Lecture Set # 16: Packages

1. Packages

Java Program Organization

- **Program Organization**:
  - **Java program**: is composed of **1 or more Java source files**.
  - **Source file**: can have **1 or more class and/or interface declarations**. (In our projects we have implemented one class/interface per file.)
  - **Public Class/Interface**: If a class/interface is declared **public** the source file must use the **same name**.
  - Only **one public class/interface** is allowed **per source file**. (Can you have non-public classes? We will discuss this later.)
  - **Packages**: When a program is very large, its classes can be further organized **hierarchically** into packages.

Packages

- **Package**: a collection of **related** classes and/or interfaces.
- **Examples**: The Java API

  javax.swing: classes dealing with the development of GUIs.

  java.lang: essential classes required by the Java language.

  java.text: facilities for formatting text output.

  java.util: classes for storing/accessing collections of objects.

  java.net: for network communication.
- **Hierarchical**: Packages can be **divided** into subpackages.

  java.awt: classes for basic GUI elements and graphics.

  java.awt.font: classes and interface relating to fonts.

  java.awt.geom: classes for defining 2-dimensional objects.

  There is no limit to the nesting depth.

Access to Package Members

- **Review of Package Basics**:

  Accessing Package Members:

  Fully qualified name: E.g., **javax.swing.JOptionPane**

  Importing a single class:

```
import javax.swing.JOptionPane;
...
JOptionPane.showMessageDialog( ... );
```

  Importing all the classes:

```
import javax.swing.*;
...
JOptionPane.showMessageDialog( ... );
```

  Import semantics: import does not "**insert**" the Java files (as C/C++ do with "include" files). Instead, it tells the compiler **where to look** to find classes that the program refers to.

  Multiple import statements: You can have as many as you like. They go **at the top of your .java** file (before any classes or interfaces).

  java.lang: is **automatically imported** into every program.

Defining your own package

- **Why packages?** Packages enable a programmer organize the code into smaller logically related units. A large program may consists of hundreds of classes. (Although we may not need to use them for the little projects in CMSC 131, but it is important to know how to create packages for when you will need them.)
- **Every class is part of some package**:
  - **Default package**: If you do not specify a package a class becomes part of the "**default package**". Doesn't require the package statement at the top of the .java file.
- **What special privileges do packages provide?** Classes defined within the same package can access one another more easily (without the need for importing or fully qualified names).

Defining your own package

- **Defining a package**: Add a "**package**" statement to specify the package containing the classes of this file.

```
package mypackage;
…
public class myClass { … }        // myClass is part of mypackage
```

- This must be the **first statement** of your file. (Other than comments.)
- **Subpackages**: Packages organized into subpackages. This is specified using the notation "**main.subpackage**". Example:

```
package mypackage.mysubpackage;
…
public class myClass2 { … }       // myClass2 is part of mysubpackage
                                  // … which is within mypackage
```

- **Packages in Eclipse**: **File→New→Package**. Enter the full name of the package (e.g. "**mypackage**" or "**mypackage.mysubpackage**").
- **Without Eclipse**: Just insert this yourself ("**package mypackage**;")

Class Access and Packages

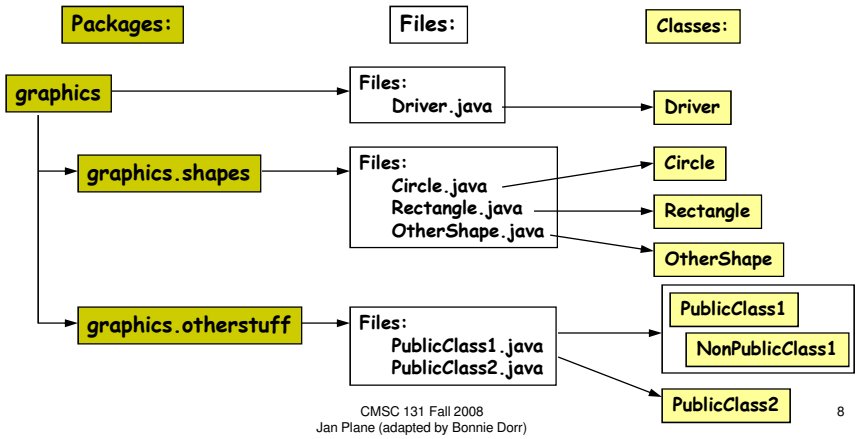
- **Class access within a package**:
  - Classes within a package can refer to each other **without full qualification**.
  - If a class is **not** given an access specifier (public or private), it is assumed to have package access and it can **only** be accessed by other classes **within the package**.
- **Class access across packages**:
  - A **public class** can be accessed from **other packages**.
  - When this is done, either its name is **fully qualified** or is **imported**.
  - We can view **public classes of a package** as the "**interface**" of the package with the outside world. (This is analogous to public methods of a class forming its interface.)
- **Subpackages are not automatically imported**:
  - When you import a package (e.g. **import java.awt.***) it **does not** import the subpackages (e.g. **java.awt.font** must be **explicitly** imported).

