15-440: Distributed Systems

Recitation 1

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Need help?

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Object-Oriented Programming (OOP)

OOP

PROCEDURAL PROGRAMMING

OBJECT-ORIENTED PROGRAMMING

```
name = “Hammoud”;
gpa = 3.6;
year = 3;
courses = [“15440”, “15230”];

function canGraduate(gpa, year,
courses) {
    return if (year > 2 && gpa > 2);
}
```

```
Student = {
    name = “Hammoud”;
    gpa = 3.6;
    year = 3;
    courses = [“15440”, “15230”];

    canGraduate: function() {
        return if (this.year > 2 &&
                this.gpa > 2);
    }
}
Student.canGraduate();
```

OOP

PROCEDURAL PROGRAMMING

- You have methods that operate on data
- Methods and attributes/data are decoupled

OBJECT-ORIENTED PROGRAMMING

- Combine group of related functions and variables into a unit (object)
- Function does not have any inputs (because these inputs are encapsulated in the students object)
- Methods and attributes/data are coupled

OOP

A programming paradigm based on objects

OOP

A programming paradigm based on objects

- **Encapsulation**
- **Inheritance**
- **Polymorphism**
- **Abstraction**

Objects

OOP (objects)

A class groups attributes/data and methods

```
public class Student {

}
```

Access modifiers describe the accessibility (*scope*) of data

A *class* is the **blueprint** from which individual **objects** are created

OOP (objects)

A class groups attributes/data and methods

```
public class Student {
        String name;
        Double gpa;
        Integer year;
        public Boolean canGraduate(){
                return if (year > 2 &&
                gpa > 2);
        }
}
```

Instantiate objects

```
Student s1 = new Student();
Student s2 = new Student();
Student s3 = new Student();
```

Constructors

OOP (constructors)

A class groups attributes/data and methods

```
public class Student {
        String name;
        Double gpa;
        Integer year;
        public Boolean canGraduate(){
                return if (year > 2 &&
                gpa > 2);
        }
}
```

```
Student s1 = new Student();
Student s2 = new Student();
Student s3 = new Student();
```

We need to set attributes when we instantiate objects!

OOP (constructors)

A class groups attributes/data and methods

```
public class Student {
        String name;
        Double gpa;
        Integer year;
        public Student() {


        }
        public Boolean canGraduate(){
                return if (year > 2 &&
                gpa > 2);
        }}
```

```
Student s1 = new Student();

Student s2 = new Student();

Student s3 = new Student();
```

OOP (constructors)

A class groups attributes/data and methods

```
public class Student {
        String name;
        Double gpa;
        Integer year;
        public Student(name) {


        }
        public Boolean canGraduate(){
                return if (year > 2 &&
                gpa > 2);
        }}
```

```
Student s1 = new Student();

Student s2 = new Student();

Student s3 = new Student();
```

OOP (constructors)

A class groups attributes/data and methods

```
public class Student {
        String name;
        Double gpa;
        Integer year;
        public Student(name) {
                name = name;
        }
        public Boolean canGraduate(){
                return if (year > 2 &&
                gpa > 2);
        }}
```

```
Student s1 = new Student();
Student s2 = new Student();
Student s3 = new Student();
```

OOP (constructors)

A class groups attributes/data and methods

```
public class Student {
        String name;
        Double gpa;
        Integer year;
        public Student(name) {
                this.name = name;
        }
        public Boolean canGraduate(){
                return if (year > 2 &&
                gpa > 2);
        }}
```

```
Student s1 = new Student();
Student s2 = new Student();
Student s3 = new Student();
```

OOP (constructors)

A class groups attributes/data and methods

```
public class Student {
        String name;
        Double gpa;
        Integer year;
        public Student(name, sGpa) {
                this.name = name;
        }
        public Boolean canGraduate(){
                return if (year > 2 &&
                gpa > 2);
        }}
```

```
Student s1 = new Student();
Student s2 = new Student();
Student s3 = new Student();
```

OOP (constructors)

