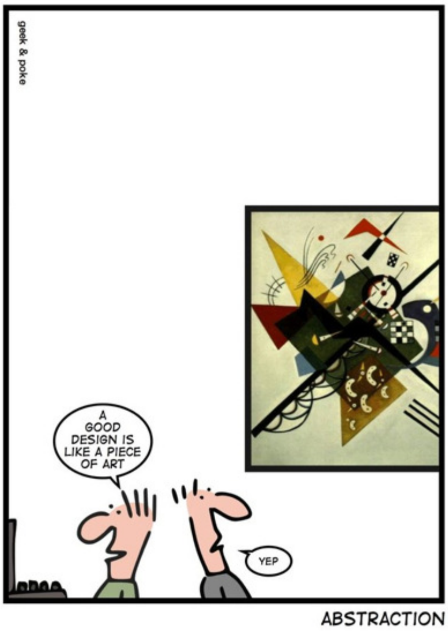


OBJECT-ORIENTED PROGRAMMING

Controlling State and Behavior of Objects

Lecture #2

TECHNICAL UNIVERSITY OF KOSICE

Encapsulation

- "*Encapsulation is the process of compartmentalizing the elements of an abstraction that constitute its structure and behavior; encapsulation serves to separate the contractual interface of an abstraction and its implementation.*" (G. Booch)
- "*Encapsulation is a mechanism used to hide the data, internal structure, and implementation details of an object. All interaction with the object is through a public interface of operations.*" (C. Larman)
- Classes should be **opaque**
- Classes should **not expose** their internal implementation details

Encapsulation

- An **abstraction** focuses on the outside view of an object and separates an object's behavior from its implementation
  - There are internal (hidden) details of the object and external (exposed) details – interface of the object
  - **Encapsulation** is the main tool of object abstraction
- **Instance variables** of the class represent **state** of the object
  - State of the object is its internal property and should be controlled only by the object itself
  - The sate of the object can be manipulated only by the **behavior** of the object
- **Methods** of the class represent **behavior** of the object
  - Some behaviors are internal and controlled only within the object
  - Some behaviors represents interaction of the object with other objects
    - This forms the **interface** of the object

Practical information hiding

- General principle of information hiding: Use private members and appropriate public **accessors** and **mutators** (get/set methods) wherever possible
- Wrong implementation

```
public double price;
```

- Correct implementation

```
private double price;
public double getPrice() {
  return this.price;
}
public void setPrice(double price) {
  this.price = price;
}
```


Accessibility modificators

- Accessibility of each class member can be defined by the **accessibility modificators** in OO programming languages
- **`public`**
  - The member is accessible from the outside of the object
  - Another object can freely access this member, e.g.

```
article.price = 10.35;
shop.sell(article, 1);
```

- **`private`**
  - The member is accessible only from the internal members (methods) of the object and cannot be directly exposed to other objects
  - Private members are hidden inside the object

Using accessors and mutators

- You can put constraints on values

```
public void setPrice(double newPrice) {
  if (newPrice < 0.0) {
    sendErrorMessage(...);
    newPrice = Math.abs(newPrice);
  }
  this.price = newPrice;
}
```

- If users of your class accessed the fields directly, then they would each be responsible for checking constraints

TECHNICAL UNIVERSITY OF KOSICE

Using accessors and mutators

- You can change your internal representation without changing the interface

```
// Now using euro currency (EUR, not SKK)
public void setPriceInSKK(double newPrice) {
  this.price = convert(newPrice);
}
public void setPriceInEUR(double newPrice) {
  this.price = newPrice;
}
```

TECHNICAL UNIVERSITY OF KOSICE

Using accessors and mutators

- You can perform arbitrary side effects

```
public void setPrice(double newPrice) {
  this.price = newPrice;
  notifyObservers();
}
```

- If users of your class accessed the fields directly, then they would each be responsible for executing side effects

Using the `this` keyword

- Within an instance method or a constructor, **`this`** is a reference to the current object (the object whose method or constructor is being called)
  - You can refer to any member of the current object from within an instance method or a constructor by using **`this`**
- Object-oriented programming languages implement reference to the current object
  - To access the shadowed class members
  - To have a reference to itself
- Using **`this`** in Java programming language
  - With an instance variable
  - With a constructor

