns `false`, the `else` statement is executed, and "Not Equal" is printed out.

Section 7. Overriding, overloading, and object orientation

Encapsulation

Encapsulation is the concept of hiding the implementation details of a class and allowing access to the class through a public interface. For this, we need to declare the instance variables of the class as private or protected. The client code should access only the public methods rather than accessing the data directly. Also, the methods should follow the Java Bean's naming convention of `set` and `get`.

Encapsulation makes it easy to maintain and modify code. The client code is not affected when the internal implementation of the code changes as long as the public method signatures are unchanged. For instance:

```
public class Employee
{
  private float salary;
  public float getSalary()
  {
    return salary;
  }
  public void setSalary(float salary)
  {
    this.salary = salary;
  }
```

IS-A relationship

The IS-A relationship is based on inheritance. In Java programming, it is implemented using the keyword `extends`. For instance:

```
public class Animal {...}
public class Cat extends Animal
{
  // Code specific to a Cat. Animal's common code is inherited
}
```

Here `Cat extends Animal` means that `Cat` inherits from `Animal`, or `Cat` is a type of `Animal`. So `Cat` is said to have an IS-A relationship with `Animal`.

HAS-A relationship

If an instance of class A has a reference to an instance of class B, we say that class A HAS-A B. For instance:

```
class Car
{
  private Engine e;
}
class Engine {}
```

Here the `Car` class can make use of the functionality of the `Engine` class, without having the `Engine` class's specific methods in it. This gives us a chance to reuse the `Engine` class in multiple applications. Thus the HAS-A relationship allows us to have specialized classes for

specific functions.

Polymorphism

Polymorphism means "any forms." In object-oriented programming, it refers to the capability of objects to react differently to the same method. Polymorphism can be implemented in the Java language in the form of multiple methods having the same name. Java code uses a late-binding technique to support polymorphism; the method to be invoked is decided at runtime.

Overloaded methods are methods that have the same name, but different argument lists. *Overriding*, on the other hand, occurs when a subclass method has the same name, same return type, *and* same argument list as the superclass method.

Overloading

As we mentioned, it is mandatory for overloaded methods to have the same names but different argument lists. The arguments may differ in type or number, or both. However, the return types of overloaded methods can be the same or different. They may have different access modifiers and may throw different checked exceptions.

Consider a `print()` method used to output data. The data might be `int`, `boolean`, or `char`. For each type of data, the `print()` method should be implemented differently. We can use overloaded methods as shown here:

```
void print(int i) {}
void print(boolean b) {}
void print(char c) {}
```

The method invoked depends on the type of argument passed. A subclass can overload the methods, which it inherits from its superclass. Constructors can be overloaded, which allows us to instantiate a class with different types of arguments. In the following example, the subclass constructor invokes the overloaded constructor of the superclass, which takes an integer argument:

```
class Base
{
  Base() {}
  Base(int a)
  {
    System.out.println(a);
  } //Overloaded constructors
}

class Derived
{
  Derived(int a, int b){ super(a); }
}
```

Overriding

A subclass can redefine a method that it inherits from its superclass. Now the method actually called depends on the type of the invoking object at runtime. The overriding method

must have the same name, arguments, and return type as the overridden method.

The overriding method cannot be less public than the overridden method. The overriding method should not throw new or broader checked exceptions that are not declared by the original method. In the following example, the overridden version of the `print()` method is invoked because the invoking object is an instance of the derived class:

```
class Base
{
  void print()
  {
    System.out.println("Base");
  }
}
class Derived extends Base
{
  void print()
  {
    System.out.println("Derived");
  }
  public static void main(String args[])
  {
    Base obj = new Derived();
    obj.print();         // "Derived" is printed
  }
}
```

To invoke the superclass version of an overridden method from the subclass, use `super.methodName()`. In the above example, the subclass can use the functionality of the superclass `print()` method by calling `super.print()`.

Methods declared as final cannot be overridden by subclasses. Even though constructors can be overloaded, they cannot be overridden because they are not inherited.