Package Visibility

- Package visibility is half-way between public and private.
- Package Visibility of classes:
  - If a *class* is **not** declared **public** or **private**, it can be accessed by **all and only** the classes **within the package**.
- Package visibility of class members:
  - If *instance variables* or *instance methods* are **not** declared **public** or **private**, they can be accessed by **all and only** the classes **within the package**.
  - Package visibility is used in industry:
    - A team working on a certain part of a project is likely to have its own package within which elements are "shared" among classes within the package.
    - Used for cases where "shared" elements are not intended to be publicly visible (e.g., to other teams).

Example

- To illustrate these points, let's consider an example of a simple hierarchical package, which we will create.



Example: graphics.shapes package

File: Circle.java

```
package graphics.shapes;
public class Circle {
    private double radius;
    public String toString( ) { return "I'm a circle"; }
}
```

File: Rectangle.java

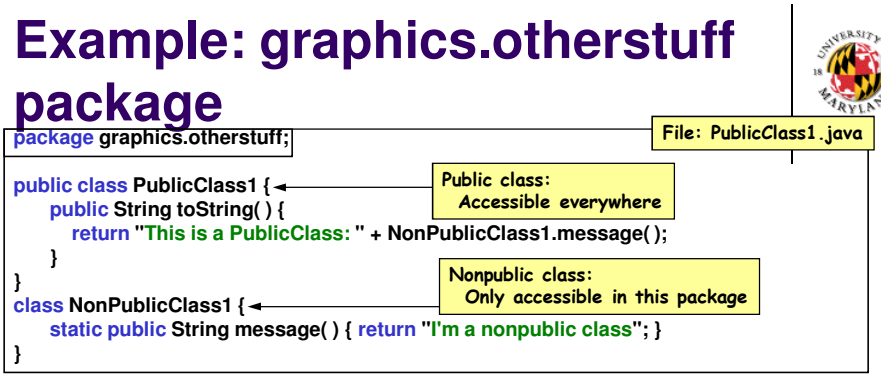
```
package graphics.shapes;
public class Rectangle {
    private double height, width;
    public String toString( ) { return "I'm a rectangle"; }
}
```

File: OtherShape.java

```
package graphics.shapes;
public class OtherShape {
    private Circle c;
    private Rectangle r;
}
```

Note: Classes of this package can be accessed without the need for import or using graphics.shapes.Circle

Example: graphics.otherstuff package



File: PublicClass1.java

```
package graphics.otherstuff;

public class PublicClass1 {
    public String toString( ) {
        return "This is a PublicClass: " + NonPublicClass1.message( );
    }
}
class NonPublicClass1 {
    static public String message( ) { return "I'm a nonpublic class"; }
}
```

Public class: Accessible everywhere

Nonpublic class: Only accessible in this package

File: PublicClass2.java

```
package graphics.otherstuff;

public class PublicClass2 {
    private Driver d;
    private Circle c1;
    private graphics.shapes.Circle c2;

    public String toString( ) {
        return "This is a PublicClass2: " + NonPublicClass1.message( );
    }
}
```

Compiler error! We have no direct access to classes outside this package. Import or use qualified name.

Okay, using the fully qualified name.

Okay: Can access a nonpublic classes within this package.

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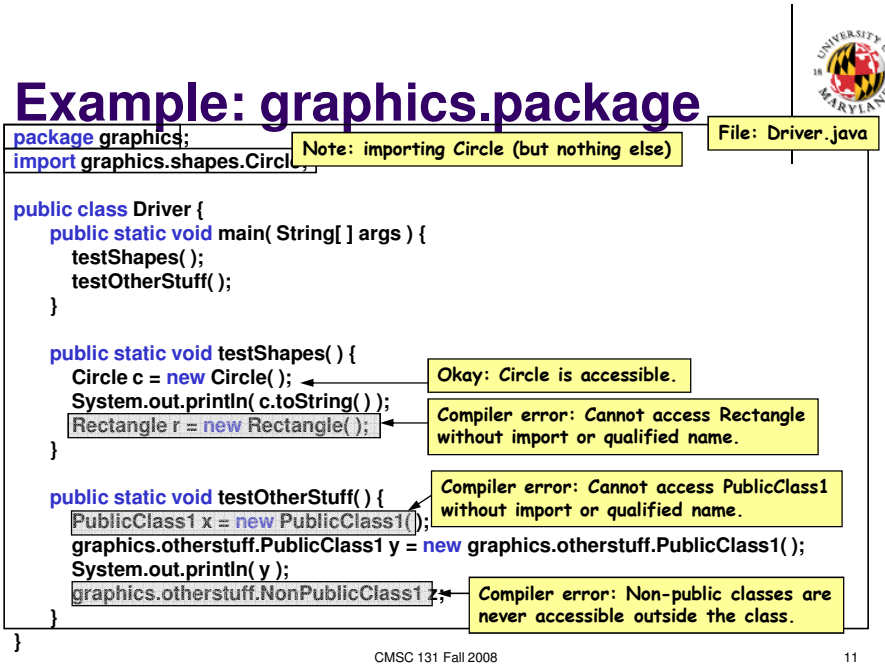
Example: graphics.package



