CMPS 251

Read Chapter 8

Packages, Enumeration & Exceptions

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Outline

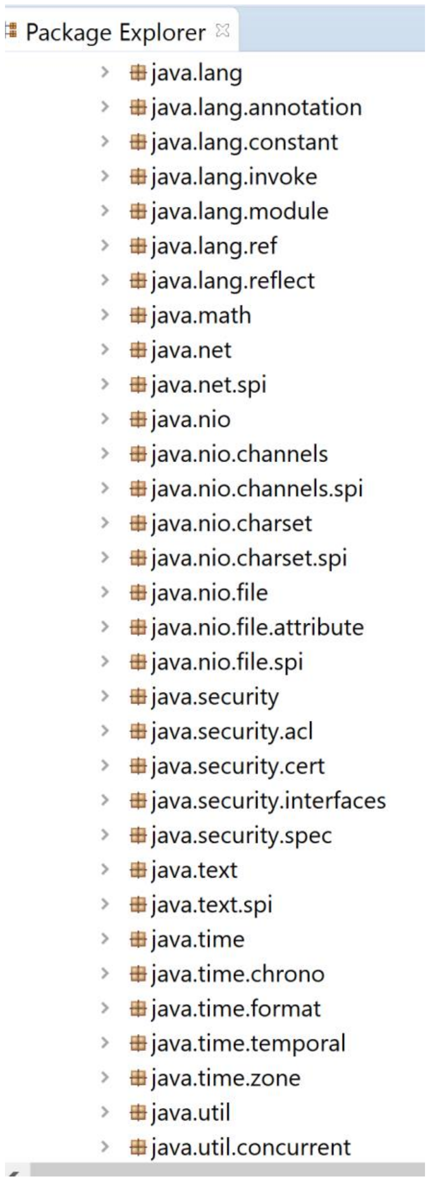
- Java Packages
- Access Modifiers
- Enumeration
- Exceptions

Packages

Packages

- Packages in Java are a way of grouping related classes together:
  - Classes performing a specific set of tasks or providing similar functionality.
- **Package = directory**. A package name is the same as the directory (folder) name which contains the .java files.
- Two main reasons packages are used:
  - Code organization: grouping functionally related classes into a package to make it easier to find and use classes
  - Avoid names collision: distinguish between classes with the same name but belong to different packages

Built-in Packages


Package Explorer

- java.lang
- java.lang.annotation
- java.lang.constant
- java.lang.invoke
- java.lang.module
- java.lang.ref
- java.lang.reflect
- java.math
- java.net
- java.net.spi
- java.nio
- java.nio.channels
- java.nio.channels.spi
- java.nio.charset
- java.nio.charset.spi
- java.nio.file
- java.nio.file.attribute
- java.nio.file.spi
- java.security
- java.security.acl
- java.security.cert
- java.security.interfaces
- java.security.spec
- java.text
- java.text.spi
- java.time
- java.time.chrono
- java.time.format
- java.time.temporal
- java.time.zone
- java.util
- java.util.concurrent

- Java fundamental classes are in *java.lang*, classes for reading and writing (input and output) are in *java.io*, lists and collections in *java.util* and so on.
- To use a class from a package, first **import** it. E.g.,

```
import java.util.ArrayList;
import java.util.List;
```

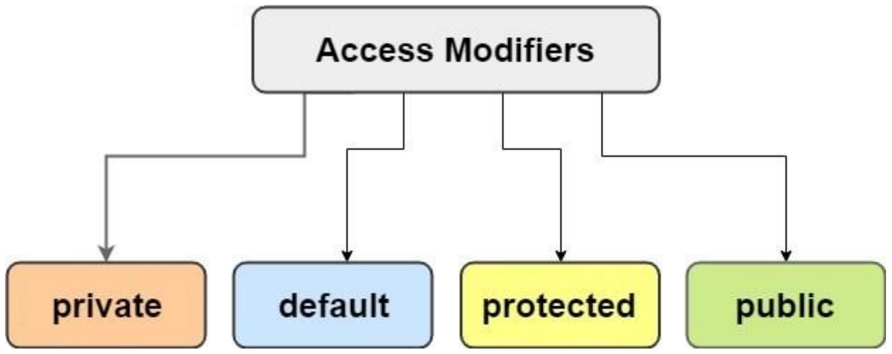
Creating a Package

- To create a package, you add **package statement** with the package name at the top of every source file that you want to include in the package

```
package quBank;

public class Account {
// OOP Principle of Encapsulation:
all attributes are private
private int id;
private String name;
private String type;
private double balance;

…
}
```