A class groups attributes/data and methods

```
public class Student {
        String name;
        Double gpa;
        Integer year;
        public Student(name, sGpa) {
                this.name = name;
                gpa = sGpa
        }
        public Boolean canGraduate(){
                return if (year > 2 &&
                gpa > 2);
```

```
Student s1 = new Student();

Student s2 = new Student();

Student s3 = new Student();
```

OOP (constructors)

A class groups attributes/data and methods

```
public class Student {
        String name;
        Double gpa;
        Integer year;
        public Student(name, sGpa) {
                this.name = name;
                gpa = sGpa
        }
        public Boolean canGraduate(){
                return if (year > 2 &&
                gpa > 2);
```

```
Student s1 = new Student("snoopy"
,"2.1");

Student s2 = new Student("popeye"
,"4.0");

Student s3 = new Student("Goofy"
,"3.6");
```

OOP (constructors)

A class groups attributes/data and methods

```
public class Student {
        String name;
        Double gpa;
        Integer year;
        public Student(name, sGpa) {
                this.name = name;
                gpa = sGpa
        }
        public Boolean canGraduate(){
                return if (year > 2 &&
                gpa > 2);
```

```
Student s1 = new Student("snoopy"
,"2.1");

Student s2 = new Student("popeye"
,"4.0");

Student s3 = new Student("Goofy"
,"3.6");
```

What happens if we don't use "this"?

OOP (constructors)

A class groups attributes/data and methods

```
public class Student {
        String name;
        Double gpa;
        Integer year;
        public Student(name, sGpa) {
                name = name;
                gpa = sGpa
        }
        public Boolean canGraduate(){
                return if (year > 2 &&
                gpa > 2);
```

```
Student s1 = new Student("snoopy"
,"2.1");

Student s2 = new Student("popeye"
,"4.0");

Student s3 = new Student("Goofy"
,"3.6");
```

What happens if we don't use "this"?

OOP (constructors)

```
s1.canGraduate();

s2.canGraduate();

s3.canGraduate();
```

```
Student s1 = new Student("snoopy","2.1");

Student s2 = new Student("popeye","4.0");

Student s3 = new Student("Goofy","3.6");
```

Encapsulation

OOP (encapsulation)

PROCEDURAL PROGRAMMING

OBJECT-ORIENTED PROGRAMMING

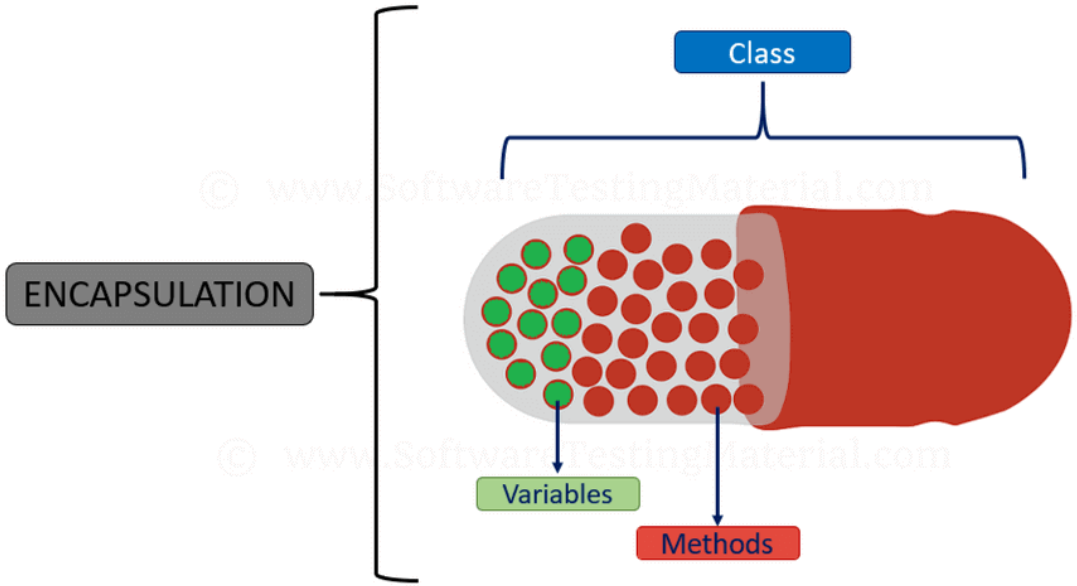
```
name = “Hammoud”;
gpa = 3.6;
year = 3;
courses = [“15440”, “15230”];

function canGraduate(gpa, year,
courses) {
    return if (year > 2 && gpa > 2);
}
```

```
Student = {
    name = “Hammoud”;
    gpa = 3.6;
    year = 3;
    courses = [“15440”, “15230”];

    canGraduate: function() {
        return if (this.year > 2 &&
                this.gpa > 2);
    }
}
Student.canGraduate();
```

