Object-Oriented Programming, Part 2

- Packages
- Information hiding
- Access modifiers
  - private
  - protected
  - public
  - "friendly"
- Designing an email class
- Designing and implementing a debug message facility

Packages in Java

- A package is a collection of classes (a *library*).
- In a file the first line must specify the package, e.g.,
  - **`package mypackage;`**
- Characteristic of a package
  - Organized in a hierarchy
    - Uses the file system for implementing the hierarchy
    - A package corresponds to a directory (and typically subdirectories)
  - Every package is a name space
- By default, classes belong to the *unnamed package*.
- Packages introduce new scope rules.

Packages in Java, cont.

- Typical problems with packages
  - Tied to local directory structure
  - Case sensitive
  - Default package in current directory.

- Good design
  - All classes should be in a explicit package, i.e., do not use the unnamed package (except for teaching :-))

Package Example

```
package com.mycompany.misc; // file Car.java

public class Car {
   public Car(){
      System.out.println("com.mycompany.misc.Car");
   }
}

package com.mycompany.misc; // file Truck.java

public class Truck {
   public Truck(){
      System.out.println("com.mycompany.misc.Truck");
   }
}
```

Accessing Classes in Package

- A class **`MyClass`** in a package **`mypackage`** is accessed via
  - **`mypackage.MyClass`**
- This can be nested to any level
  - **`mypackage1.mypackage2.mypackage3.MyOtherClass`**
- Naming convention package names all lower case and words run together.

- To avoid too much doting packages can be imported, e.g.,
  - In a file **`import mypackage1.mypackage2.mypackage3.*`**, then, **`MyOtherClass`** does not have to be qualified.
- If name clashes, i.e., same class name in two imported packages, then use fully qualified name.
- The package **`java.lang`** is always imported.

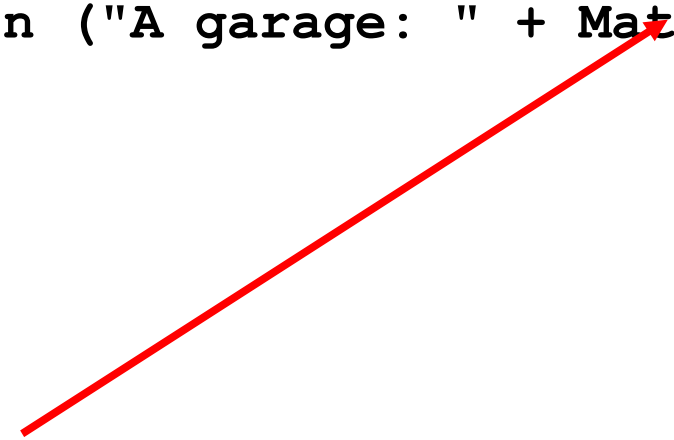
Accessing Classes, Example One

```
import java.lang.*; // not needed always done

public class Garage1 {
    com.mycompany.misc.Car car1;
    com.mycompany.misc.Truck truck1;
    public Garage1(){
        car1 = new com.mycompany.misc.Car();
        truck1 = new com.mycompany.misc.Truck();
    }

    public void toPrint(){
        System.out.println ("A garage: " + Math.PI);
    }

}
```



from **java.lang**

Accessing Classes, Example Two

```
import com.mycompany.misc.*;
//import com.mycompany.*; // not possible
import java.lang.*;       // not needed always done

public class Garage {
    Car car1;
    Truck truck1;
    public Garage(){
        car1 = new Car();
        truck1 = new Truck();
    }

    public void toPrint(){
        System.out.println ("A garage: " + Math.PI);
    }

}
```

from **com.mycompany.misc**

from **java.lang**

CLASSPATH

- Store **`misc`** package in /user/torp/java/com/mycompany/misc directory, i.e., the files Car.class and Truck.class.
- CLASSPATH = .;/user/torp/java;/user/torp/something.jar
- CLASSPATH = c:\java;c:\user\torp\something.jar
  - Test **`echo %CLASSPATH%`** on windows
- Compiler starts search at CLASSPATH
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Information Hiding

