Organizing Classes in Java

Packages

Organization of Code - Motivation

- It is important to group together classes/interfaces that are related
- We need to provide a layer of access / protection
- Avoid name clash

Solution in Java: Packages

- Classes can be grouped in a collection called *package*
  - Each package has a name
  - A package can also have sub-packages
  - Java's standard library consists of hierarchical packages, such as java.lang and java.util
- Definition of the ***package-private*** access level
  - The class can be *package-private*
  - Members of a class can be *package-private*
- Packages provides a name space
  - Classes have a simple name (just the name of the class) and
  - A full name: concatenation of the package name and simple name
  - The name of a class **is always** the full name
  - Classes with same (**simple**) name can be encapsulated in different packages

Sub-packages

- We can create hierarchies of nested packages
- Sub-package name must always be prefixed with name of parent package (separated by '**.**')
  - `java.awt` and `java.awt.event`
- *Sub-packages* have a similar name to parent package but are not actually contained inside
  - `java.awt` represents all classes belonging to this package only
    - **does not** consider classes of sub-packages of java.awt
    - **does not** contain `java.awt.event`

Class importation (1)

- Two ways of accessing **PUBLIC** classes of another package
  1) explicitly give the full package name before the class name.
     - E.g.

       ```
       java.util.Date today = new java.util.Date( );
       ```

  2) import the package by using the `import` statement at the top of your source files (but below package statements). No need to give package name any more.
     - to import a single class from the java.util package

       ```
       import java.util.Date;
       Date today = new Date( );
       ```

     - to import all the public classes from the java.util package

       ```
       import java.util.*;
       Date today = new Date( );
       ```

     - * is used to import classes at the current package level. It will **NOT** import classes in a sub-package.
- A class can access other classes belonging to the same package using just the simple name
- All classes of the `java.lang` package are imported automatically into all classes

Class importation - Example

Consider the class javax.swing.event.MenuEvent

```
import javax.swing.*;
import javax.swing.event.MenuEvent;



public class SampleClass {
  MenuEvent c;
}
```

```
%> javac SampleClass.java

SampleClass.java:4: cannot find symbol
Symbol  : class MenuEvent
Location: class SampleClass
    MenuEvent c;
    ^
1 error
```

To correct this error you need to add:

```
import javax.swing.event.MenuEvent;
```

Or

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Class importation - Example

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To correct this error you need to add:

```
import javax.swing.event.MenuEvent;
```

Or

```
import javax.swing.event.*;
```

Or use

```
javax.swing.event.MenuEvent instead of MenuEvent
```

Class importation (2)

- What if you have a name conflict?

  E.g: java.util.Date and java.sql.Date

```
import java.util.*;
import java.sql.*;
Date today = new Date( );
//ERROR:java.util.Date or java.sql.Date?
```

  - if you only need to refer to one of them, import that class explicitly

```
import java.util.*;
import java.sql.*;
import java.util.Date;
Date today = new Date( ); // java.util.Date
```

  - if you need to refer to both of them, you have to use the full package name before the class name

```
import java.util.*;
import java.sql.*;

java.sql.Date today = new java.sql.Date( );
java.util.Date nextDay = new java.util.Date( );
```

or

```
import java.util.*;
import java.sql.*;
Import java.util.Date;

java.sql.Date today = new java.sql.Date( );
Date nextDay = new Date( );
```

Import of Static Members

Consider following code:

```
import java.lang.Math;

public class ImportTest {
  double x = sqrt(1.44);
}
```

Compile:

```
%> javac ImportTest.java
ImportTest.java:3: cannot find symbol
symbol  : method sqrt(double)
location: class importTest
double x = sqrt(1.44);
           ^
1 error
```

?

For the static members, you need to refer them as **className.memberName**

Static importation

- In J2SE 5.0, importation can also be applied on static fields and methods, not just classes. You can directly refer to them after the static importation.
  - E.g. import all static fields and methods of the Math class

```
import static java.lang.Math.*;
double x = PI;
```

  - E.g. import a specific field or method

```
import static java.lang.Math.sqrt;
public class ImportTest {
    double x = sqrt(1.44);
}
```

```
Now compiles without errors;
```

- Any version before J2SE 5.0 does NOT have this feature!
- **Try** to avoid using this. Makes code harder to read

The default package

- Compilation units (files) that do not declare a package are put into a default, unnamed, package.

