Packages:

- A Package can be defined as a grouping of related types(classes, interfaces)
- A package represents a directory that contains related group of classes and interfaces.
- Packages are used in Java in order to prevent naming conflicts.
- There are two types of packages in Java.
    1. Pre-defined Packages(built-in)
    2. User defined packages

Pre-defined Packages:

Package Name	Description
java.lang	Contains language support classes (for e.g classes which defines primitive data types, math operations, etc.). This package is automatically imported.
java.io	Contains classes for supporting input / output operations.
java.util	Contains utility classes which implement data structures like Linked List, Hash Table, Dictionary, etc and support for Date / Time operations. This package is also called as **Collections.**
java.applet	Contains classes for creating Applets.
java.awt	Contains classes for implementing the components of graphical user interface (like buttons, menus, etc.).
java.net	Contains classes for supporting networking operations.
javax.swing	This package helps to develop GUI Applications. The 'x' in javax represents that it is an extended package which means it is a package developed from another package by adding new features to it. In fact, javax.swing is an extended package of java.awt.
java.sql	This package helps to connect to databases like Oracle/Sybase/Microsoft Access to perform different operations.

Defining a Package(User defined):

To create a package is quite easy: simply include a **package** command as the first statement in a Java source file. Any classes declared within that file will belong to the specified package. The **package** statement defines a name space in which classes are stored. If you omit the **package** statement, the class names are put into the default package, which has no name.

This is the general form of the **package** statement:

package *pkg*;

Here, *pkg* is the name of the package.

For example, the following statement creates a package called **MyPackage**:

package MyPackage;

Java uses file system directories to store packages. For example, the **.class** files for any classes you declare to be part of **MyPackage** must be stored in a directory called **MyPackage**. Remember that case is significant, and the directory name must match the package name exactly. More than one file can include the same **package** statement.

Most real-world packages are spread across many files. You can create a hierarchy of packages. To do so, simply separate each package name from the one above it by use of a period. The general form of a multileveled package statement is shown here:

package *pkg1*[.*pkg2*[.*pkg3*]];

A package hierarchy must be reflected in the file system of your Java development system. For example, a package declared as

package java.awt.image;

Example: Package demonstration

```
package pack;
public class Addition
{
        int x,y;
        public Addition(int a, int b)
        {
                x=a;
                y=b;
        }
        public void sum()
        {
                System.out.println("Sum :"+(x+y));
        }
}
```

Step 1: Save the above file with Addition.java

```
package pack;
public class Subtraction
{
```

```
        int x,y;
        public Subtraction(int a, int b)
        {
                x=a;
                y=b;
        }
        public void diff()
        {
                System.out.println("Difference :"+(x-y));
        }
}
```

Step 2: Save the above file with Subtraction.java

Step 3: Compilation

To compile the java files use the following commands

javac -d directory_path name_of_the_java file

Javac –d . name_of_the_java file

Note: -d is a switching options creates a new directory with package name. Directory path represents in which location you want to create package and . (dot) represents current working directory.

```
D:\Materials\JAVA Material\Unit 2\PackExamples>javac -d . Addition.java

D:\Materials\JAVA Material\Unit 2\PackExamples>javac -d . Subtraction.java
```

Step 4: Access package from another package

There are three ways to use package in another package:

1. **With fully qualified name.**

```
class UseofPack
{
        public static void main(String arg[])
        {
                pack.Addition a=new  pack.Addition(10,15);
                a.sum();
                pack.Subtraction s=new pack.Subtraction(20,15);
                s.difference();
        }
}
```

2. **import package.classname;**

```
import pack.Addition;
import pack.Subtraction;
class UseofPack
{
        public static void main(String arg[])
        {
                 Addition a=new  Addition(10,15);
                a.sum();
                Subtraction s=new Subtraction(20,15);
                s.difference();
        }
}
```

3. **import package.*;**

```
import pack.*;
class UseofPack
{
        public static void main(String arg[])
        {
                 Addition a=new  Addition(10,15);
                a.sum();
                Subtraction s=new Subtraction(20,15);
                s.difference();
        }
}
```

Note: Don't place Addition.java, Subtraction.java files parallel to the pack directory. If you place JVM searches for the class files in the current working directory not in the pack directory.

Access Protection

- Access protection defines actually how much an element (class, method, variable) is exposed to other classes and packages.
- There are four types of access specifiers available in java:
    1. Visible to the class only (private).
    2. Visible to the package (default). No modifiers are needed.
    3. Visible to the package and all subclasses (protected)
    4. Visible to the world (public)

	Private	No Modifier	Protected	Public
Same class	Yes	Yes	Yes	Yes
Same package subclass	No	Yes	Yes	Yes
Same package non-subclass	No	Yes	Yes	Yes
Different package subclass	No	No	Yes	Yes
Different package non-subclass	No	No	No	Yes

Example:

The following example shows all combinations of the access control modifiers. This example has two packages and five classes. The source for the first package defines three classes: **Protection**, **Derived**, and **SamePackage**.