OOP (encapsulation)



OBJECT-ORIENTED PROGRAMMING

```
Student = {
     name = “Hammoud”;
     gpa = 3.6;
     year = 3;
     courses = [“15440”, “15230”];

     canGraduate: function() {
          return if (this.year > 2 &&
                    this.gpa > 2);
     }
}
Student.canGraduate();
```

OOP (encapsulation)

Restricting access to an object's components

So how can we change an attribute as we encapsulate?

OOP (setters & getters)

```
public class Student {

        String name;
        Double gpa;
        Integer year;
        public Student(name, sGpa)  {…}
        public String canGraduate(){…}
        public void setName(String newName) {
                this.name = newName;
        }
        public String getName() { return name }
}
```

```
Student s1 = new Student("snoopy"
,"2.1");
s1.setName("Goofy");
```

Inheritance

OOP (inheritance)

```
public class Student {
        String name; Double gpa;
        Integer year;
        public Student() {
        }
        public String canGraduate(){
        }
}
```

```
public class IntStudent {
        String name; Double gpa;
        Integer year;
        String origin;
        public Student() {
        }
        public String canGraduate(){
        }
}
```

```
public class CrossStudent {
        String name; Double gpa;
        Integer year; String university;
        public Student() {
        }
        public String canGraduate(){
        }
}
```

OOP (inheritance)

```
public class Student {
        String name; Double gpa;
        Integer year;
        public Student() {
        }
        public String canGraduate(){
        }
}
```

Redundant code!

```
public class IntStudent {
        String name; Double gpa;
        Integer year;
        String origin;
        public Student() {
        }
        public String canGraduate(){
        }
}
```

```
public class CrossStudent {
        String name; Double gpa;
        Integer year; String university;
        public Student() {
        }
        public String canGraduate(){
        }
}
```

OOP (inheritance)

```
public class Student {
        String name; Double gpa;
        Integer year;
        public Student() {
        }
        public String canGraduate(){
        }
}
```

```
public class IntStudent extends Student {
        String origin;
}
```

```
public class CrossStudent extends Student {
        String university;
}
```

OOP (inheritance)