- Classes in the default package:
  - Cannot be imported
  - Cannot be used by classes in other packages

- Many editors discourage the use of the default package.

Encapsulation of classes into a package

- Add a class into a package — two steps:
  1. put the name of the package at the top of your source file
     - Use **package** statement to define the package of a class
     - **Must** be the first statement of a file

```
package com.hostname.corejava;
public class Employee {
        . . .
}
```

  2. Store .java and .class files in a directory tree that mimics package structure

```
stored in the file "Employee.java" which is stored under
"somePath/com/hostname/corejava/"
```

How to store files and packages?

- Class files must be stored in a directory structure that mirrors package hierarchy
  - class ←→ file
  - package ←→ directory (folder)
  - sub-package ←→ sub-directory into directory of parent package (folder)
- Location of class a.b.c.D?
  - **a/b/c/D.class**
    - Somewhere in the file system!
    - Usually, it is relative to the root of your project
- Compiled classes can be stored in different locations in the file systems
- How does the Java finds them to compile and run?

Jar Files

- **JAR**: **J**ava **AR**chive. A group of Java classes and supporting files combined into a single file compressed with ZIP format, and given .JAR extension.

- Advantages of JAR files:
  - compressed; quicker download
  - just one file; less mess
  - can be executable

JAR Archive - Creation

- From the command line:
  `jar -cvf` **filename**`.jar` **files**

- Example:
  - Creates a jar file containing all class files in current directory
    ```
    jar -cvf MyProgram.jar *.class
    ```
  - Creates a jar archive containing the package stored in a given directory
    ```
    jar -cvf MyProgram.jar dirName
    ```
    - The jar file contains all files in dirName and preserves the directory structure
  - See the content of a jar file
    - `jar -tf MyProgram.jar`
- Some Linux have a menu option to create jars
  - Do not use it. The structure is wrong!

How does the virtual machine locate classes?

- How to tell the java virtual machine where to find the .class files?
  Answer: set the ***class path***
- Class path is the collection of all directories and archive files that are starting points for locating classes.
- Can include:
  - the current "working directory" from which you ran javac / java
  - other folders
  - JAR and ZIP archives
    - Archive must store class files within the appropriate directory structure
  - URLs
  - ...

Setting the class path

- This is needed both for running and compiling in Java!
- Tedious way:
  - set the class path with the `-classpath` option for the `javac/java` programs
  - In command line
    - $> java –classpath /home/jcp/project animal.Animal
  - There is a lazier way
    - -cp instead of -classpath
    - $> java –cp /home/jcp/project animal.Animal
- Set classpath in environment variable CLASSPATH
  - $> export CLASSPATH="/home/jcp/project"
  - $> java animal.Animal

Setting the class path – 2

- Set the CLASSPATH environment variable in a permanent way
  - UNIX/Linux
    - If you use the C shell, add a line such as the following to the .cshrc file in your home directory

      ```
      setenv CLASSPATH /home/user/classdir:.
      ```

    - If you use `bash`, add a line such as the following to the `.bashrc` or `.bash_profile` file in your home directory

      ```
      export CLASSPATH=$CLASSPATH:.:/home/user/classdir
      ```

    - after you save the modified files, run the command

      ```
      source .bashrc(or .cshrc or .bash_profile)
      ```

  - Windows
    - Open the control panel, then open the **System** icon and select the **Environment** tab. Add a new environment variable named CLASSPATH and specify its value, or edit the variable if it exists already.