Name of the package: pkg1

This file is Protection.java

```
package pkg1;

public class Protection
{
        int n = 1;
        private int n_priv = 2;
        protected int n_prot = 3;
        public int n_publ = 4;

        public Protection()
        {
                System.out.println("base constructor");
                System.out.println("n = " + n);
                System.out.println("n_priv = " + n_priv);
                System.out.println("n_prot = " + n_prot);
                System.out.println("n_publ = " + n_publ);
        }
}
```

This is file Derived.java:

```
package pkg1;

class Derived extends Protection
{
   Derived()
   {
     System.out.println("Same package - derived (from base) constructor");
     System.out.println("n = " + n);
```

```
        /* class only
        *  System.out.println("n_priv = "4 + n_priv); */

        System.out.println("n_prot = " + n_prot);
        System.out.println("n_publ = " +n_publ);
    }
}
```

This is file SamePackage.java

```
package pkg1;

class SamePackage
{
    SamePackage()
    {
      Protection pro = new Protection();
      System.out.println("same package - other constructor");
      System.out.println("n = " + pro.n);

      /* class only
      *  System.out.println("n_priv = " + pro.n_priv); */

      System.out.println("n_prot = " + pro.n_prot);
      System.out.println("n_publ = " + pro.n_publ);
    }
}
```

Name of the package: pkg2

This is file Protection2.java:

```
package pkg2;

class Protection2 extends pkg1.Protection
{
        Protection2()
        {
            System.out.println("Other package-Derived (from Package 1-Base)
          Constructor");

          /* class or package only
          *  System.out.println("n = " + n); */
```

```
            /* class only
            *  System.out.println("n_priv = " + n_priv); */

            System.out.println("n_prot = " + n_prot);
            System.out.println("n_publ = " + n_publ);
          }
}
```

This is file **OtherPackage.java**

```
package pkg2;

class OtherPackage
{
   OtherPackage()
   {
     pkg1.Protection pro = new pkg1.Protection();

     System.out.println("other package - Non sub class constructor");

     /* class or package only
     *  System.out.println("n = " + pro.n); */

     /* class only
     *  System.out.println("n_priv = " + pro.n_priv); */

     /* class, subclass or package only
     *  System.out.println("n_prot = " + pro.n_prot); */

     System.out.println("n_publ = " + pro.n_publ);
   }
}
```

If you want to try these t two packages, here are two test files you can use. The one for package **pkg1** is shown here:

```
/* demo package pkg1 */

package pkg1;

/* instantiate the various classes in pkg1 */
public class Demo
{
   public static void main(String args[])
   {
     Derived obj2 = new Derived();
```

```
      SamePackage obj3 = new SamePackage();
    }
}
```

The test file for package pkg2 is

```
package pkg2;

/* instantiate the various classes in pkg2 */
public class Demo2
{
    public static void main(String args[])
    {
      Protection2 obj1 = new Protection2();
      OtherPackage obj2 = new OtherPackage();
    }
}
```

```
D:\Materials\JAVA Material\Unit 2\Packages\AccessSpecifier>javac -d . Demo.java

D:\Materials\JAVA Material\Unit 2\Packages\AccessSpecifier>javac -d . Demo2.java

D:\Materials\JAVA Material\Unit 2\Packages\AccessSpecifier>java pkg1.Demo
base constructor
n = 1
n_priv = 2
n_prot = 3
n_publ = 4
Same package - derived (from base) constructor
n = 1
n_prot = 3
n_publ = 4
base constructor
n = 1
n_priv = 2
n_prot = 3
n_publ = 4
same package - other constructor
n = 1
n_prot = 3
n_publ = 4
```

```
D:\Materials\JAVA Material\Unit 2\Packages\AccessSpecifier>java pkg2.Demo2
base constructor
n = 1
n_priv = 2
n_prot = 3
n_publ = 4
Other package - Derived (from Package 1-Base)Constructor
n_prot = 3
n_publ = 4
base constructor
n = 1
n_priv = 2
n_prot = 3
n_publ = 4
other package - Non sub class constructor
n_publ = 4
```

Exception

An exception (or exceptional event) is a problem that arises during the execution of a program. When an **Exception** occurs the normal flow of the program is disrupted and the program/Application terminates abnormally, which is not recommended, therefore, these exceptions are to be handled.