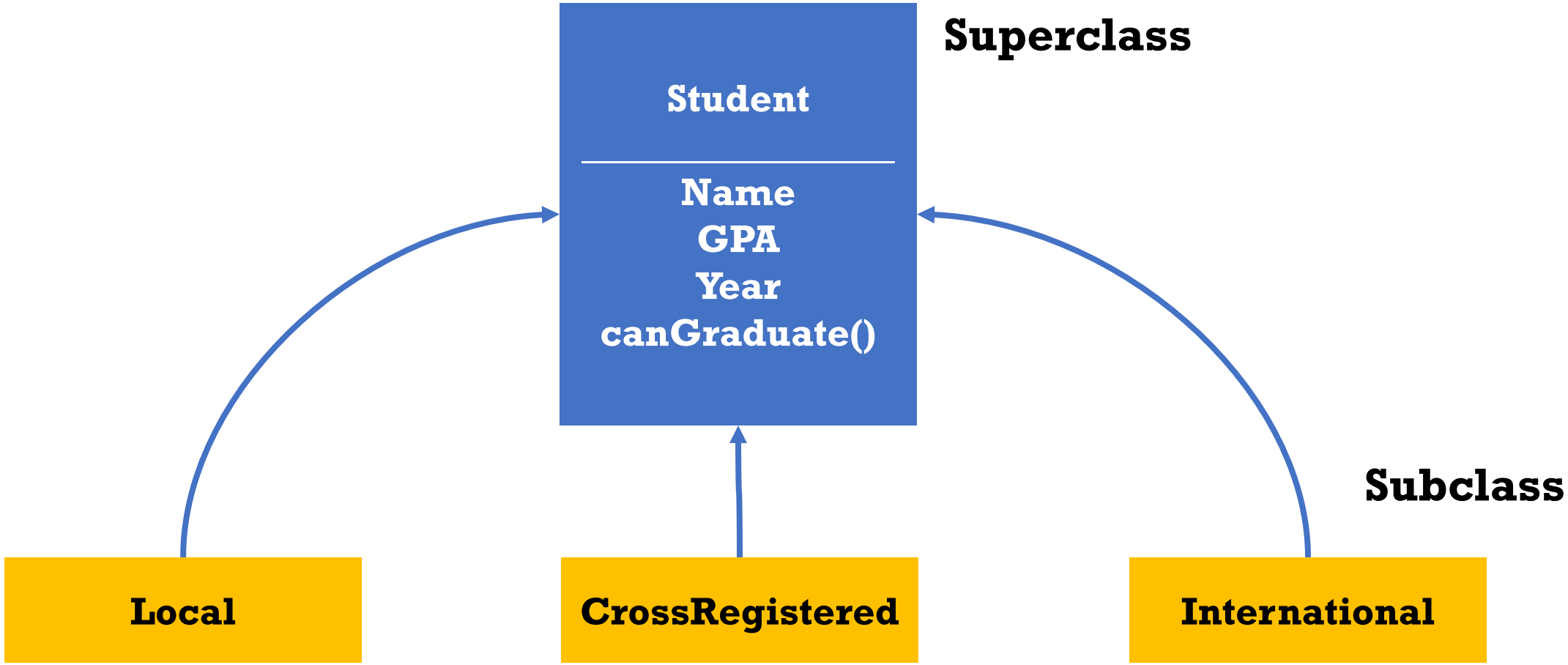
```
public class Student {
        String name; Double gpa;
        Integer year;
        public Student() {
        }
        public String canGraduate(){
        }
}
```

```
public class IntStudent extends Student {
        String origin;
}
```

```
public class CrossStudent extends Student {
        String university;
}
```

This introduces polymorphism (discussed in the next section)

OOP (inheritance)



OOP (inheritance)

- Organizes related classes in a hierarchy, which allows for reusability and extensibility of common code
- Subclasses extend the functionality of a superclass
- Subclasses inherit all the methods of the superclass (***excluding constructors and privates***)
- Subclasses can **override** methods from the superclass (more on this later)

Polymorphism

OOP (Polymorphism)

Polymorphism means "many forms", and it occurs when we have many classes that are related to each other by inheritance

Polymorphism (example)

```
public class Student {
        String name; Double gpa;
        Integer year;
        public Student() {
        }
        public Boolean canGraduate(){
        }
}
public class CrossStudent extends Student {
        String university;
        Integer grade_level;
        public Boolean canGraduate() {
                return (grade_level > 3)
        }
}
```

```
public class IntStudent extends Student {
        String origin;
        Boolean pass;
        public Boolean canGraduate() {
                return pass;
        }
}
```

Access Control

OOP (Access control)

Access modifiers describe the accessibility scope of data, methods and constructors.

Public

Allows the **access** of the object/attributes/methods from **any other** program that is using this object

Protected

You can use objects, attributes or methods with protected access modifier if within the same class, within the same package, or referenced from a subclass.

Private

Restricted than a protected variable: you can use attributes, variables and methods **only in the same class**.

```
public String name;

public String getName() { … }

private Student(String name, int sAge) { … }
```

OOP (Access control)

Public

Allows the **access** of the object/attributes/methods from **any other** program that is using this object

```
public class Student {

    public void setName(String newName) {

        this.name = newName;

    }

}

public class Test {
    public static void main(String[] args) {
        Student s1 = new Student();
        s1.setName("Snoopy");
    }
}
```

OOP (Access control)

```
public class Student {

    private void setName(String newName) {

        this.name = newName;

    }

}

public class Test {
    public static void main(String[] args) {
        Student sl = new Student();
        sl.setName("Snoopy");
    }
}
```

Private

Restricted than a protected variable: you can use attributes, variables and methods **only in the same class**.

