Packages: Putting Classes Together

Introduction

- The main feature of OOP is its ability to support the reuse of code:
  - Extending the classes (via inheritance)
  - Extending interfaces
- The features in basic form limited to reusing the classes within a program.
- What if we need to use classes from other programs without physically copying them into the program under development ?
- In Java, this is achieved by using what is known as "packages", a concept similar to "class libraries" in other languages.

Packages

- Packages are Java's way of grouping a number of related classes and/or interfaces together into a single unit. That means, packages act as "containers" for classes.
- The benefits of organising classes into packages are:
  - The classes contained in the packages of other programs/applications can be reused.
  - In packages classes can be unique compared with classes in other packages. That two classes in two different packages can have the same name. If there is a naming clash, then classes can be accessed with their fully qualified name.
  - Classes in packages can be hidden if we don't want other packages to access them.
  - Packages also provide a way for separating "design" from coding.
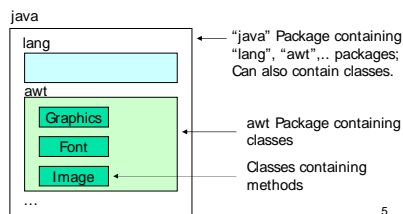
Java Foundation Packages

- Java provides a large number of classes groped into different packages based on their functionality.
- The six foundation Java packages are:
  - java.lang
    - Contains classes for primitive types, strings, math functions, threads, and exception
  - java.util
    - Contains classes such as vectors, hash tables, date etc.
  - java.io
    - Stream classes for I/O
  - java.awt
    - Classes for implementing GUI – windows, buttons, menus etc.
  - java.net
    - Classes for networking
  - java.applet
    - Classes for creating and implementing applets

Using System Packages

- The packages are organised in a hierarchical structure. For example, a package named "java" contains the package "awt", which in turn contains various classes required for implementing GUI (graphical user interface).

"java" Package containing "lang", "awt",.. packages; Can also contain classes.

awt Package containing classes

Classes containing methods

Accessing Classes from Packages

- There are two ways of accessing the classes stored in packages:
  - Using fully qualified class name
    - java.lang.Math.sqrt(x);
  - Import package and use class name directly.
    - import java.lang.Math
    - Math.sqrt(x);
- Selected or all classes in packages can be imported:

```
import package.class;
import package.*;
```

- Implicit in all programs: import java.lang.* ;
- package statement(s) must appear first

Creating Packages

- Java supports a keyword called "package" for creating user-defined packages. The package statement must be the first statement in a Java source file (except comments and white spaces) followed by one or more classes.

```
package myPackage;
public class ClassA {
        // class body
}
class ClassB {
    // class body
}
```

- Package name is "myPackage" and classes are considred as part of this package; The code is saved in a file called "ClassA.java" and located in a directory called "myPackage".

Creating Sub Packages

- Classes in one ore more source files can be part of the same packages.
- As packages in Java are organised hierarchically, sub-packages can be created as follows:
  - package myPackage.Math
  - package myPackage.secondPakage.thirdPackage
- Store "thirdPackage" in a subdirectory named "myPackage\secondPackage". Store "secondPackage" and "Math" class in a subdirectory "myPackage".

Accessing a Package

- As indicated earlier, classes in packages can be accessed using a fully qualified name or using a short-cut as long as we import a corresponding package.
- The general form of importing package is:
  - import package1[.package2][...].classname
  - Example:
    - import myPackage.ClassA;
    - import myPackage.secondPackage
  - All classes/packages from higher-level package can be imported as follows:
    - import myPackage.*;

Using a Package

- Let us store the code listing below in a file named "ClassA.java" within subdirectory named "myPackage" within the current directory (say "abc").

```
package myPackage;
public class ClassA {
// class body
public void display()
{
        System.out.println("Hello, I am ClassA");
    }
}
class ClassB {
    // class body
}
```

Using a Package

- Within the current directory ("abc") store the following code in a file named "ClassX.java"

```
import myPackage.ClassA;

public class ClassX
{
        public static void main(String args[])
        {
            ClassA objA = new ClassA();
            objA.display();
        }
}
```

Compiling and Running

- When ClassX.java is compiled, the compiler compiles it and places .class file in current directly. If .class of ClassA in subdirectory "myPackage" is not found, it comples ClassA also.
- Note: It does not include code of ClassA into ClassX
- When the program ClassX is run, java loader looks for ClassA.class file in a package called "myPackage" and loads it.

