CMPS 251

Read Chapter 8

Packages, Enumeration & Exceptions

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Outline

- Java Packages
- Access Modifiers
- Enumeration
- Exceptions

Packages

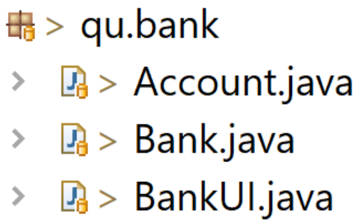
Packages

- Packages are a way of grouping functionality related classes

- 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

- Packages are mapped to **nested folders** on disk to provide physical grouping of `.java` files. E.g.,

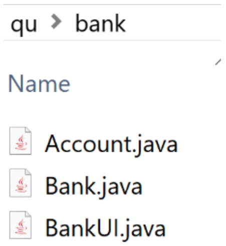
Package



> qu.bank
> Account.java
> Bank.java
> BankUI.java

Mapped to

Folders and files on Disk

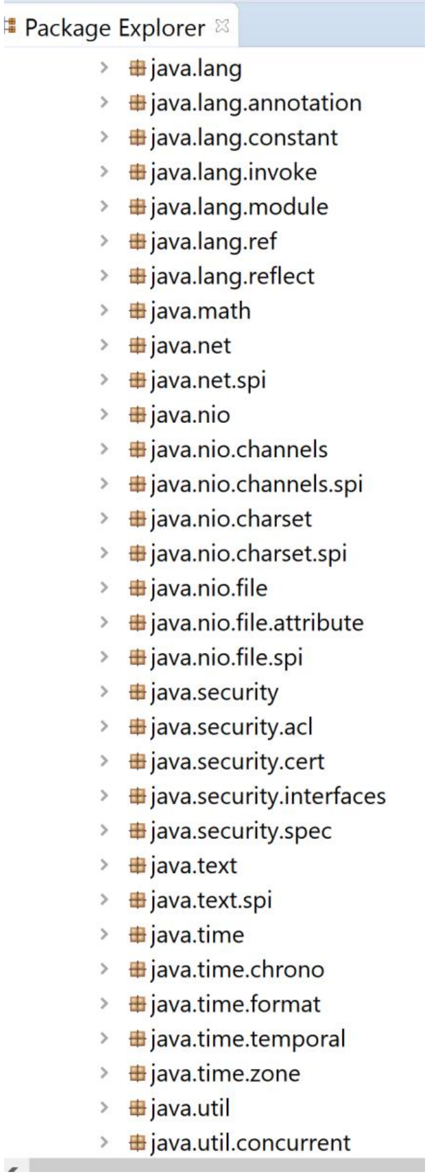


qu › bank

Name

Account.java
Bank.java
BankUI.java

Built-in Packages



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

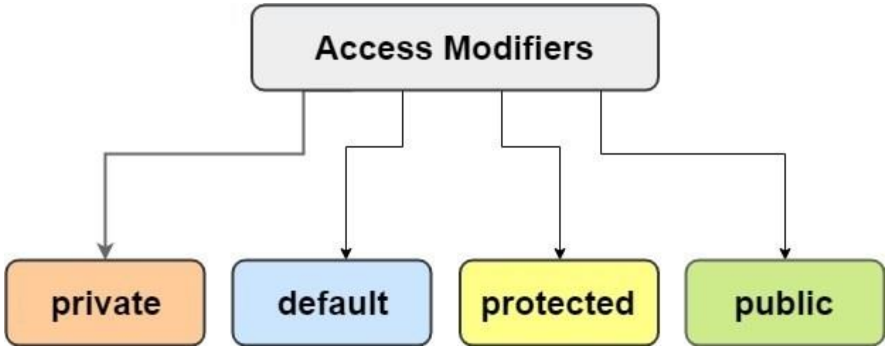
- To create a package, you add **package statement** with the package name at the top of every source file that you want to include in the package

```
package qu.bank;

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 **qu.bank** package will be saved in **qu\bank** folder