Locating files - Example

- First suppose the following is the current classpath:

  /home/user/classdir:.:/home/user/archives/archive.jar
- then suppose the interpreter is searching for the class file of the pt.tecnico.po.core.Employee class.
- It will search whether the following files exist in the following order:

  1. pt/tecnico/po/core/Employee.class inside archives in jre/lib (default)
  2. pt/tecnico/po/core/Employee.class inside archives in jre/lib/ext (default)
  3. /home/user/classdir/pt/tecnico/po/core/Employee.class (first directory in classpath)
  4. ./pt/tecnico/po/core/Employee.class (second directory in classpath)
  5. pt/tecnico/po/core/Employee.class inside /home/user/archives/archive.jar (third directory in classpath)
- if any of them is found, then the interpreter stops searching process
- If none is found: ClassNotFoundException

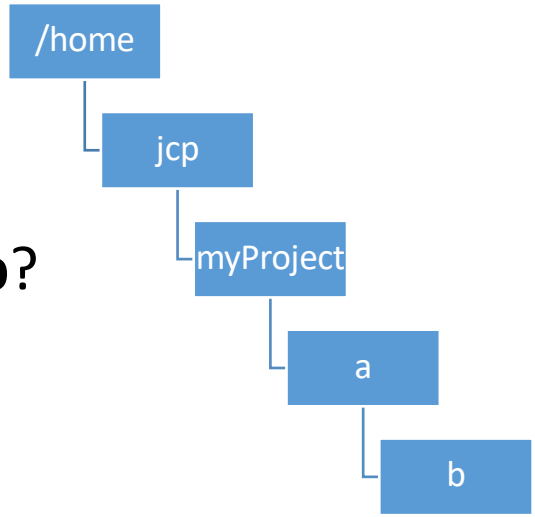
Organizational Package Naming Conventions

- Package names should be all lowercase characters whenever possible.
- How to guarantee unique name space for a company?
  - Package names should be made as unique as possible to prevent name clashes
- Frequently a package name begins with the top level domain name of the organization and then the organization's domain and then any subdomains listed in reverse order.
  - Tradition of package name: reverse of the company’s Internet domain name
    e.g. hostname.com -> com.hostname

- The organization can then choose a specific name for their package.

Compilation Examples

- How to compile all classes in package **a**?
  - In directory /home/jcp/myProject do
    - $> javac a/*.java
- How to compile all classes in packages **a** and **b**?
  - In directory /home/jcp/myProject do
    - $> javac a/*.java a/b/*.java
- How to compile all classes in packages **b**?
  - In directory /home/jcp/myProject do
    - $> javac a/b/*.java
  - In directory /home/jcp do
    - $> javac myProject/a/b/*.java
    - What happens?
      - Cannot find class a.A2
    - $> javac –cp myProject myProject/a/b/*.java



package a
  A1
  A2
  A3
package a.b
  B1
  B2 extends A2
  B3

Generic compilation command - Unix

- In root project directory
  - javac –cp <libs> `find rootPackageDir –name *.java`

Common Mistakes

- In directory /home/jcp/myProject do
  - $> java A1.class
    - Exception in thread "main" java.lang.NoClassDefFoundError: A1.class
  - $> java A1
    - Exception in thread "main" java.lang.NoClassDefFoundError: A1
  - Correct way
    - $> java a.A1
- In directory /home/jcp/ do
  - $> java a.A1
    - Exception in thread "main" java.lang.NoClassDefFoundError: a/A1
  - Correct way
    - $> java –cp myProject a.A1
    - $> java –cp /home/jcp/myProject a.A1

```
package a
  A1
  A2
  A3
Package a.b
  B1
  B2 extends A2
  B3
```

Implementation Example

- Um habitat permite guardar aves. Cada habitat tem um número máximo de aves que pode guardar. A adição de uma nova ave deve indicar se teve sucesso ou não. Deve ser possível saber o número de aves do habitat. O habitat pode dizer as todas as aves para voarem. Esta classe deve pertencer ao package habitat.
- Uma ave tem um nome e pode voar. Quando voa escreve a mensagem “Estou a voar”. É possível saber o nome de uma ave. Uma ave está triste se o habitat tiver menos do que 3 aves.
- Um pinguim é uma ave que não sabe voar mas que sabe mergulhar. Quando voa escreve a mensagem “Não sei voar”. Um pinguim quando mergulha fica molhado e só volta a ficar seco quando se secar.
- Pinguim e Ave pertencem ao package animal.