An exception can occur for many different reasons. Following are some scenarios where an exception occurs.

- A user has entered an invalid data.
- A file that needs to be opened cannot be found.
- A network connection has been lost in the middle of communications or the JVM has run out of memory.

Some of these exceptions are caused by user error, others by programmer error, and others by physical resources that have failed in some manner.

A Java exception is an object that describes an exceptional (that is, error) condition that has occurred in a piece of code. When an exceptional condition arises, an object representing that exception is created and thrown in the method that caused the error. That method may choose to handle the exception itself, or pass it on. Either way, at some point, the exception is caught and processed.

Exceptions can be generated by the Java run-time system, or they can be manually generated by your code. Java exception handling is managed via five keywords: **try, catch, throw, throws, and finally**. Briefly, here is how they work. Program statements that you want to monitor for exceptions are contained within a try block. If an exception occurs within the try block, it is thrown. Your code can catch this exception (using catch) and handle it in some rational manner. System-generated exceptions are automatically thrown by the Java runtime system. To manually throw an exception, use the keyword throw. Any exception that is thrown out of a method must be specified as such by a throws clause. Any code that absolutely must be executed after a try block completes is put in a finally block.

This is the general form of an exception-handling block:

```
try {
 // block of code to monitor for errors
}
catch (ExceptionType1 exOb) {
 // exception handler for ExceptionType1
}
catch (ExceptionType2 exOb) {
 // exception handler for ExceptionType2
}
// ...
finally {
 // block of code to be executed after try block ends
```

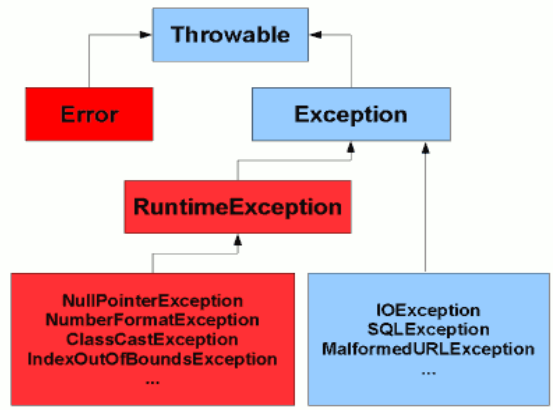
}

Here, *ExceptionType* is the type of exception that has occurred. The remainder of this chapter describes how to apply this framework.

Exception Types

All exception types are subclasses of the built-in class **Throwable**. Thus, **Throwable** is at the top of the exception class hierarchy. Immediately below **Throwable** are two subclasses that partition exceptions into two distinct branches. One branch is headed by **Exception**. This class is used for exceptional conditions that user programs should catch. This is also the class that you will subclass to create your own custom exception types. There is an important subclass of **Exception**, called **RuntimeException**. Exceptions of this type are automatically defined for the programs that you write and include things such as division by zero and invalid array indexing.

The other branch is topped by **Error**, which defines exceptions that are not expected to be caught under normal circumstances by your program. Exceptions of type **Error** are used by the Java run-time system to indicate errors having to do with the run-time environment, itself. Stack overflow is an example of such an error.



Uncaught Exception:

This small program includes an expression that intentionally causes a divide-by-zero error:

```
class Exc0 {
    public static void main(String args[]) {
        int d = 0;
        int a = 42 / d;
    }
}
```

When the Java run-time system detects the attempt to divide by zero, it constructs a new exception object and then *throws* this exception. This causes the execution of **Exc0** to stop, because once an exception has been thrown, it must be *caught* by an exception handler and dealt with immediately. In this example, we haven't supplied any exception handlers of our own, so the exception is caught by the default handler provided by the Java run-time system. Any exception that is not caught by your program will ultimately be processed by the default handler. The default handler displays a string describing the exception, prints a stack trace from the point at which the exception occurred, and terminates the program.

Here is the exception generated when this example is executed:

java.lang.ArithmeticException: / by zero
at Exc0.main(Exc0.java:4)

Using try and catch:

To guard against and handle a run-time error, simply enclose the code that you want to monitor inside a **try** block. Immediately following the **try** block, include a **catch** clause that specifies the exception type that you wish to catch.

