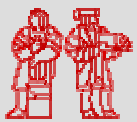
Lecture 11: Scope and Packages

Data Organization and Access Control

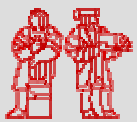
Access & Organization

- Your computer has thousands of files.
- The internet has millions of sites.
- Projects have thousands of classes.
- How do we find particular classes, files, or sites?
- How do we deal with duplicate or similar names?
- How do we restrict access to private data?



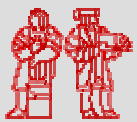
This Lecture

- Scope: What is accessible where.
- How to use Java packages.
- How to create Java packages.
- Reading: Eckel, “Chapter 5: Hiding the Implementation”, Thinking in Java



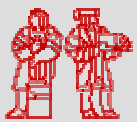
Scope

- A variable, field, method, or class's *scope* consists of all code where it is accessible.
- Variables are accessible within the *block* that they are declared.
- Blocks are contained in curly braces.
- *Local variable*: A variable defined only in the current block.
- The accessibility of fields, methods, and classes is determined by their *modifiers*.



Anonymous Variables

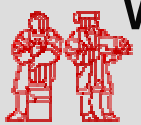
- *Anonymous variables* are allocated and initialized, but never declared.
- In C/C++ anonymous variables are a bug; in Java they are a feature.
- They have no name, and cannot be referenced -- thus have no scope.
- Examples:
  - `System.out.println("Hello");`
  - `(new String("Hello"))`
  - `(new int[] {1,2,3,4})`
- (The last example is new notation we haven't used; in fact we just learned.)



Variable Scope Example

```
0     void foo(int x) {
1          int y = 3;
2          if (y > 0) {
3               int z = 4;
4               if (z > 0) {
5                    int w = 0;
6                    {
7                         int v = 1;
8                    } // end block
9               } // end if (z>0)
10              } // end if (y>0)
11    } // end Foo
```

Which lines are v, w, x, y, and z accessible?



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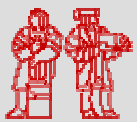
Method Scope Example

```
class TestScope {
 int x = 0;
 void foo(int z) {
   int y = 20;
   x = 10;
   int z = 30; // Error
 }// end foo()
 void print() {
   System.out.println(x);
   foo(x);
   System.out.println(x);
   /* Next line error */
   System.out.println(y);
 }// end print()
}// end TestScope
```

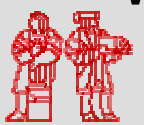
- x is defined for the whole class block.
- y is defined inside the method f(int).
- z is already defined in f(int) by the argument.



Field Scope Example

```
class Scope {
    int x = 3;
    void foo(int y) {
       System.out.println(x);
       int x = 2;
       System.out.println(x);
       System.out.println(this.x);
       System.out.println(y);
    }
    public static void main(String[] args) {
       int x = 1;
       (new Scope()).foo(x); // Anonymous Object
    }
}
```

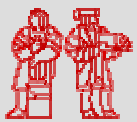
What is the output of this program?



Loop Scope

```
int sigma(int n) {
  for (int i = 0; i<n; i++) {
   int sum += i;
  }
  return sum;
}
```

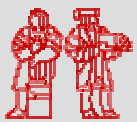
- The method *sigma* is supposed to return $\sum_{i=0}^{n} i$
- Why won't *sigma* compile?



Scope Quiz

```
class TestScope {
 int x = 0;
 void foo() {
   int y = 20;
   x = 10;
 }// end foo
 void print() {
   int y = 0;
   System.out.println(x);
   foo();
   System.out.println(x);
   System.out.println(y);
 }// end print()
}// end Class TestScope
```

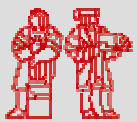
- What is the output of this program?
  - 0
  - 10
  - 0



Scope Quiz 2

```
class TestScope {
 int x = 0;
 int y = 0;
 void foo() {
   int y;
   y = 20;
   x = 10;
 }
 void print() {
   System.out.println(x);
   foo();
   System.out.println(x);
   System.out.println(y);
 }
}
```

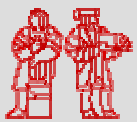
- Now, we declare a new field, y.
- What is the output of print()?
  - 0
  - 10
  - 0



Scope Quiz 3

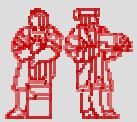
```
class TestScope {
 int x = 0;
 int y = 0;
 void foo() {
   y = 20;
   x = 10;
 }
 void print() {
   System.out.println(x);
   foo();
   System.out.println(x);
   System.out.println(y);
 }
}
```

- Now, we change the method foo().
- What is the output of print()?
  - 0
  - 10
  - 20



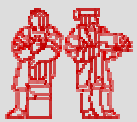
Naming in Big Projects

- Large projects may have thousands of classes.
- You may collaborate and share classes with people all over the world.
- How do we make sure our class names don't collide with someone else's?
- Could use really long, unique names..
  - "UtilityClassForPreparingTaxReturnsByAnthonyGfromWestlandsNairobiKenya"
- This is difficult to remember and use.