Summary

In this section, we discussed the advantages of encapsulation. You saw that inheritance relationships are also known by the term "IS-A" relationships. A "HAS-A" relationship indicates that one class holds a reference to another. You should be able to identify the type of relationship from a given scenario. Be clear about the distinction between overriding and overloading.

Exercise

Question:

Which of the choices below can legally be inserted at the "insert code here" position in the following code?

```
class Parent
{
  public void print(int i)
```

```
    {
    }
  }
  public class Child extends Parent
  {
    public static void main(String argv[])
    {
    }
    // insert code here
  }
```

Choices:

- A. public void print(int i, byte b) throws Exception {}
- B. public void print(int i, long i) throws Exception {}
- C. public void print(long i) {}
- D. public void print(int i) throws Exception {}
- E. public int print(int i)

Correct choices:

- A, B, and C

Explanation:

Option D will not compile because it attempts to throw a checked exception that is not declared in the `Parent` class. Option E will not compile because only the return type is different; the argument list and method name are the same. This is not allowed in both overriding and overloading. Options A, B, and C have different argument lists, so they represent *overloading*, not *overriding*. Because they can throw any exceptions, they are legal.

Section 8. Threads

Creating threads

Threads are objects in the Java language. A thread can be defined by extending the `java.lang.Thread` class or by implementing the java.lang.Runnable interface. The `run()` method should be overridden and should have the code that will be executed by the new thread. This method must be public with a `void` return type and should not take any arguments. See Resources on page 48 for more information on threads.

Extending `thread`

If we need to inherit the behavior of the `Thread` class, we can have a subclass of it. In this case, the disadvantage is that you cannot extend any other class. For instance:

```
class MyThread extends Thread
{
  public void run()
  {
    System.out.println("Inside run()");
  }
}
```

Now the `Thread` object can be instantiated and started. Even though the execution method of your thread is called `run`, you do not call this method directly. Instead, you call the `start()` method of the `thread` class. When the `start()` method is called, the thread moves from the new state to the runnable state. When the Thread Scheduler gives the thread a chance to execute, the `run()` method will be invoked. If the `run()` method is called directly, the code in it is executed by the current thread and not by the new thread. For instance:

```
MyThread mt = new MyThread();
mt.start();
```

Implementing `Runnable`

To implement `Runnable`, you need to define only the `run()` method:

```
class MyRunnable implements Runnable
{
  public void run()
  {
    System.out.println("Inside run()");
  }
}
```

Next, create an instance of the class and construct a thread, passing the instance of the class as an argument to the constructor:

```
MyRunnable mc = new MyRunnable();
Thread t = new Thread(mc);
```

To start the thread, use the `start()` method as shown here:

```
t.start();
```

Thread constructors

The `Thread` constructors available are:

- `Thread()`
- `Thread(String name)`
- `Thread(Runnable runnable)`
- `Thread(Runnable runnable, String name)`
- `Thread(ThreadGroup g, Runnable runnable)`
- `Thread(ThreadGroup g, Runnable runnable, String name)`
- `Thread(ThreadGroup g, String name)`

Thread states

Threads can be in one of the following states:

New. After the thread is instantiated, the thread is in the New state until the `start()` method is invoked. In this state, the thread is not considered alive.

Runnable. A thread comes into the runnable state when the `start()` method is invoked on it. It can also enter the runnable state from the running state or blocked state. The thread is considered alive when it is in this state.

Running. A thread moves from the runnable state into the running state when the thread scheduler chooses it to be the currently running thread.

Alive, but not runnable. A thread can be alive but not in a runnable state for a variety of reasons. It may be waiting, sleeping, or blocked.

Waiting. A thread is put into a waiting state by calling the `wait()` method. A call to `notify()` or `notifyAll()` may bring the thread from the waiting state into the runnable state. The `sleep()` method puts the thread into a sleeping state for a specified amount of time in milliseconds, as follows:

```
try {
  Thread.sleep(3 * 60 * 1000); // thread sleeps for 3 minutes
} catch(InterruptedException ex){}
```

Blocked. A thread may enter a blocked state while waiting for a resource like I/O or the lock of another object. In this case, the thread moves into the runnable state when the resource becomes available.