File: Driver.java

```
package graphics;
import graphics.shapes.Circle;

public class Driver {
    public static void main( String[ ] args ) {
        testShapes( );
        testOtherStuff( );
    }

    public static void testShapes( ) {
        Circle c = new Circle( );
        System.out.println( c.toString( ) );
        Rectangle r = new Rectangle( );
    }

    public static void testOtherStuff( ) {
        PublicClass1 x = new PublicClass1( );
        graphics.otherstuff.PublicClass1 y = new graphics.otherstuff.PublicClass1( );
        System.out.println( y );
        graphics.otherstuff.NonPublicClass1 z;
    }
}
```

Note: importing Circle (but nothing else)

Okay: Circle is accessible.

Compiler error: Cannot access Rectangle without import or qualified name.

Compiler error: Cannot access PublicClass1 without import or qualified name.

Compiler error: Non-public classes are never accessible outside the class.

File Structure

- Java organizes the package files using your system's directory structure.

When you create new packages in Eclipse, this is done automatically.

graphics:

Driver.class Driver.java
otherstuff/
shapes/

Note that nonpublic classes generate their own .class file, even though there is no .java file.

graphics/otherstuff:

NonPublicClass1.class
PublicClass1.java PublicClass2.java
PublicClass1.class PublicClass2.class

graphics/shapes:

Circle.class	OtherShape.class	Rectangle.class
Circle.java	OtherShape.java	Rectangle.java

Packages and .jar Files

- Packages are convenient, but large directories are not.
- **Jar File**: Java allows you to **bundle up an entire directory** of files into a single file, called a **jar file**.
- **Creating a jar file**:
  - **In Eclipse**: In the Package Explorer window, right click on the project and select "**Export → JAR file**".
  - **On Unix**:

    jar –cvf myJarFile.jar … **(list the file names and/or directories)**

    (c = create; t = list names; x = extract; v = verbose; f = jar file)
- **Examples**:

  cmsc131PictureLib.jar: A jar file we created for the picture library.

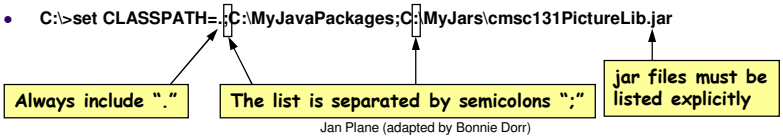
  cmsc131PuzzleLib.jar: A jar file we created for HW#5.

  C:\...\Java\j2re1.4.2_05\lib\rt.jar: This is a large (20+Mbyte) file with all the class files from the Java runtime library.

Packages and Classpath

- You may have many different packages on your system (e.g. the Java runtime library, cmsc131PictureLib, cmsc131PuzzleLib) in many different locations. **How does Java know where to look** for them?
- **ClassPath**: is a system **environment variable** that gives a list of directories and jar files where Java should look up its classes.
- **Windows Example**: Suppose we want to use
  - **graphics package**: stored in directory C:\MyJavaPackages\graphics.
  - **cmsc131PictureLib.jar**: stored in C:\MyJars\cmsc131PictureLib.jar
  - classes compiled in the **current working directory**: The current directory is denoted by "." (period) on most systems.

- **C:\>set CLASSPATH=.;C:\MyJavaPackages;C:\MyJars\cmsc131PictureLib.jar**



Packages and Classpath

- **In Eclipse**: The ClassPath is already set with important default directories (e.g. the Java runtime library). To modify the ClassPath:
  - In the **Package Explorer**, right click on the project name
  - Select "**Properties** → **Java Build Path** → **Libraries**"
  - **To add Jars**: Select: "**Add External JARs…**" and browse for the file name.
  - **To add a directory to the ClassPath**: Select:

    Add Variable… → **Configure Variables** → **New**

    and add the name of the new directory.