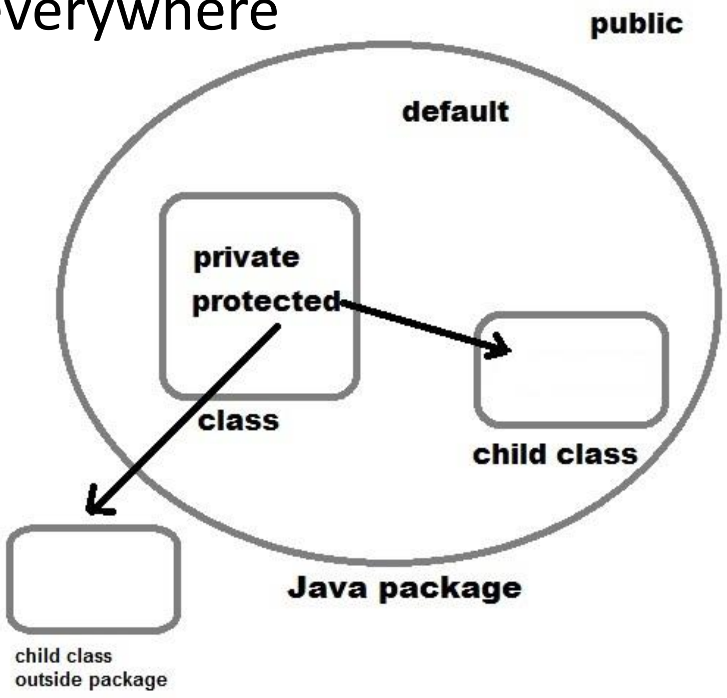
- All .java files in **quBank** package will be saved in quBank folder
- Package names are usually written in lowercase