Dead. A thread is considered dead when its `run()` method is completely executed. A dead thread can never enter any other state, not even if the `start()` method is invoked on it.

Important thread methods

The `sleep()` method causes the current thread to sleep for a given time in milliseconds:

```
public static void sleep(long millis) throws InterruptedException
```

The `yield()` method causes the current thread to move from the running state to the runnable state, so that other threads may get a chance to run. However, the next thread chosen for running might not be a different thread:

```
public static void yield()
```

The `isAlive()` method returns `true` if the thread upon which it is called has been started but not moved to the dead state:

```
public final boolean isAlive()
```

When a thread calls `join()` on another thread, the currently running thread will wait until the thread it joins with has completed:

```
void join()
void join(long millis)
void join(long millis, int nanos)
```

Thread synchronization

Every object in Java code has one lock, which is useful for ensuring that only one thread accesses critical code in the object at a time. This synchronization helps prevent the object's state from getting corrupted. If a thread has obtained the lock, no other thread can enter the synchronized code until the lock is released. When the thread holding the lock exits the synchronized code, the lock is released. Now another thread can get the object's lock and execute the synchronized code. If a thread tries to get the lock of an object when another thread has the lock, the thread goes into a blocked state until the lock is released.

Synchronized

You can use the `synchronized` keyword to declare a method as synchronized. This method cannot be accessed by multiple threads simultaneously. The `synchronized` keyword can also be used to mark a block of code as synchronized. For this, the argument passed should be the object whose lock you want to synchronize on. The syntax is shown below:

```
synchronized(obj)
{
  // here add statements to be synchronized
}
// obj is the object being synchronized
```

wait(), notify(), and notifyAll()

The `wait()`, `notify()`, and `notifyAll()` methods are defined in the `java.lang.Object` class.

When the `wait()` method is invoked, a thread releases the lock on an object and moves from the running state to the waiting state. The `notify()` method is used to signal one of the threads waiting on the object to return to the runnable state. It is not possible to specify which of the waiting threads should be made runnable. The `notifyAll()` method causes all the waiting threads for an object to return to the runnable state.

A thread can invoke `wait()` or `notify()` on a particular object only if it currently holds the lock on that object. `wait()`, `notify()`, and `notifyAll()` should be called only from within the synchronized code.

Summary

We saw how threads are defined in Java code either by implementing the `Runnable` interface or by extending the `Thread` class. For the exam, you should know all the `Thread` constructors. You should also know how a thread moves into and out of the blocked state. To prevent multiple threads from running the same object's method, we can use the `synchronized` keyword.

Exercise

Question:

Which of the following statements is *not* true about threads?

Choices:

- A. If the `start()` method is invoked twice on the same `Thread` object, an exception is thrown at runtime.
- B. The order in which threads were started might differ from the order in which they actually run.
- C. If the `run()` method is directly invoked on a `Thread` object, an exception is thrown at runtime.
- D. If the `sleep()` method is invoked on a thread while executing synchronized code, the lock is not released.

Correct choice:

- C

Explanation:

Statement C is the correct answer; it is not true about threads. If the `run()` method is directly invoked on a `Thread` object, no exception is thrown at runtime. However, the code written in the `run()` method would be executed by the current thread, not by a new thread. So the correct way to start a thread is by invoking the `start()` method, which causes the

`run()` method to be executed by the new thread. However, invoking the `start()` method twice on the same `Thread` object will cause an `IllegalThreadStateException` to be thrown at runtime, so A is true.

B is true because the order in which threads run is decided by the thread scheduler, no matter which thread was started first. D is true because a thread will not relinquish the locks it holds when it goes into the sleeping state.

Section 9. Fundamental classes in the java.lang package

Using the Math class

The `Math` class is `final` and all the methods defined in the `Math` class are `static`, which means you cannot inherit from the `Math` class and override these methods. Also, the `Math` class has a private constructor, so you cannot instantiate it.