OOP (Access control)

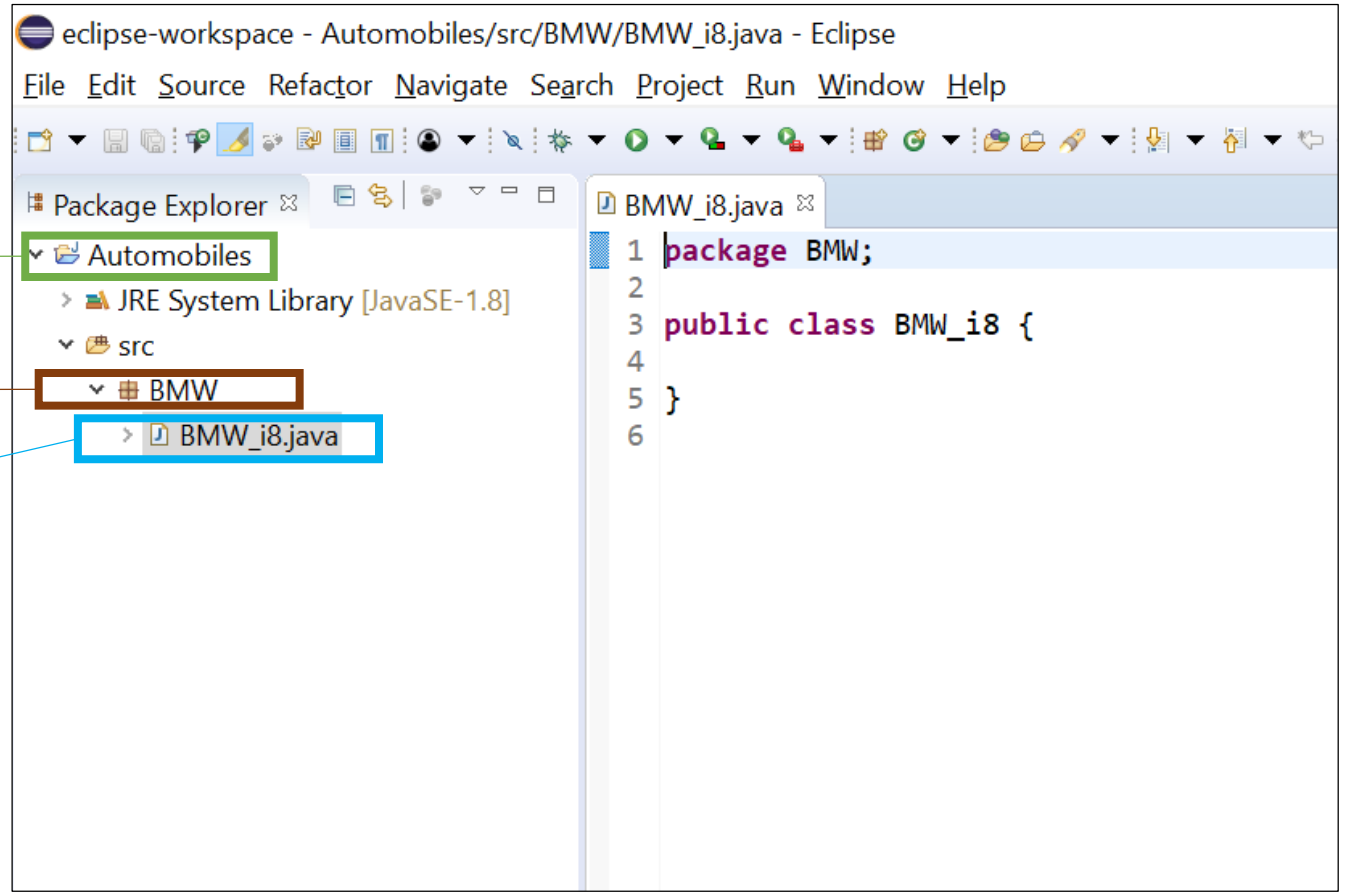
Protected

You can use objects, attributes or methods with protected access modifier if within the same class, within the same **package**, or referenced from a subclass.