- Package names are usually written in lowercase

Access Modifiers



Access Modifiers

private

default

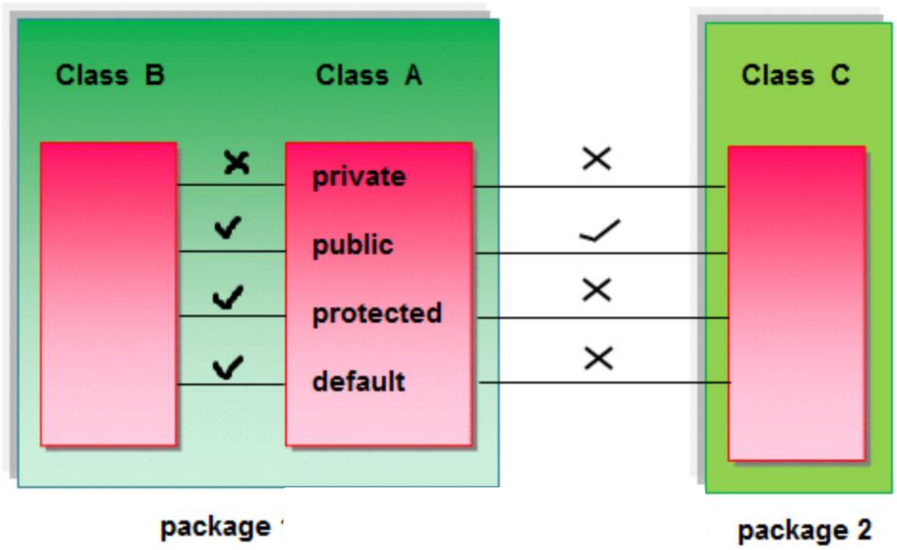
protected

public

Access Modifiers

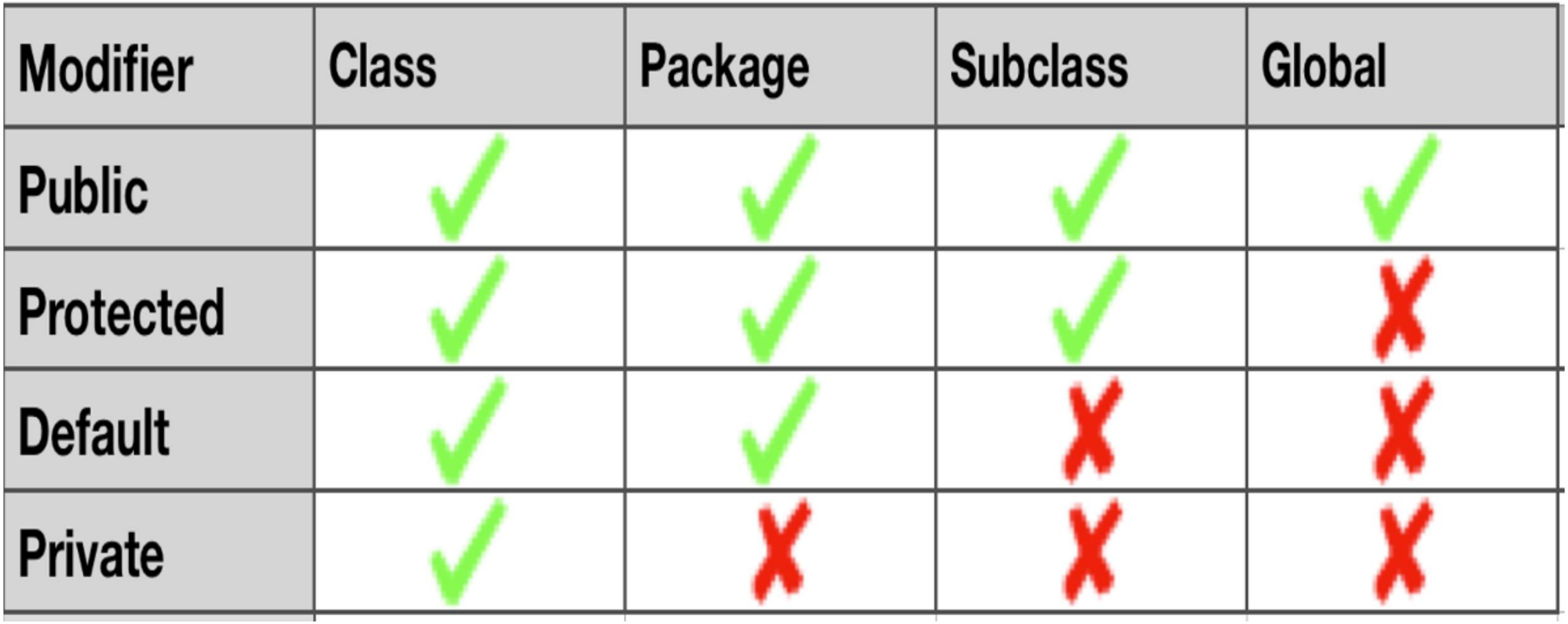
- Java language has four access modifier to control access to classes, attributes, methods and constructors.
  - **Private**: visible only within the class
  - **Default (no modifier)**: visible only within the same package.

    Very rarely used. Don’t omit modifier without a good reason.
  - **Protected**: visible within the same package and to sub classes outside the package.
  - **Public**: visible everywhere



If *Class C* is child of *Class A* then the protected members of *A* will be visible in *C*

Access Modifiers Summary



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

Access Modifiers Summary

Situation	public	protected	default	private
Accessible to class from same package?	yes	yes	yes	no
Accessible to class from different package?	yes	no, unless it is a subclass	no	no

Enumeration