Using a Package

- Let us store the code listing below in a file named "ClassA.java" within subdirectory named "secondPackage" within the current directory (say "abc").

```
package secondPackage;
public class ClassC {
  // class body
      public void display()
      {
            System.out.println("Hello, I am ClassC");
      }
}
```

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Using a Package

- Within the current directory ("abc") store the following code in a file named "ClassX.java"

```
import myPackage.ClassA;
import secondPackage.ClassC;
public class ClassY
{
      public static void main(String args[])
      {
            ClassA objA = new ClassA();
            ClassC objC = new ClassC();
            objA.display();
            objC.display();
      }
}
```

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Output

[raj@mundroo] package % java ClassY

```
  Hello, I am ClassA
  Hello, I am ClassC
```

[raj@mundroo] package %

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Protection and Packages

- All classes (or interfaces) accessible to all others in the same package.
- Class declared public in one package is accessible within another. Non-public class is not
- Members of a class are accessible from a difference class, as long as they are not *private*
- *protected* members of a class in a package are accessible to subclasses in a different class

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Visibility - Revisited

- *Public* keyword applied to a class, makes it available/visible everywhere. Applied to a method or variable, completely visible.
- *Private* fields or methods for a class only visible within that class. Private members are *not* visible within subclasses, and are *not* inherited.
- *Protected* members of a class are visible within the class, subclasses and *also* within all classes that are in the same package as that class.

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Visibility Modifiers

Accessible to:	public	protected	Package (default)	private
Same Class	Yes	Yes	Yes	Yes
Class in package	Yes	Yes	Yes	No
Subclass in different package	Yes	Yes	No	No
Non-subclass different package	Yes	No	No	No

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Adding a Class to a Package

- Consider an existing package that contains a class called "Teacher":

```
package pack1;
public class Teacher
{
  // class body
}
```

- This class is stored in "Teacher.java" file within a directory called "pack1".
- How do we a new public class called "Student" to this package.

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Adding a Class to a Package

```
package pack1;
  class Teacher
  class Student
```

- Define the public class "Student" and place the package statement before the class definition as follows:

```
package pack1;
public class Student
{
  // class body
}
```

- Store this in "Student.java" file under the directory "pack1".
- When the "Student.java" file is compiled, the class file will be created and stored in the directory "pack1". Now, the package "pack1" will contain both the classes "Teacher" and "Student".

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Packages and Name Clashing

- When packages are developed by different organizations, it is possible that multiple packages will have classes with the same name, leading to name classing.

```
package pack1;
  class Teacher
  class Student
```

```
package pack2;
  class Student
  class Courses
```

- We can import and use these packages like:
  - import pack1.*;
  - import pack2.*;
  - Student student1; // Generates compilation error

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Handling Name Clashing

- In Java, name classing is resolved by accessing classes with the same name in multiple packages by their fully qualified name.
- Example:
  import pack1.*;
  import pack2.*;
  pack1.Student student1;
  pack2.Student student2;
  Teacher teacher1;
  Courses course1;

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Extending a Class from Package

- A new class called "Professor" can be created by extending the "Teacher" class defined the package "pack1" as follows:

```
import pack1.Teacher;
public class Professor extends Teacher
{
  // body of Professor class
  // It is able to inherit public and protected members,
  // but not private or default members of Teacher class.
}
```

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Summary

- Packages allow grouping of related classes into a single united.
- Packages are organised in hierarchical structure.
- Packages handle name classing issues.
- Packages can be accessed or inherited without actual copy of code to each program.

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