Using **this** with instance variables

- The most common reason for using the **this** keyword is because an instance variable is shadowed by a method or constructor parameter
- For example, the `Article` class could be written like this

```
public class Article {
  private String name;
  private int number;
  private double price;

  public Article(String newName, int newNumber, double newPrice) {
    name = newName;
    number = newNumber;
    price = newPrice;
  }
  ...
}
```


Using **this** with instance variables

- But it has been written like this

```
public class Article {
  private String name;
  private int number;
  private double price;

  public Article(String name, int number, double price) {
    this.name = name;
    this.number = number;
    this.price = price;
  }
  ...
}
```

- Each argument to the constructor shadows one of the instance variables – inside the constructor **`price`** is a local copy of the constructor’s first argument
- To refer to the `Article` member **`price`**, the constructor must use **`this.price`**

Using **`this`** with constructor

- From within a constructor, you can also use the **`this`** keyword to call another constructor in the same class
  - Doing so is called an **explicit constructor invocation**

```
public class Article {
  private String name;
  private int number;
  private double price;

  public Article() {
    this("", 0, 0.0);
  }

  public Article(String name, int number, double price) {
    this.name = name;
    this.number = number;
    this.price = price;
  }
  ...
}
```

TECHNICAL UNIVERSITY OF KOŠICE

Using **`this`** with constructor

- There are two constructors for this class to initialize instance variables
- The no-argument constructor provides default values for all instance variables
  - Because initial values are not provided by arguments
  - The no-argument constructor calls the three-arguments constructor with three default values
- If present, the invocation of another constructor **must be the first line** in the constructor

TECHNICAL UNIVERSITY OF KOŠICE

Tends to complicate

- The existence of **static** members tends to break up the simple structures that we have discussed in previous lectures
- Static memory mode is in contrast to heap memory mode
  - Similar in other languages (e.g. C, static variables vs. dynamic memory allocation)
- Support of **global variables** and **global methods** that can be accessed without creating objects of a class

Class members

- Static variables
  - Use **`static`** keyword to define a static variable of a class
  - Static variable uses static memory mode
- Static methods
  - Use **`static`** keyword to define a static method of a class
  - Static method can be called directly, out of any class instances

Why using static variables?

- Static variable is like a **global variable**
- Value of the static variable is stored in static memory which is common for all objects of the class
  - Java creates only one copy for a static variable which can be used even if the class is never instantiated
  - Encapsulation is not broken, it is common only for objects of the class
- This feature is useful when we want to create a variable common to all instances of a class
- Example
  - One of the most common example is to have a variable that could keep a count of how many objects of a class have been created

Static variables

```
public class Circle {
  // class variable, one for the Circle class, how many circles
  public static int numCircles;

  //instance variables, one for each instance of a Circle
  public double x, y, r;

  // Constructors...
}
```

- Direct access with a class name (`ClassName.StaticVariableName`)

```
n = Circle.numCircles
```

Static variables – Example

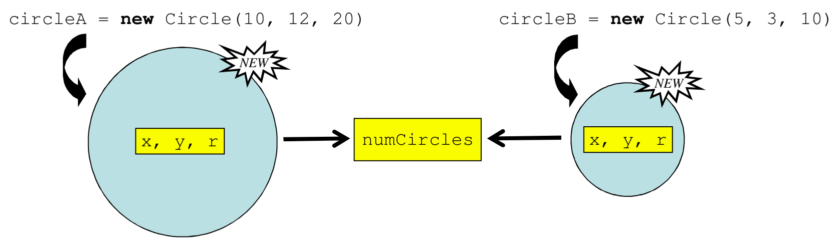
```
public class Circle {
  // class variable, one for the Circle class, how many circles
  private static int numCircles = 0;
  private double x, y, r;

  // Constructors...
  public Circle(double x, double y, double r) {
    this.x = x;
    this.y = y;
    this.r = r;
    numCircles++;
  }
}
```