Access Modifiers

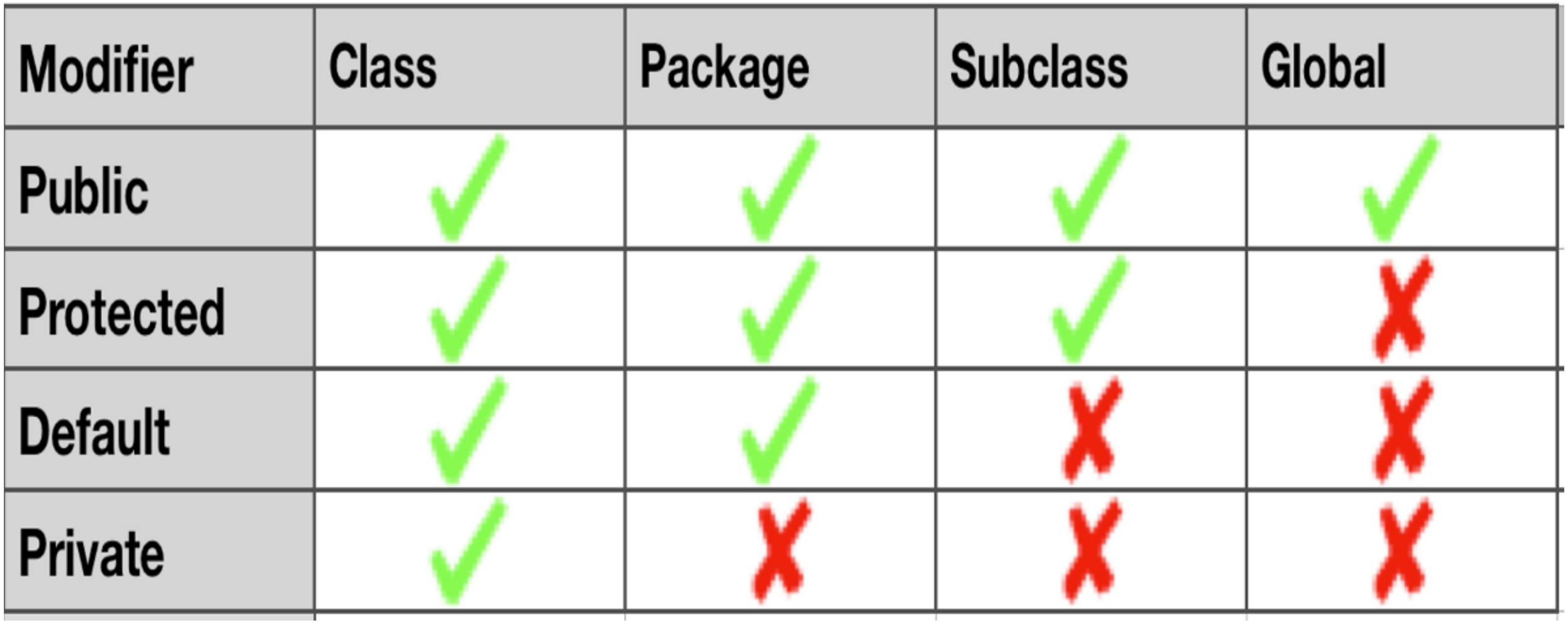


Access Modifiers

- Java language has four access modifier to control access to classes, attributes, methods and constructors.
  - Private: visible only within the classes
  - Default: visible only inside the same package
  - Protected: visible within the package and all sub classes
  - Public: is visible everywhere



Access Modifiers Summary



Modifier	Class	Package	Subclass	Global
Public	✓	✓	✓	✓
Protected	✓	✓	✓	✗
Default	✓	✓	✗	✗
Private	✓	✗	✗	✗

Enumeration

```
enum LightState {...}
```

Enumerations

- The basic enum type defines a set of constants represented as unique identifiers
- An enum type is declared with an `enum declaration`, which is a comma-separated list of enum constants
- The declaration may optionally include constructors, attributes and methods

Enumerations (Cont.)

- Each `enum` declaration declares an `enum` class with the following restrictions:
  - `enum` constants are implicitly `final`, because they declare constants that shouldn't be modified.
  - `enum` constants are implicitly `static`.
  - Any attempt to create an object of an enum type with operator `new` results in a compilation error.
  - `enum` constants can be used anywhere constants can be used, such as in the `case` labels of `switch` statements and the condition of an if statement.
- For every `enum`, the compiler generates the `static` method values that returns an array of the `enum`'s constants.
- When an `enum` constant is converted to a `String`, the constant's identifier is used as the `String` representation.

`enum` is actually a class

```
enum LightState {
  OFF,
  ON,
  DIMMED,
  FLICKERING
}
```

LightState class

public static objects

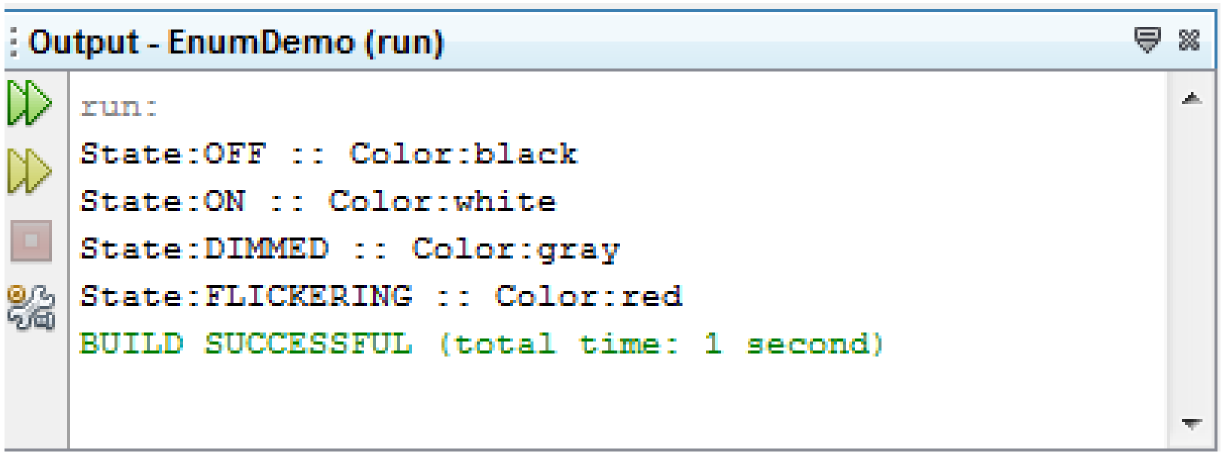
<EnumDemo.java>

```
public class EnumDemo {
    enum LightState {
        // Each object is initialized to a color.
        OFF("black"),
        ON("white"),
        DIMMED("gray"),
        FLICKERING("red");

        private final String colorField;

        // Private constructor to set the color.
        private LightState(String color) {
            colorField = color;
        }

        // Public accessor to get color.
        public String getColor() {
            return colorField;
        }
}

    public static void main(String[] args) {
        LightState off = LightState.OFF;
        LightState on = LightState.ON;
        LightState dimmed = LightState.DIMMED;
        LightState flickering = LightState.FLICKERING;
```