The `Math` class has the following methods: `ceil()`, `floor()`, `max()`, `min()`, `random()`, `abs()`, `round()`, `sin()`, `cos()`, `tan()`, and `sqrt()`.

The `ceil()` method returns the smallest double value that is not less than the argument and is equal to a mathematical integer. For instance:

```
Math.ceil(5.4)          // gives 6
Math.ceil(-6.3)         // gives -6
```

The `floor()` method returns the largest double value that is not greater than the argument and is equal to a mathematical integer. For instance:

```
Math.floor(5.4)         // gives 5
Math.floor(-6.3)        // gives -7
```

The `max()` method takes two numeric arguments and returns the greater of the two. It is overloaded for `int`, `long`, `float`, or `double` arguments. For instance:

```
x = Math.max(10,-10); // returns 10
```

The `min` method takes two numeric arguments and returns the smaller of the two. It is overloaded for `int`, `long`, `float`, or `double` arguments. For instance:

```
x = Math.min(10,-10); // returns -10
```

The `random()` method returns a double value with a positive sign, greater than or equal to 0.0 and less than 1.0.

The `abs()` method returns the absolute value of the argument. It is overloaded to take an `int`, `long`, `float`, or `double` argument. For instance:

```
Math.abs(-33)         // returns 33
```

The `round()` method returns the integer closest to the argument (overloaded for `float` and `double` arguments). If the number after the decimal point is less than 0.5, `Math.round()` returns the same result as `Math.floor()`. In all the other cases, `Math.round()` works the same as `Math.ceil()`. For instance:

```
Math.round(-1.5)  // result is -1
```

```
Math.round(1.8)   // result is 2
```

Trigonometric functions

The `sin()`, `cos()`, and `tan()` methods return the sine, cosine, and tangent of an angle, respectively. In all three methods, the argument is the angle in radians. Degrees can be converted to radians by using `Math.toRadians()`. For instance:

```
x = Math.sin(Math.toRadians(90.0)); // returns 1.0
```

The `sqrt()` function returns the square root of an argument of type `double`. For instance:

```
x = Math.sqrt(25.0); // returns 5.0
```

If you pass a negative number to the `sqrt()` function, it returns `NaN` ("Not a Number").

String and StringBuffer

Immutability of `String` objects

As you know, `Strings` are objects in Java code. These objects, however, are *immutable*. That is, their value, once assigned, can never be changed. For instance:

```
String msg = "Hello";
msg += " World";
```

Here the original `String` "Hello" is not changed. Instead, a new `String` is created with the value "Hello World" and assigned to the variable `msg`. It is important to note that though the `String` object is immutable, the reference variable is not.

String literals

In Java code, the `String` literals are kept in a memory pool for efficient use.

If you construct two `Strings` using the same `String` literal without the `new` keyword, then only one `String` object is created. For instance:

```
String s1 = "hello";
String s2 = "hello";
```

Here, both `s1` and `s2` point to the same `String` object in memory. As we said above, `String` objects are immutable. So if we attempt to modify `s1`, a new modified `String` is created. The original `String` referred to by `s2`, however, remains unchanged.

`StringBuffer`

`StringBuffer` objects are *mutable*, which means their contents can be changed. For instance:

```
Stringbuffer s = new StringBuffer("123");
s.append("456"); // Now s contains "123456"
```

You can see how this differs from the `String` object:

```
String s = new String("123");
s.concat("456"); // Here s contains "123"
```

Wrapper classes

Wrapper classes correspond to the primitive data types in the Java language. These classes represent the primitive values as objects. All the wrapper classes except `Character` have two constructors -- one that takes the primitive value and another that takes the `String` representation of the value. For instance:

```
Integer i1 = new Integer(50);
Integer i2 = new Integer("50");
```

The `Character` class constructor takes a `char type` element as an argument:

```
Character c = new Character('A');
```

Wrapper objects are immutable. This means that once a wrapper object has a value assigned to it, that value cannot be changed.