Definition and initialization of the static variable

Usage of the static variable

Static variables – Example

```
public class CountCircles {
  public static void main(String[] args) {
    Circle circleA = new Circle(10, 12, 20);   // numCircles is 1
    Circle circleB = new Circle(5, 3, 10);     // numCircles is 2
  }
}
```



Instance vs. static variables

- Instance variables
  - One copy per **object**
  - Every object **has its own** instance variable, e.g. `x`, `y`, `r` (centre and radius in the circle)
- Static variables
  - One copy per **class** (all instances)
  - Every object **use the same** static variable, e.g. `numCircles` (total number of circle objects created)

TECHNICAL UNIVERSITY OF KOSICE

Constants in Java

- Static variables are mostly used as constants with **`final`** keyword in the declaration

```
public class MaxUnits {
  public static final int MAX_UNITS = 25;
}
```

- For example
  - `Math.PI`
  - `Math.E`
  - `Double.POSITIVE_INFINITY`
  - `Double.NEGATIVE_INFINITY`

TECHNICAL UNIVERSITY OF KOSICE

Static methods

- A class can have methods that are defined as static (e.g. `main` method)
- Static methods can be accessed without using objects
  - Also, there is no need to create instances
- Static methods are generally used to group related **library functions** that don't depend on data members of its class
  - For example, `Math` library functions

Static methods – Example

```
// A class with static data items comparison methods
public class Comparator {

  public static int max(int a, int b) {
    if (a > b)
      return a;
    else
      return b;
  }

  public static String max(String a, String b) {
    if (a.compareTo(b) > 0)
      return a;
    else
      return b;
  }

}
```

Static method – Example

```
public class ComapartorExample {
  public static void main(String[] args) {
    String s1 = "Kosice";
    String s2 = "Bratislava";
    String s3 = "Presov";

    int a = 10;
    int b = 20;

    System.out.println(Comparator.max(a, b));    // which number is big
    System.out.println(Comparator.max(s1, s2));  // which city is big
    System.out.println(Comparator.max(s1, s3));  // which city is big
  }
}
```

Directly accessed using classname (no objects)

Static methods restrictions

- They can only call other static methods
- They can only access static data
- They cannot refer to **`this`** or **`super`** in anyway

Guidelines for use of static variables

- Do not ever use static variables without declaring them final unless you understand exactly why you are declaring them static
  - Static final variables, or constants, are often very appropriate
- There are only few situations where the use of a non-final static variable (global variable) might be appropriate
  - One appropriate use might be to count the number of objects instantiated from a specific class
  - I suspect there are a few other appropriate uses as well
  - Always reduce the usage of global variables as much as possible

TECHNICAL UNIVERSITY OF KOŠICE

Guidelines for use of static methods

- Do not declare methods static if there is any requirement for the method to remember anything from one invocation to the next
  - There is no way to use the instance variables in static methods
- The method should probably also be self-contained.
  - All information that the method needs to do its job should either come from incoming parameters or from final static member variables (constants)
- The method probably should not depend on the values stored in non-final static member variables, which are subject to change over time
  - A static method only has access to other static members of the class, so it cannot depend on instance variables defined in the class
  - An example of a static method is the `sqrt()` method of the `Math` class. This method computes and "returns the correctly rounded positive square root of a `double`" where the `double` value is provided as a parameter to the method. Each time the method is invoked, it completes its task and does not attempt to save any values from that invocation to the next. Furthermore, it gets all the information that it needs to do its job from an incoming parameter

TECHNICAL UNIVERSITY OF KOŠICE

Example: Implementation of Singleton design pattern

- **Singleton** is a design pattern that restricts the instantiation of a class to one object
  - This is useful when exactly one object is needed to coordinate actions across the system

```
public class MyClass {
  private static final MyClass uniqueInstance = new MyClass();

  ...

  private MyClass() { ... }

  public static MyClass getInstance() {
    return uniqueInstance;
  }

  ...
}
```

TECHNICAL UNIVERSITY OF KOSICE

Readings

- ECKEL, B.: *Thinking in Java*. 4th Edition, Prentice Hall, 2006
  - Initialization & Cleanup (pp. 107 - 144)
  - Access Control (pp. 145 – 164)

TECHNICAL UNIVERSITY OF KOSICE