You can enhance the enum class with instance variables and methods

<EnumDemo.java>

```
        System.out.println("State:" + off.toString() +
                                   " :: Color:" + off.getColor());
        System.out.println("State:" + on.toString() +
                                   " :: Color:" + on.getColor());
        System.out.println("State:" + dimmed.toString() +
                                   " :: Color:" + dimmed.getColor());
        System.out.println("State:" + flickering.toString() +
                                   " :: Color:" + flickering.getColor());
    }// end main()
}// end EnumDemo
```



Output - EnumDemo (run)

```
run:
State:OFF :: Color:black
State:ON :: Color:white
State:DIMMED :: Color:gray
State:FLICKERING :: Color:red
BUILD SUCCESSFUL (total time: 1 second)
```

Exceptions

Handling Exceptions

- An exception is an error that happens during the program execution.
- When the Java Virtual Machine (JVM) or a method detects a problem, such as an *invalid array index* or an *invalid method argument*, it **throws an exception**.
- E.g., trying to access an array element outside the bounds of the array.
  - Java doesn’t allow this.
  - JVM checks that array indices to ensure that they are greater **>= 0** and **< the array size**. This is called **bounds checking**.
  - If a program uses an invalid index, JVM throws an exception to indicate that an error occurred in the program at execution time.

Handling Exceptions (Cont.)

- An **exception** indicates a problem that occurs while a program executes.
- Exception handling helps you create **fault-tolerant programs** that can resolve (or handle) exceptions.
- To handle an exception, place any code that might throw an exception in a **`try` statement**.
- The **`catch` block** contains the code that *handles* the exception. You can have many `catch` blocks to handle different *types* of exceptions.

Handling Exceptions - Example

```
try {
    int nums[] = {3, 5, 9};
    System.out.println(nums[3]);
    System.out.println("nums array size: " + nums.length);
}
catch (IndexOutOfBoundsException ex){
     System.out.println(ex.getMessage());
}
```

- The program attempts to access an element *outside* the bounds of the array
  - the array has only 3 elements (with indexes 0-2).
- JVM throws **`ArrayIndexOutOfBoundsException`** to notify the program of this problem.
- At this point the **`try` block** terminates and the **`catch` block** begins executing
  - if you declared any local variables in the `try` block, they're now out of scope.

Handling Exceptions - Example

```
try {
    int[] nums = null;
    System.out.println("nums array size: " + nums.length);
}
catch (NullPointerException ex){
     System.err.println(ex.toString());
}
```

- A `NullPointerException` occurs when you try to call a method on a **null reference**.
- Ensuring that references are not null before you use them to call methods prevents `NullPointerExceptions`.

Throwing Exceptions

```java
// Time1.java
// Time1 class declaration maintains the time in 24-hour format.

public class Time1 {
   private int hour; // 0 - 23
   private int minute; // 0 - 59
   private int second; // 0 - 59

   // set a new time value using universal time; throw an
   // exception if the hour, minute or second is invalid
   public void setTime(int hour, int minute, int second) {
      // validate hour, minute and second
      if (hour < 0 || hour >= 24 || minute < 0 || minute >= 60 ||
         second < 0 || second >= 60) {
         throw new IllegalArgumentException(
            "hour, minute and/or second was out of range");
      }

      this.hour = hour;
      this.minute = minute;
      this.second = second;
   }
```

Throwing Exceptions

- Method `setTime` declares three `int` parameters and uses them to set the time.
- Lines 13–14 test each argument to determine whether the value is outside the proper range.
- For incorrect values, `setTime` throws an exception of type **`IllegalArgumentException`**
  - Notifies the client code that an invalid argument was passed to the method.
  - The **throw statement** creates a new object of type **`IllegalArgumentException`** and specifies a custom error message.
  - `throw` statement immediately terminates method `setTime` and the exception is returned to the calling method that attempted to set the time.

try and catch

```java
18       // attempt to set time with invalid values
19       try {
20          time.setTime(99, 99, 99); // all values out of range
21       }
22       catch (IllegalArgumentException e) {
23          System.out.printf("Exception: %s%n%n", e.getMessage());
24       }
25
26       // display time after attempt to set invalid values
27       displayTime("After calling setTime with invalid values", time);
28    }
29
30    // displays a Time1 object in 24-hour and 12-hour formats
31    private static void displayTime(String header, Time1 t) {
32       System.out.printf("%s%nUniversal time: %s%nStandard time: %s%n",
33          header, t.toUniversalString(), t.toString());
34    }
35 }
```

Lines 19 to 24 use **try…catch** to catch and handle the exception (e.g., display the error message to the user)