```
public enum Gender
{
   FEMALE,
   MALE;
}
```

Enumerations

- You can group a set of **related constant values** in an **`enum`** type (short for enumeration).
  - For example, gender enum values could be Male, Female. The direction could be North, South, East, and West.
- It makes sense to create an **`enum`** type when the possible values of a variable can be enumerated (e.g., Gender, Direction, Days of week, Month of yea)
- An enum type is declared with: **`enum EnumName`**

Then a comma-separated list of enum constants

- The enum type may optionally include constructors, attributes and methods

Enumerations (Cont.)

- Each `enum` internally implemented by using 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

Color class

```
enum Color
{
    RED,
    GREEN,
    BLUE;
}
```

public static
objects

```
/* Internally above enum Color is converted to Color class */
class Color
{
     public static final Color RED = new Color();
     public static final Color BLUE = new Color();
     public static final Color GREEN = new Color();
}
```

TrafficLight Enum Example

- You can enhance the enum class with instance attributes and methods

```
public enum TrafficLight {
    // Each object initialize its associated duration.
    GREEN(50),
    YELLOW(4),
    RED(60);

    private final int duration;
    // Private constructor to set the duration.
    private TrafficLight(int duration) {
      this.duration = duration;
    }

    // Public accessor to get the duration.
    public int getDuration() {
      return duration;
    }
}
```

Enum Usage Example

```java
public static void main(String[] args) {
  TrafficLight lightState = TrafficLight.GREEN;
  // String to Enum value
  lightState = TrafficLight.valueOf("GREEN");


  System.out.println("lightState value: " + lightState + " -
                lightState.toString(): " + lightState.toString());

  for (var state : TrafficLight.values()) {
      System.out.println(state + " stays on for " +
           state.getDuration() + "s");
  }
}
```

```
lightState value: GREEN - lightState.toString(): GREEN

GREEN stays on for 50s
YELLOW stays on for 4s
RED stays on for 60s
```

Exceptions

What is an Exception?

- An exception indicates a problem that occurs while a program executes.
- 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 **>= 0** and **< the array’s 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

- 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 that might be thrown in the corresponding try block
  - An exception object's .**toString** or .**getMessage** method returns the exception's error message

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.err.println(ex.getMessage());
}
```

- The program attempts to access an element *outside* the bounds of the array
  - the array has only 3 elements (with an index 0 to 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.