- Separate interface from implementation
  - Also hide your own errors that you made in the implementation

- How much should a user of a class see?
- Rules of thumb
  - Make instance variables private
  - Make at least one constructor public
  - Make part of the methods public

Access Modifiers on Variables/Methods

- **`private`**
  - Variable/method is private to the class.
  - *"Visible to my self"*.
- **`protected`**
  - Variable/method can be seen by the class, all subclasses, and other classes in the same package.
  - *"Visible to the family"* or *"beware of dog"*.
- **`public`**
  - Variable/method can be seen by all classes.
  - *"Visible to all"*.

Access Modifiers on Variables/Methods, cont.

- "Friendly"
  - Default access modifier, has no keyword.
  - **`public`** to other members of the same package.
  - **`private`** to anyone outside the package.
  - Also called *package access*.
  - *"Visible in the neighborhood"*

Public/"Friendly" Example

```
package com.mycompany.misc;

public class Car{
   public Car(){
      System.out.println("com.mycompany.misc.Car");
   }
   void foo () {
      System.out.println("foo");
   }
}
```

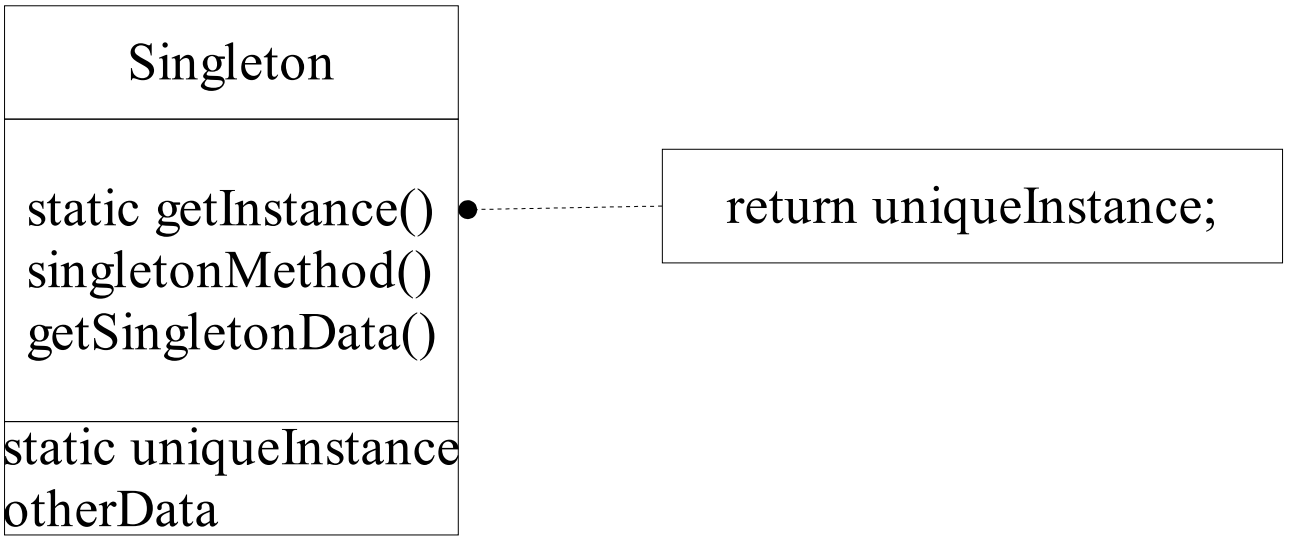
```
package mynewpackage; // in another package
import com.mycompany.misc.*;

public static void main(String[] args){
   Car car1 = new Car();
   car1.foo(); // compile error "private" in this package
}
```

Private Example

```
class Singleton{
   private int myData = 42;
   private static Singleton s = new Singleton();

   // make default constructor private
   private Singleton(){ }
   public static Singleton getSingleton(){
      return s;
   }
   public void singletonMethod() { /* do stuff */ };
   public int getSingletonData() { return myData; }
}
```

```
public class UseSingleton {
   public static void main (String[] args){
      Singleton s1 = new Singleton(); // compile error
      Singleton s2 = Singleton.getSingleton();
      s2.singletonMethod();
      // s2 and s3 are reference equal
      Singleton s3 = Singleton.getSingleton();
}
```