Example:

```
class UsingTry_Catch
{
	public static void main(String args[])
	{
		int d, a;
		try { // monitor a block of code.
			d = 0;
			a = 42 / d;
			System.out.println("This will not be printed.");
		}
		catch (ArithmeticException e) { // catch divide-by-zero error
			System.out.println("Division by zero.");
		}
		System.out.println("After catch statement.");
	}
}
```

Output:

```
D:\Materials\JAVA Material\Unit 3\Exceptions>java UsingTry_Catch
Division by zero.
After catch statement.
```

Multiple catch Clauses:

- In some cases, more than one exception could be raised by a single piece of code.
- To handle this type of situation, you can specify two or more catch clauses, each catching a different type of exception.
- When an exception is thrown, each catch statement is inspected in order, and the first one whose type matches that of the exception is executed.
- If one catch statement is executed, the others are bypassed, and execution continues after the try / catch block.
- When you use multiple catch statements, it is important to remember that exception subclasses must come before any of their super classes. This is because a catch

statement that uses a super class will catch exceptions of that type plus any of its subclasses. Subclass would never be reached if it came after its super class.

- A subclass must come before its super class in a series of catch statements. If not unreachable code will be created and a compile time error will result.

Example:

```
// Demonstrate multiple catch statements.
class MultipleCatches
{
        public static void main(String args[])
        {
                try {
                        int a = args.length;
                        System.out.println("a = " + a);
                        int b = 42 / a;
                        int c[] = { 1 };
                        c[42] = 99;
                }

                catch(ArithmeticException e)
                {
                        System.out.println("Divide by 0: " + e);
                }
                catch(Exception e)
                {
                        System.out.println("Array index out of bounds: " +
e);
                }
                System.out.println("After try/catch blocks.");
        }
}
```

Nested try Statements

- The try block within a try block is known as nested try block in java.

Syntax:

```
try{
        try  {
        statement 1;
        statement 2;
        try
         {
```

```
                    statement 1;
                    statement 2;
                  }
                catch(Exception e)    {    }
            }

        }
        catch(Exception e){}
```

- Each time a try statement is entered, the context of that exception is pushed on the stack. If an inner try statement does not have a catch handler for a particular exception, the stack is unwound and the next try statement's catch handlers are inspected for a match.
- This continues until one of the catch statements succeeds, or until all of the nested try statements are exhausted. If no catch statement matches, then the Java run-time system will handle the exception (default handler).

Example:

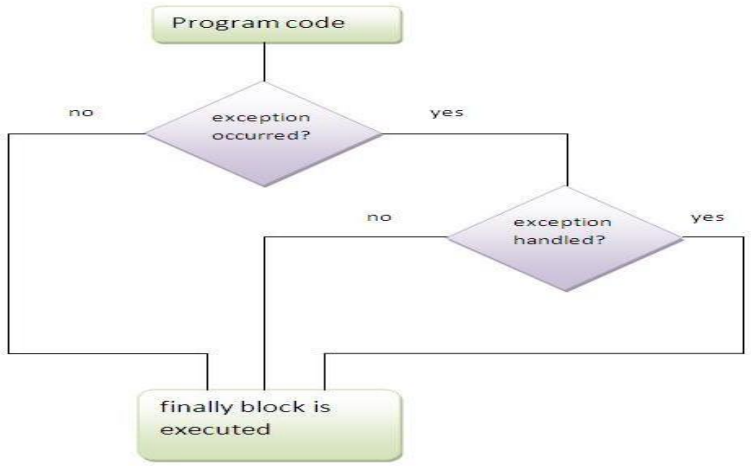
```
class NestTry
{
    public static void main(String args[])
    {
            try
            {
                    int a = args.length;
                    /* If no command-line args are present, the following statement
    will
                    generate a divide-by-zero exception. */

                    int b = 42 / a;
                    System.out.println("a = " + a);

                    try { // nested try block
                            /* If one command-line arg is used, then a divide-by-zero
                           exception        will be generated by the following code. */

                            if(a==1)
                                    a = a/(a-a); // division by zero

                        /* If two command-line args are used, then generate an out-of-
                       bounds  exception. */
                            if(a==2)
                            {
                                    int c[] = { 1 };
                                    c[42] = 99; // generate an out-of-bounds exception
                            }
```

```
                }
                catch(ArrayIndexOutOfBoundsException e)
                {
                        System.out.println("Array index out-of-bounds: " + e);
                }
        }
        catch(ArithmeticException e)
        {
                System.out.println("Divide by 0: " + e);
        }
    }
}
```

```
D:\Materials\JAVA Material\Unit 3\Exceptions>java NestTry 2 3
a = 2
Array index out-of-bounds: java.lang.ArrayIndexOutOfBoundsException: 42
```

finally block:

- Java finally block is a block that is used *to execute important code* such as closing connections (databases, network, disks, commit in databases) etc.
- Java finally block is always executed whether exception is handled or not.
- Java finally block follows try or catch block.