The `valueOf()` method

All wrapper classes (except `Character`) define a static method called `valueOf()`, which returns the wrapper object corresponding to the primitive value represented by the `String` argument. For instance:

```
Float f1 = Float.valueOf("1.5f");
```

The overloaded form of this method takes the representation base (binary, octal, or hexadecimal) of the first argument as the second argument. For instance:

```
Integer I = Integer.valueOf("10011110",2);
```

Converting wrapper objects to primitives

All the numeric wrapper classes have six methods, which can be used to convert a numeric wrapper to any primitive numeric type. These methods are `byteValue`, `doubleValue`, `floatValue`, `intValue`, `longValue`, and `shortValue`. An example is shown below:

```
Integer i = new Integer(20);
byte b = i.byteValue();
```

Parser methods

The six parser methods are `parseInt`, `parseDouble`, `parseFloat`, `parseLong`, `parseByte`, and `parseShort`. They take a `String` as the argument and convert it to the corresponding primitive. They throw a `NumberFormatException` if the `String` is not

properly formed. For instance:

```
double d = Double.parseDouble("4.23");
```

It can also take a radix(base) as the second argument:

```
int i = Integer.parseInt("10011110",2);
```

Base conversion

The `Integer` and `Long` wrapper classes have methods like `toBinaryString()` and `toOctalString()`, which convert numbers in base 10 to other bases. For instance:

```
String s = Integer.toHexString(25);
```

Summary

We discussed the usage and signature of the various utility methods of the `Math` class. You are expected to memorize these for the exam. We also saw how `String` objects are immutable, while `StringBuffer` objects are not. The wrapper classes provide utility methods that allow you to represent primitives as objects. Make sure you are familiar with all the parsing and conversion methods.

Exercise

Question:

What will be the result of an attempt to compile and run the following program?

```
class Test
{
  public static void main(String args[])
  {
    String s1 = "abc";
    String s2 = "abc";
    s1 += "xyz";
    s2.concat("pqr");
    s1.toUpperCase();
    System.out.println(s1 + s2);
  }
}
```

Choices:

- A. "abcxyzabc"
- B. "abcxyzabcpqr"
- C. "ABCXYZabcpqr"
- D. "ABCXYZabc"
- E. Code does not compile

Correct choice:

- A

Explanation:

This code compiles and runs without errors, printing "abcxyzabc." In the given code, `s1` and `s2` initially refer to the same `String` object "abc." When "xyz" is concatenated to `s1`, a new `String` object "abcxyz" is created and `s1` is made to refer to it. Note that `s2` still refers to the original `String` object "abc," which is unchanged. The `concat()` and `toUpperCase()` methods do not have any effect, because the new `String` objects created as a result of these operations do not have any references stored. So `s1` contains "abcxyz" and `s2` contains "abc" at the end, making A the correct result.

Section 10. The Collections framework

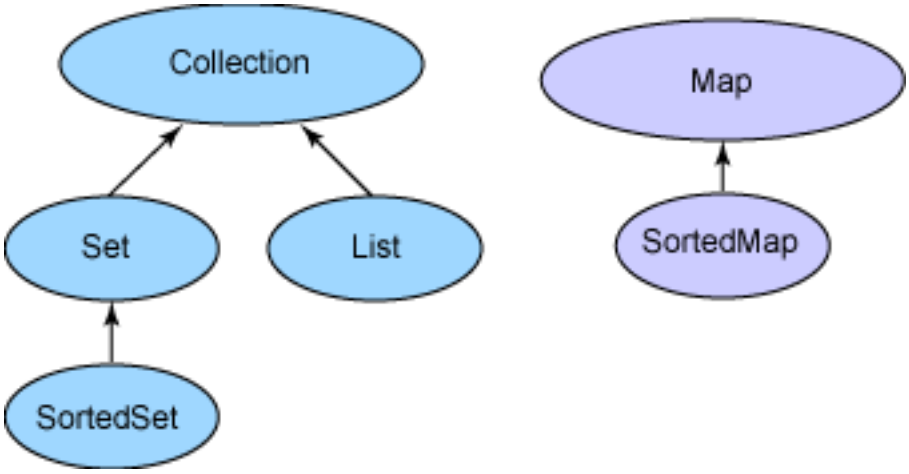
Collections and collections interfaces

`Collections` are objects used to group together and manipulate multiple data elements. They can dynamically grow and shrink, which is their advantage over arrays. `Collections` provide methods to add objects to a collection, remove objects from it, check if an object is present in it, retrieve objects from it, and iterate through it. See Resources on page 48 for more information on the Collections framework.