Singleton Design Pattern



- Controlled access to one instance
- Reduced name space (not a “global” variable)
- Permits refinement of operations and representation
- Permits a variable number of instances
- More flexible than static methods
- Very good object-oriented design

Design an Email Class

- Instance variables
  - **`from`** single email address, should provide a default
  - **`to`** multiple email addresses, mandatory
  - **`cc`** multiple email addresses, default empty
  - **`bcc`** multiple email addresses, default empty
  - **`reply-to`** single email address, default empty
  - **`subject`** string
  - **`body`** large string
- Open questions
  - What are the data types of the instance variables?
    - Should subject and body be the same data type?
    - Should email address be a class or simply a string?
  - What should the access specifiers be for the instance variables?
  - How to store list of multiple email addresses?
  - Should subject and body be mandatory?

Design an Email Class, cont.

- Methods
  - **`setDefaultFrom(emailAddress)`**, sets default from address
  - **`setFrom(emailAddress)`**, sets from this email
  - **`getFrom() return emailAddress`**, get the from for this email
  - **`setTo(emailAddress)`**, sets single to in to email address
  - **`setTo(emailAddress[])`**, sets more than one email address in to
  - **`send()`**, sends the email
  - **`send(emailAddress)`**, sends the email to the email address specified
  - **`send(emailAddress[])`**, sends the email to the list specified
  - **`clean()`**, clean all the instance variables
  - **`show()`**, shows what is currently stored in the instance variables in a nice human readable fashion
  - **`setSubjectMandatory(boolean)`**, should a subject be specified before the email can be send?

Design an Email Class, cont.

- Constructors
  - **`Email()`**
  - **`Email(to, subject, body)`**
  - **`Email(to, cc, subject, body)`**
  - **`Email(to, cc, bcc, subject, body)`**
  - **`Email(to, cc, bcc, reply-to, subject, body)`**
- Open questions
  - How many constructors are enough?
    - There can be too few, however there can also be too many!
    - Pick the most simple and the most complete and add some in between!
  - Should we automatically send the email when all mandatory instance variables are supplied to the constructor?

Design an Email Class, cont.

- Missing, then we must reiterate the design!
  - Must count the number of emails send
    - Simpel lets do it, to make the customer satisfied.
  - Default at-address, e.g., torp means torp@cs.auc.dk
    - Semi complex, would be nice but not strictly needed! (postpone to the next release?)
  - Save draft of email that can be restored later!
    - Complicated and is not in the original requirement specification!
    - Postpone delivery deadline or add to the price of the product!

- List of good idea for next release of Email class
  - Adding attachements
  - Setup to mail server

Evaluation of Design of an Email Class

- Open questions
  - Does the class do *one and only one* thing well?
  - Do we have a coherent and general class?
  - Are the method names saying and easy to understand and use?
  - Are the internal data structures encapsulated (*information hiding*)?
    - The correct access modifiers applied
  - Did we prepare for refinements of the class by other programmers?
    - Inheritance (covered in next lectures)
  - Do we have good documentation for the clients?
  - Is it stored in the right package?

Access Modifiers on Classes

- **`private`**
  - Not supported in Java! (however, works for *inner class*)
  - Default see the slide on friendly
- **`protected`**
  - Not supported in Java!
- **`public`**
  - Can be seen by all other classes in other packages
  - Only one public class per file
- "Friendly"
  - A class without an access modifier can be accessed from the classes within the same package.

- Packages have no access modifiers
  - What would it mean?

Class Properties

- A *class variable* is a variable that is common to all instances of the same class.
- A *class method* is a method that operates on a class as it was an object.

- Classes are objects (*meta objects*)
  - Class variables are stored in meta objects
  - Java supports meta object via the class **`Class`**. Further there is a set of classes in the package **`java.lang.reflect`.** See Chapter 12 "Run-Time Type Identification".