Example 1:

```
class Finally_Case1   //exception not occured
{
        public static void main(String args[])
        {
            try{
                    int data=25/25;
                    System.out.println(data);
```

```
                    }
                     finally
                    {
                            System.out.println("finally block is always
executed");
                    }
                    System.out.println("rest of the code...");
                }
            }
```

Example 2:

```
class Finally_Case2   //exception occured and not handled.
{
    public static void main(String args[])
    {
        try{
            int data=25/0;
            System.out.println(data);
        }
        catch(ArrayIndexOutOfBoundsException e)
        {
            System.out.println(e);
        }
        finally
        {
            System.out.println("finally block is always
executed");
        }
        System.out.println("rest of the code...");
    }
}
```

Example 3:

```
class Finally_Case3   //exception occured and handled.
{
    public static void main(String args[])
    {
        try{
            int data=25/0;
            System.out.println(data);
        }
        catch(ArithmeticException e)
        {
            System.out.println(e);
        }
```

```
                finally
                {
                        System.out.println("finally block is always executed");
                }
                System.out.println("rest of the code...");
            }
        }
```

Use of throw

- So far, you have only been catching exceptions that are thrown by the Java run-time system. However, it is possible for your program to throw an exception explicitly, using the throw statement.
- The general form of throw is shown here:

  throw *ThrowableInstance*;
- Here, *ThrowableInstance* must be an object of type Throwable or a subclass of Throwable.

- There are two ways to obtain a Throwable instance:
  - creating one with the new operator
    throw new exception_class("error message");
  - using the parameter in catch clause - **throw** exception;
- The flow of execution stops immediately after the **throw** statement; any subsequent statements are not executed. The nearest enclosing **try** block is inspected to see if it has a **catch** statement that matches the type of exception. If it does find a match, control is transferred to that statement. If not, then the next enclosing **try** statement is inspected, and so on. If no matching **catch** is found, then the default exception handler halts the program and prints the stack trace.

Example:

/*

In this example, we have created the validate method that takes integer value as a parameter. If the age is less than 18, we are throwing the ArithmeticException otherwise print a message welcome to vote.*/

```
public class UseofThrow
{
    static void validate(int age)
    {
        try{
            if(age<18)
               throw new ArithmeticException("not valid\n");
            else
                System.out.println("Welcome to participate in voting");
        }
        catch(ArithmeticException e)
        {
            System.out.println(e);
            throw e;
        }
     }
    public static void main(String args[])
    {
        validate(13);
        System.out.println("rest of the code...");
    }
}
```

Use of throws: If you are not in a position to handle the exception use throws clause to intimate to the caller.

Syntax:

```
type method-name(parameter-list) throws exception-list
        {
            // body of method
        }
```

Exceptions and its types:

There are two types of exceptions.

1. Unchecked exceptions
2. Checked exceptions

Unchecked Exceptions: Found during running of a program

ArithmeticException	Arithmetic error, such as divide-by-zero.
ArrayIndexOutOfBoundsEx	Array index is out-of-bounds.

ception	
ArrayStoreException	Assignment to an array element of an incompatible type.
ClassCastException	Invalid cast.
IllegalArgumentException	Illegal argument used to invoke a method.
IllegalThreadStateException	Requested operation not compatible with current thread state.
NegativeArraySizeException	Array created with a negative size.
NullPointerException	Invalid use of a null reference.
SecurityException	Attempt to violate security.
StringIndexOutOfBounds	Attempt to index outside the bounds of a string.

Checked Exceptions: Found at compilation time

ClassNotFoundException	Class not found.
IllegalAccessException	Access to a class is denied.
InterruptedException	One thread has been interrupted by another thread.
NoSuchFieldException	A requested field does not exist.
NoSuchMethodException	A requested method does not exist.

Creating user-defined exception:

- We can also create our own exception by creating a sub class simply by extending java Exception class.
- Define a constructor for Exception sub class (not compulsory) and override the toString() method to display customized message in catch clause.
  - Exception();
  - Exception(parameter);
- The first form creates an exception that has no description. The second form lets you specify a description of the exception.

Syntax of toString():

- String toString( )

- Returns a String object containing a description of the exception.

- This method is called by println( ) when outputting a Throwable object.

- belongs to Object class

Example:

```
class MyException extends Exception
{
        String s ;
        MyException( String s)
        {
                this.s=s;
        }
        public String toString()
        {
            return ("User Defined " +s) ;
        }
}
class UserDefinedException
{
        public static void main(String args[])
        {
          try{
                        throw new MyException("Exeption"); // throw is used to
                create //a new exception and throw it.
          }
          catch(MyException e)
          {
                    System.out.println(e) ;
          }
```

```
        }
    }
```