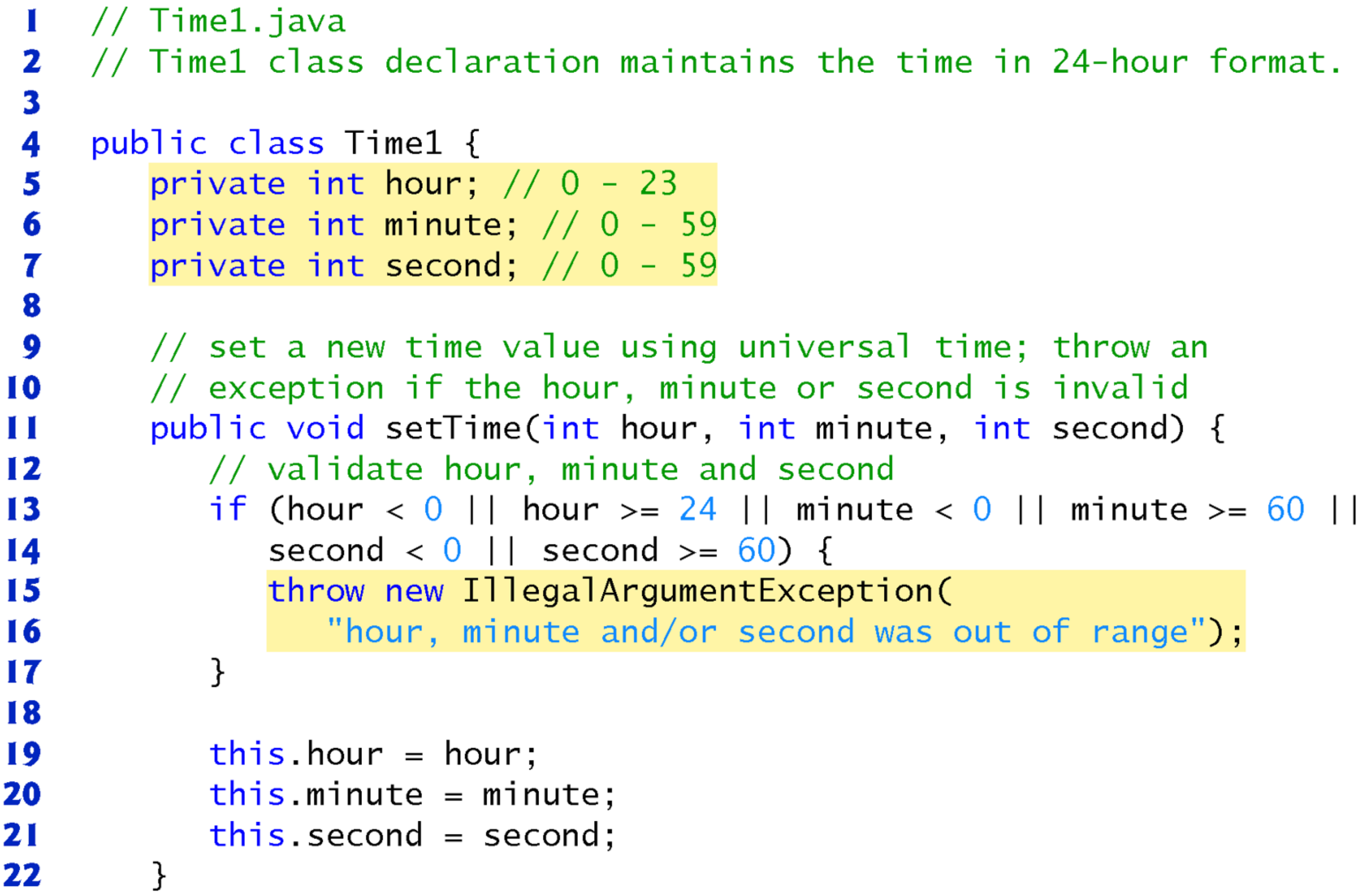
Handling Exceptions – Example 2

```
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 Null Pointer Exceptions.

Throwing Exceptions

- Use **throw** to return an exception object to the caller



```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

```
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)