Class Properties, cont.

- Variables marked with **`static`** are class variables.
  - **`public static float tax = 22.75;`**

- Methods marked with **`static`** are class methods
  - **`public static void main (String[] args){}`**

- The **`Math`** class consists entirely of static methods and variables.
  - We never construct a **`Math`** object.
  - In general this is not a good object-oriented design.

Design a Debug Message Facility

- Be able to produce output from method without having to recompile.

```
public class TestDebug{
   public void complicatedMethod(){
        int i = (int)(Math.PI + 89 * 62); // complicated stuff
        Debug.show("int debug", i);
        char c = 'x';
        Debug.show("char debug", c);
        String s = "build " + "a " + "string";
        Debug.show("Object debug", s);
    }
}
```

Design a Debug Message Facility, cont

- Methods
  - enable/disable debugging
  - show(int value)
  - show(String message, int value)
  - show(char value)
  - show(String message, char value)
  - show(Object value)
  - show(String message, Object value)
  - collect debug information and print all later, only when debugging
  - showCollect(), prints the collected debug information
  - clearCollect(), deletes all the collected debug information
- Open questions
  - All methods are static, is this okay?

Implementation of Debug Message Facility

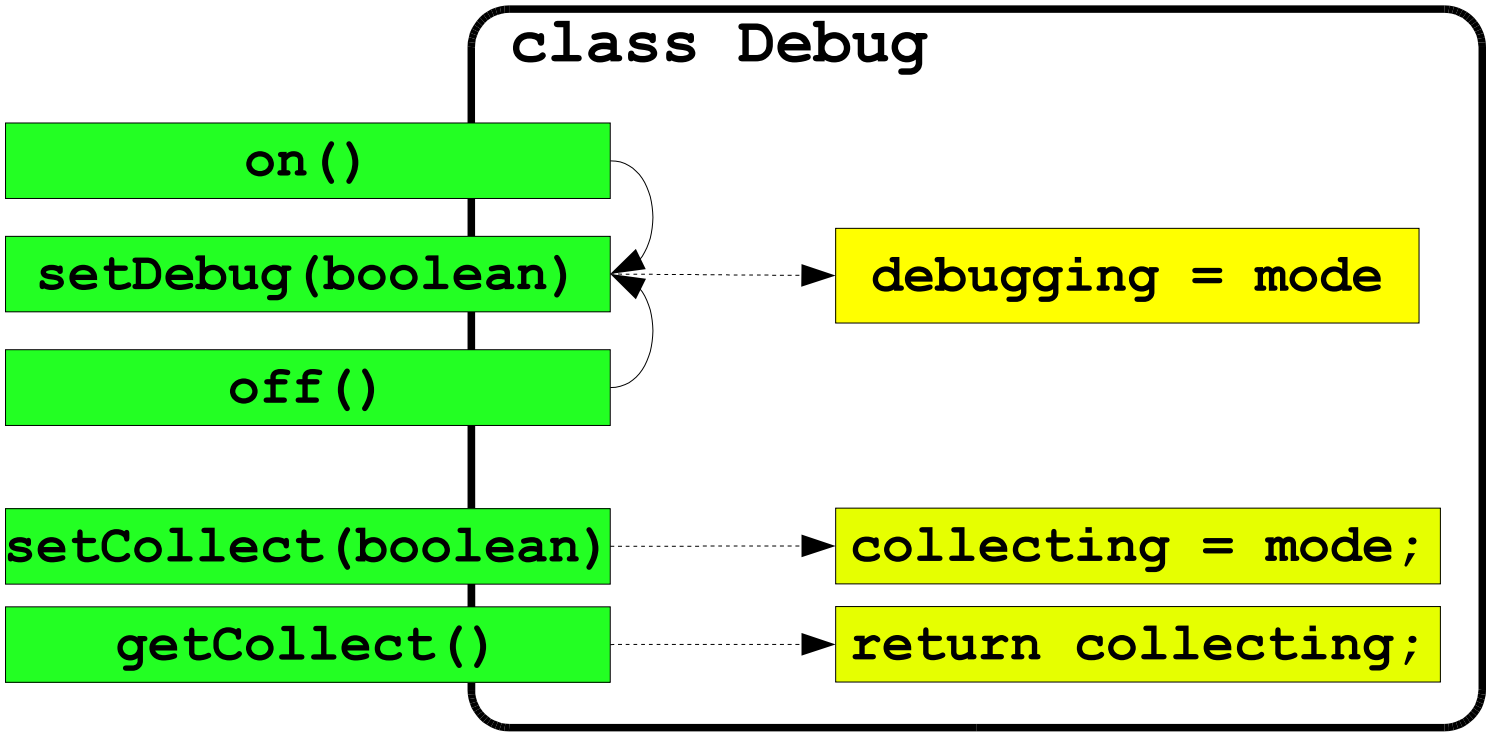
```
public class Debug{
    /** Is debugging enabled, default it is off */
    private static boolean debugging = false;
    /** Is collecting debug information on, default is off */
    private static boolean collecting = false;
    /** Maximum no of String that can be collected */
    public static final int MAX = 99;
    /** Array to which messages are collected, fixed size */
    private static String[] coll = new String[MAX];
    /** index within coll array */
    private static int counter = 0;

    /** The method that actual displays the message */
    private static void realShow(String msg){
        if (debugging){
            if (collecting) {coll[counter++] = msg; }
            else { System.out.println(msg);
            }
        }
     }
}
```