`Collection` interfaces

The inheritance hierarchy of the core `collection` interface is shown here:

Figure 2. Inheritance hierarchy of the core collection interface



`Collection` is the root interface, from which the `Set` and `List` interfaces extend. The `Map` interface does not extend the `Collection` interface. Also, do not confuse the `Collection` *interface* with the `Collections` *class*, which holds static utility methods for collections.

Let's analyze the basic behavior of these interfaces. The `List` interface represents ordered collections while `Set` cannot contain duplicate elements. The `Map` interface matches unique keys to values. `SortedSet` holds elements in sorted order while `SortedMap` orders the mapping in the sorted order of keys. The classes that implement these interfaces are listed below:

Set	HashSet	TreeSet	LinkedHashSet	
List	Vector	ArrayList	LinkedList	
Map	HashMap	HashTable	TreeMap	LinkedHashMa

`Set` classes

The classes implementing the `Set` interface do not allow duplicate elements.

A `HashSet` is not ordered or sorted. This class offers constant time performance for basic operations like `add` and `remove`. `TreeSet` arranges the elements in ascending element

order, sorted according to the natural order of the elements.

A `LinkedHashSet` is an ordered `HashSet`, which gives the elements in the order of insertion or last access. For instance:

```
LinkedHashSet linkSet = new LinkedHashSet();
linkSet.add("mango");
linkSet.add("apple");
linkSet.add("mango");
linkSet.add("banana");
Iterator i = linkSet.iterator();
while(i.hasNext())
  System.out.print(i.next());   // Prints "mango apple banana"
```

`List` classes

A `List` is an ordered collection, which allows positional access and search.

The classes implementing `List` are ordered by index position. An `ArrayList` enables fast iteration and constant speed positional access. A `Vector` is similar to `ArrayList`, only slower because it is synchronized. `LinkedList` allows fast insertion and deletion at the beginning or end. It is commonly used for implementing stacks and queues. For instance:

```
ArrayList list = new ArrayList();
list.add("mango");
list.add("apple");
list.add("mango");
list.add("banana");
Iterator i = list.iterator();
while(i.hasNext())
  System.out.print(i.next());     // Prints "mango apple mango banana"
```

`Map` classes

The classes implementing the `Map` interface map unique keys to specific values.

The `HashMap` class is not sorted or ordered. It allows one null key and many null values.

`Hashtable` is similar to `HashMap`, but does not allow null keys and values. It's also slower than `HashMap` because it is synchronized. The J2SE 1.4 `LinkedHashMap` class iterates by insertion or last accessed order. It allows one null key and many null values.

`TreeMap` is a map in ascending key order, sorted according to the natural order for the key's class.

The `equals()` method of `java.lang.Object`

The `equals()` method, shown below, should implement an equivalence relation:

```
public boolean equals(Object obj)
```

In addition, the `equals()` method is:

- Reflexive: For any reference value `x`, `x.equals(x)` should return `true`.

- Symmetric: For any reference values `x` and `y`, `x.equals(y)` should return `true` *only if* `y.equals(x)` returns `true`.
- Transitive: For any reference values `x`, `y`, and `z`, if `x.equals(y)` returns `true` and `y.equals(z)` returns `true`, then `x.equals(z)` should return `true`.
- Consistent: For any reference values `x` and `y`, multiple invocations of `x.equals(y)` consistently return `true` or consistently return `false`, provided no information used in equal comparisons on the object is modified.

For any non-null reference value `x`, `x.equals(null)` should return `false`.