Project name

Package name

Class name



Object & Class Variables

OOP (Object & Class Variables)

Object Variables

When each object has it's own variable/attribute. Such as student name, gpa, and year.

Class/static Variables

When an attribute should describe an **entire class** of objects instead of a specific object. For example, all students live on Earth. There's only one copy of this variable for the entire class

OOP (Object & Class Variables)

```
public class Student {
    public static final String currentPlanet = “EARTH”;

}


public class Test() {
    public static void main(String[] args) {
            Student Goofy = new Student();
           String planet = Goofy.currentPlanet;
    }
}
```

Class/static Variables

When an attribute should describe an **entire class** of objects instead of a specific object. For example, all students live on Earth. There’s only one copy of this variable for the entire class

Overloading

Overloading Methods

- Methods overload one another when they have the same method name but:
  - The **number of parameters** is different for the methods
  - The parameter **types** are different

```
public void changeDate(int year) {
    // do cool stuff here
}
```

```
public void changeDate(int year,
int month) {
    // do cool stuff here
}
```

```
public void addSemesterGPA(float newGPA)
{
    // process newGPA
}
```

```
public void addSemesterGPA(double
newGPA) {
    // process newGPA
}
```

Overloading Methods

```
public void changeDate(int year) {
    // do cool stuff here
}

public void changeDate(int month)
{
    // do cool stuff here
}
```

How about this?

We can't overload methods by just changing the parameter name!

Overriding

Overriding (methods)

```
public class ClassA {
    public Integer someMethod() {
            return 3;
    }
}

public class ClassB extends ClassA
{

    // this is method overriding:
    public Integer someMethod() {
            return 4;
    }
}
```

The same method specifications

(name and type) but different implementation

Overriding (Object class)

- Any class extends the **Java** superclass "**Object**".
- The Java "**Object**" class has 3 important methods:
  - public boolean equals(Object obj);
  - public int hashCode();
  - public String toString();
- The hashCode is just a number that is generated by any object:
  - It **shouldn't** be used to compare two objects!
  - Instead, **override** the equals, hashCode, and toString methods.

Overriding (Object class)

Example: **Overriding** the toString and equals methods in our Student class:

```
public class Student {
    …
    public String toString() {
        return this.name;
    }

}
```

Overriding (Object class)

Overriding the toString and equals methods in our Student class:

```
public class Student {
    …
    public boolean equals(Object obj) {
            if (obj.getClass() != this.getClass())
                    return false;
            else {
                    Student s = (Student) obj;
                    return (s.getName().equals(this.name));
            }
    }

}
```

Abstract Classes

Abstract Classes

- A class that is **not completely implemented.**
- Contains one or more *abstract* methods (methods with no bodies; *only signatures*) that subclasses must implement
- Cannot be used to instantiate objects
- Abstract class header:

```
accessModifier abstract class className
public abstract class Car
```

- Abstract method signature:

```
accessModifier abstract returnType methodName ( args );
public abstract int max_speed ();
```

- Subclass signature:

```
accessModifier class subclassName extends className
public class Mercedes extends Car
```

Interfaces

Interfaces

- A **special abstract class** in which *all the methods are abstract*
- Contains only abstract methods that subclasses **must implement**
- Interface header:

```
accessModifier    interface interfaceName
public            interface Car
```

- Abstract method signature:

```
accessModifier    abstract returnType methodName ( args );
public            abstract String   CarType    ( args );
```

- Subclass signature:

```
accessModifier    class subclassName    implements someInterface
public            class BMW             implements Car
```

Generic methods

Generic Methods

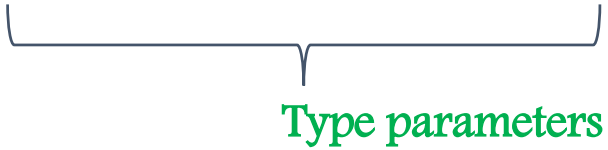
Generic or parameterized methods receive the data-type of elements as a parameter

E.g.: a generic method for sorting elements in an array (be it Integers, Doubles, Objects etc.)