Implementation of Debug Message Facility, cont

```
public class Debug{
    // snip
    /** Sets the debugging on. */
    public static void on(){ setDebug(true); }
    /** Sets the debugging off. */
    public static void off(){ setDebug(false); }
    /** Sets the debugging mode. */
    public static void setDebug(boolean mode){
        debugging = mode;
    }
    /** Gets the debugging mode. */
    public static boolean getDebug(){ return debugging; }


    /** Sets the collect mode. */
    public static void setCollect(boolean mode){
        collecting = mode;
    }
    /** Gets the collecting mode. */
    public static boolean getCollect(){ return collecting; }
}
```

Evaluation of a Debug Message Facility

- All access to variables via methods.
- Only do one thing in one place, examples are
  - `setDebug()` `setCollect()`
- Provided both `on()`/`off()` and `setDebug()`/`getDebug()`
  - `on()`/`off()` method used a lot, and very saying method names
  - `setDebug()`/`getDebug()` typical way to access private data

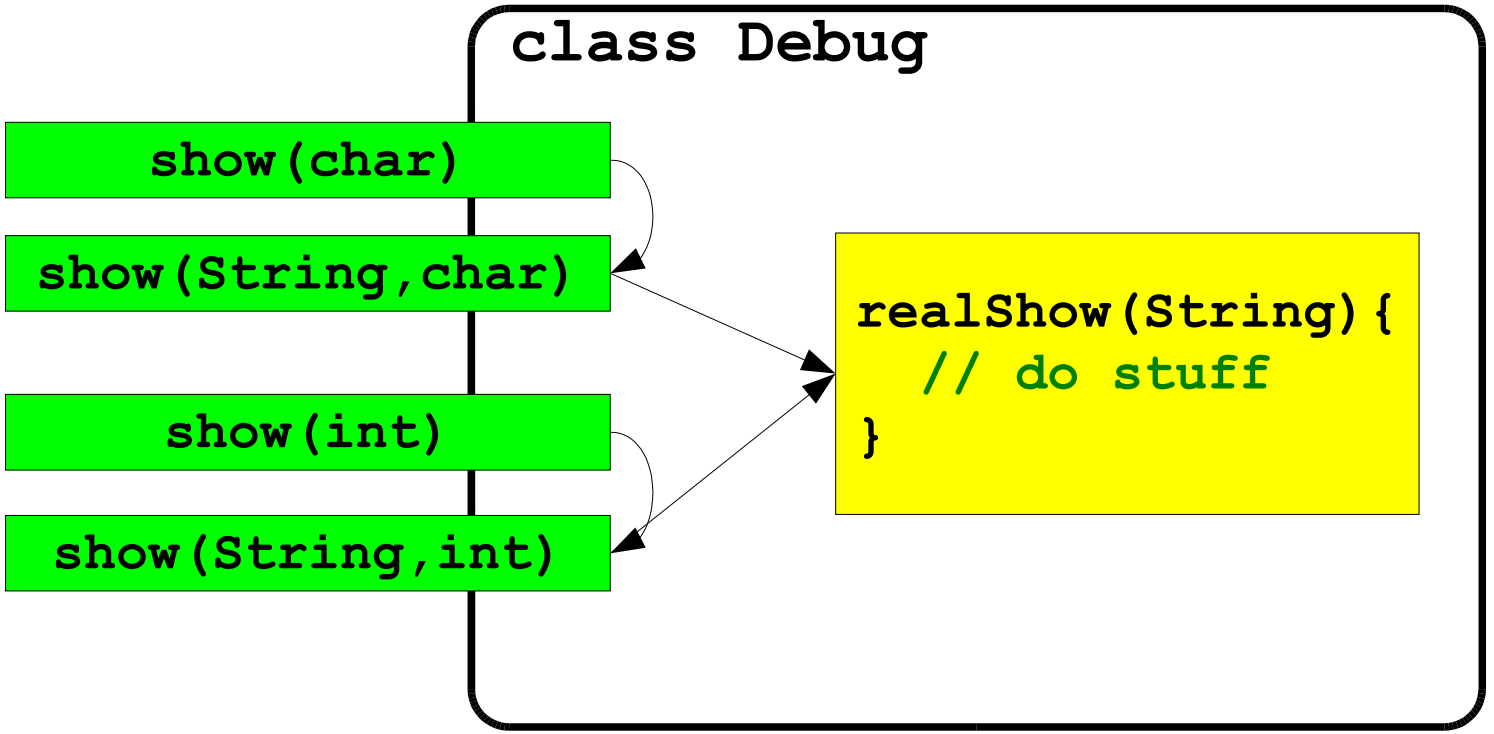


Implementation of Debug Message Facility, cont

```
public class Debug{
    // snip
   /** Shows a debug message */
   public static void show(char value){show("", value); }

   /** Shows a debug message */
   public static void show(String message, char value){
        String msg = message + " " + value;
        realShow(msg);
   }


   /** Shows a debug message */
   public static void show(int value){show("", value); }

   /** Shows a debug message */
   public static void show(String message, int value){
        String msg = message + " " + value;