The `hashCode()` method of `java.lang.Object`

The `hashCode()` method, shown below, of the `java.lang.Object` class returns the hash code value for the object. The hash code value of an object gives an integer that can be used by some collection classes like `HashSet` and `Hashtable` to map its objects into buckets in memory. The process of hashing enables efficient storage and retrieval of objects from the collection.

```
public int hashCode()
```

If two objects are equal as given by the `equals()` method, then their hash codes must be the same. So whenever `equals()` is overridden, `hashCode()` also should be implemented.

However, the reverse is not required. Two objects that are not equal can have the same hash code. This is because it is not always possible to ensure unique hash codes. However, it is better to have distinct hash codes for distinct objects to improve efficiency and performance.

The object comparison logic used by the `equals()` method usually involves instance variables of the two objects. The same instance variables should also be used by the `hashCode()` implementation. For instance:

```
public class Test
{
  int i;
  public boolean equals(Object o)
  {
    Test t = (Test)o;
    if (t.i == this.i)
      return true;
      return false;
  }
  public int hashCode()
  {
    return i * 31;
  }
}
```

Whenever it is invoked on the same object more than once during an execution of a Java application, the `hashCode()` method must consistently return the same integer, provided no information used in equal comparison on the object is modified. It is inappropriate to involve a random number when computing the hash code, because it would not return the same hash code for multiple invocations of the method. The hash code of a null element is defined

as zero.

When you implement the `equals()` and `hashCode()` methods, it is not appropriate to use transient variables.

Summary

We learned about the different types of collections like `Lists`, `Sets`, and `Maps`. It is important to understand the behavior of each of them and the situation in which they are preferred or required. We also saw the significance of the `equals()` and `hashCode()` methods. You should know the appropriate ways to implement these methods.

Exercise

Question:

Which is the most suitable Java collection class for storing various companies and their stock prices? It is required that the class should support synchronization inherently.

Choices:

- A. Hashtable
- B. HashMap
- C. LinkedHashMap
- D. HashSet
- E. TreeMap

Correct choice:

- A

Explanation:

To store the company names and their corresponding stock prices, a `Map` implementation would be appropriate because it stores key-value pairs. `HashSet` is not the correct answer because it does not implement the `Map` interface. `Hashtable`, `HashMap`, `TreeMap`, and `LinkedHashMap` are the classes that implement the `Map` interface. Among these, only the `Hashtable` class is inherently synchronized.

Section 11. Summary and resources

Summary

This wraps up the SCJP 1.4 tutorial. It would be advisable to test each new concept you learned with the help of small practice examples. This will help foster your understanding of the material presented in this tutorial.

The most difficult questions in the exam center around threads and garbage collection. Pay extra attention to these chapters. Remember that the garbage collector and thread scheduler implementations are platform specific.

It is not enough if you just memorize the syntax and APIs that are part of the exam. It is very important to acquire a deep understanding of the core concepts covered in the exam objectives.

Regardless of your reasons for going after certification -- whether you want the professional advantage or the personal challenge (or whether getting certified is a job requirement) -- your approach to the task will determine the success of its outcome. Good preparation, attention to details, and a positive attitude are essential if you want to pass the SCJP exam.

I hope this tutorial is helpful in preparing you for your exam, and I wish you the best of luck.

I would like to acknowledge Seema Manivannan for her invaluable contribution in writing this tutorial.

Resources

- Khalid Mughal and Rolf Rasmussen's *A Programmer's Guide to Java Certification* (Addison-Wesley, 1999) is a great reference if you're seeking a structured learning format.
- Kathy Sierra and Bert Bates's *Sun Certified Programmer & Developer for Java 2 Study Guide (Exam 310-035 & 310-027)* is another useful study guide.
- William Brogden's *Java 2 Exam Prep, Second Edition (Exam: 310-025)* and *Java 2 Exam Cram, Second Edition (Exam 310-025)* are both excellent books. Previously published by The Coriolis Group, the series is being relaunched by Que Publishing. *Exam Cram* is a quick review, whereas the older *Exam Prep* is a fairly comprehensive introduction to Java language fundamentals.
- *William Brogden's home page* contains a nice selection of Java certification information and resources.
- Check out "*An SCJP 1.4 certification primer*" (*developerWorks*, June 2003) by Pradeep Chopra, the author of this tutorial.
- The "*Java Collections Framework*" tutorial (*developerWorks*, April 2001) is helpful if you need to brush up on the Java Collections API.