Hierarchical Namespaces

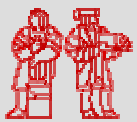
- Names are organized into a hierarchy.
- “Bill Gates”: Family: Gates, Person: Bill.
- crypto.csail.mit.edu: Crypto group, at CSAIL, at MIT, an educational institutions.
- 254-020-5555555: Kenya (254), Nairobi (020), Number 5555555
- java.lang.String: String class, in the lang *package*, in the java package.



Defining Packages

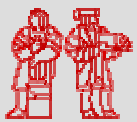
- Organize your classes into sets or units called packages.
- Reduces problems with name conflicts and identifies functionality, e.g. java.util.
- Can restrict access to within a package.
- How to specify the package for a class:

```
package packageName;

class className {
  /* Class Body */
}
```



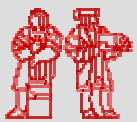
Package Caveats

- Package declaration must be first non-comment line in a file.
- The first class defined in a file must be the named the same as the file name.
- Only the first class may be public.
- javac and java will search in appropriately named subdirectories or JAR (Java Archive) for source and binaries:
  - \mypkg\util for mypkg.util (on Windows)
  - /mypkg/util/arrays for mypkg.util.arrays (on Unix)



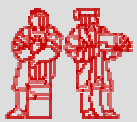
Using Packages

- Can use fully-qualified names:
  - `java.util.Date d = new java.util.Date();`
- Or specify the classes you want to import:
  - `import java.util.Date;`
  - `import java.util.ArrayList;`
- Import all classes in a package:
  - `import java.util.*;`
- Packages can have sub-packages:
  - `import java.util.logging.*;`
- Default imported package:
  - `import java.lang.*;`



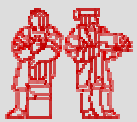
Access Modifiers

- Fields, Methods, Constructors, or Classes with *public access* are accessible to any other class in any package.
- Fields, Methods, or Constructors with *protected access* are accessible to any child class* (later lecture).
- Fields, Methods, Constructors, or Classes with *package access* are available to any class within the same package. This is the default.
- Fields, Methods, or Constructors with *private access* are only accessible within that class.



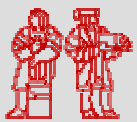
Levels of Access Control

Accessible..	`private`	`package` (default)	`protected`	`public`
From same class	Yes	Yes	Yes	Yes
From same package	No	Yes	Yes	Yes
From child classes	No	No	Yes	Yes
From anywhere	No	No	No	Yes



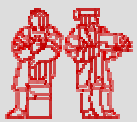
Package Example: Person.java

```
package examples;

class Person {
  String name;

  // We will complete this class by:
  // Adding a field to store a birthday
  // Writing a method to set the birthday
  // Writing a method to get the birthday

}
```



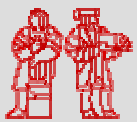
Using java.util.Date

```
package examples;

class Person {
  String name;
  java.util.Date birthDay;
  void setBirthday(java.util.Date d) {
     this.birthDay = d;
  }
  java.util.Date getBirthday() {
     return this.birthDay;
  }
}
```



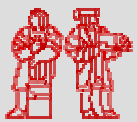
Importing java.util.Date

```
package examples;
import java.util.Date;
class Person {
  String name;
  Date birthDay;
  void setBirthday(Date d) {
     this.birthDay = d;
  }
  Date getBirthday() {
     return this.birthDay;
  }
}
```



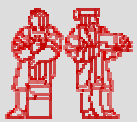
Importing java.util.ArrayList

```
package examples;
import java.util.Date;
import java.util.ArrayList;

class Person {
   String name;
   ArrayList friends;
   Date birthDay;
   void setBirthday(Date d) {
       this.birthDay = d;
   }
   Date getBirthday() {
       return this.birthDay;
   }
}
```



Importing java.util.*

```
package examples;
import java.util.*;

class Person {
   String name;
   ArrayList friends;
   Date birthDay;
   void setBirthday(Date d) {
       this.birthDay = d;
   }
   Date getBirthday() {
       return this.birthDay;
   }
}
```



EC.S01 Internet Technology in Local and Global Communities
Spring 2005-Summer 2005