A Simple Box Class

A *generic class* is defined with the following format:

```
class my_generic_class <T1, T2, ..., Tn>
{
    /* ... */
}
```



A Simple Box Class

Now to make our Box class *generic*:

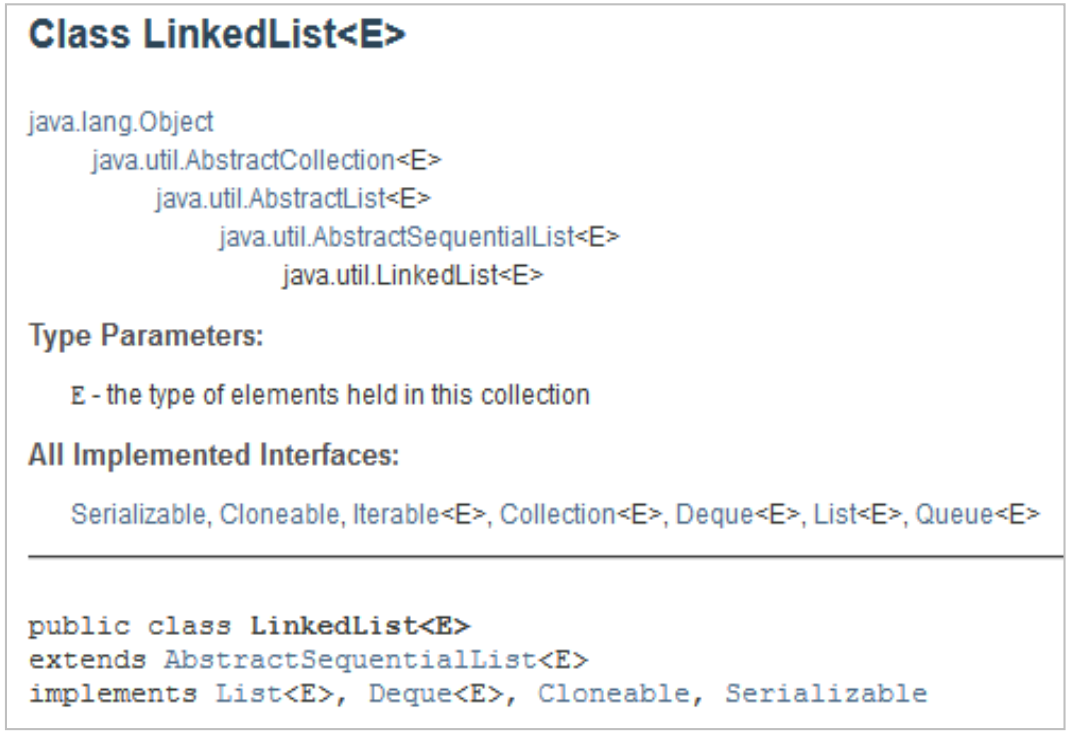
```
public class Box<T> {
        // T stands for "Type"
        private T t;
        public void set(T t) {
                this.t = t;
        }
        public T get() {
                return t;
        }
}
```

- To create, for example, an Integer "Box":

```
Box<Integer> integerBox;
```

Java Generic Collections

- Classes that represent data-structures
- *Generic* or *parameterized* since the elements' data-type is given as a parameter
- E.g.: LinkedList, Queue, ArrayList, HashMap, Tree
- They provide methods for:
  - Iteration
  - Bulk operations
  - Conversion to/from arrays



Class LinkedList<E>

java.lang.Object
  java.util.AbstractCollection<E>
    java.util.AbstractList<E>
      java.util.AbstractSequentialList<E>
        java.util.LinkedList<E>

Type Parameters:

E - the type of elements held in this collection

All Implemented Interfaces:

Serializable, Cloneable, Iterable<E>, Collection<E>, Deque<E>, List<E>, Queue<E>

```
public class LinkedList<E>
extends AbstractSequentialList<E>
implements List<E>, Deque<E>, Cloneable, Serializable
```

Bank Example

(Refer to the attached code)