- The *Programming With Assertions* study guide, also from Sun, is recommended reading before you take the new SCJP 1.4 exam.

- In his monthly *developerWorks* column, *Magic with Merlin*, John Zukowski covers new features of JDK 1.4, including one installment titled "*Working with assertions*" (*developerWorks*, February 2002).

- For more on garbage collection, see the following articles from *developerWorks*:
  - In "*Mash that trash*", you'll learn more about how incremental compaction reduces pause times.
  - The three-part series "*Sensible sanitation*" describes the garbage collection strategy employed by the IBM 1.2 and 1.3 Developer Kits for the Java Platform.
  - In his October 2003 installment of *Java theory and practice*, Brian Goetz provides "*A brief history of garbage collection*."
  - In "*Fine-tuning Java garbage collection performance* ," learn how to detect and troubleshoot garbage collection issues.

- If you're interested in learning more about threading in the Java language, "*Introduction to Java threads*" by Brian Goetz (*developerWorks*, September 2002) explores threading basics, exchanging data between threads, controlling threads, and how threads can communicate with each other.

- Marcus Green is a well-regarded Java certification guru. His *Java certification site* is home to an SCJP tutorial, free mock examinations, a certification discussion forum, and information about his Java certification training courses.

- The *IBM Education Web site* is a good place to start if you're looking for personalized Java programming training.

- Whizlabs Software specializes in IT certification simulators, including the *Whizlabs Java Certification (SCJP 1.4) Exam Simulator* for J2SE 1.4.

- Whizlabs Software also offers *instructor-led, online training for Java Certification (SCJP 1.4)*, delivered live by the author of the SCJP 1.4 exam simulator, as well as *Java certification discussion forums*.

- *JavaRanch* ("a friendly place for Java greenhorns") hosts a community discussion forum and the SCJP rules roundup, along with a free certification mock exam.

- The *IBM professional certifications* site lists the available certification programs, categorized by brand.

- Sun Microsystems's *J2SE 1.2 and J2SE 1.4 API specs* are essential reading for the SCJP exam.

- You can learn quite a lot about the `hashCode()` and `equals()` methods by reading Chapter 3 of *Effective Java*, available online courtesy of Sun Microsystems.

- See the *developerWorks Java technology tutorials index* for a complete listing of free tutorials.

- You can also find hundreds of articles about every aspect of Java programming in the *developerWorks Java technology zone*.

Feedback

Please let us know whether this tutorial was helpful to you and how we could make it better. We'd also like to hear about other tutorial topics you'd like to see covered.

For questions about the content of this tutorial, contact the author, Pradeep Chopra, at *pradeep@whizlabs.com*.

Colophon

This tutorial was written entirely in XML, using the developerWorks Toot-O-Matic tutorial generator. The open source Toot-O-Matic tool is an XSLT stylesheet and several XSLT extension functions that convert an XML file into a number of HTML pages, a zip file, JPEG heading graphics, and two PDF files. Our ability to generate multiple text and binary formats from a single source file illustrates the power and flexibility of XML. (It also saves our production team a great deal of time and effort.)

You can get the source code for the Toot-O-Matic at www6.software.ibm.com/dl/devworks/dw-tootomatic-p. The tutorial Building tutorials with the Toot-O-Matic demonstrates how to use the Toot-O-Matic to create your own tutorials. developerWorks also hosts a forum devoted to the Toot-O-Matic; it's available at www-105.ibm.com/developerworks/xml_df.nsf/AllViewTemplate?OpenForm&RestrictToCategory=11. We'd love to know what you think about the tool.