        realShow(msg);
  }
}
```

Evaluation of a Debug Message Facility, cont.

- Method with few parameters adds default parameters and call similar method with more parameters.
- Many similar public **`show`** methods map to a single private **`realShow`** method.



Evaluation of a Debug Message Facility, cont

- All variables and method are **`static`**, unusual but okay here
- The array that is collected to can easily be changed to a dynamic structure when we learn about collections
  - **`MAX`** should then be set to infinitive

- Open questions
  - Easy to add show methods for all basic type?
  - Can we write out to file or database instead of, must add functionality?

Summary

- Package, the library unit in Java.
- Access modifiers
  - Tells clients what they can and cannot see.
- Separation of interface from implementation.
  - Very important in design (and implementation).
- Guideline: Make elements as hidden as possible.

- Object-oriented design hard parts
  - Decomposing system into objects.
  - Defining the public interface of each object.
  - Finding out what is likely to change.
  - Finding out what is likely to stay the same.

Implementation of Debug Message Facility, cont

```
public class Debug{
    // snip
    /**
     * Show the debug information collected
     */
    public static void showCollect(){
        for(int i = 0; i <= counter - 1; i++){
            // do NOT call real show here!
            System.out.println(coll[i]);
        }
        clearCollect();
    }

    /**
     * Clean the collected debug information
     */
    public static void clearCollect(){
        counter = 0;
    }
}
```