15-440
Distributed Systems
Recitation 1

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Java: Object Oriented Programming

- A programming paradigm based on **objects**
- **An example of an Object** template:

```
public class Student {
}
```

Java: Object Oriented Programming

- A programming paradigm based on **objects**
- An **Object** can contain data/*attributes*:

```
public class Student {
        String name;
        int age;
        …
}
```

Java: Object Oriented Programming

- A programming paradigm based on **objects**
- An **Object** can contain *methods (behavior)*:

```
public class Student {
        …
        String name;
        public String getName() {
                return name;
        }
}
```

Java: Object Oriented Programming

- A programming paradigm based on **objects**
- To create a `Student` **Object**:

```
Student Ahmad = new Student();
```

Constructors

- Constructors take in **zero or more** variables to create an **Object**:

```
public class Student {
        String name;
        int age;
        public Student() {
        }
}

Student Ahmad = new Student();
```

Constructors

- Constructors take in **zero or more** variables to create an **Object**:

```
public class Student {
        String name;
        int age;
        public Student(String name, int sAge) {
            this.name = name;
            age = sAge;
        }
}
Student Ahmad = new Student("Ahmad","21");
```

Inheritance

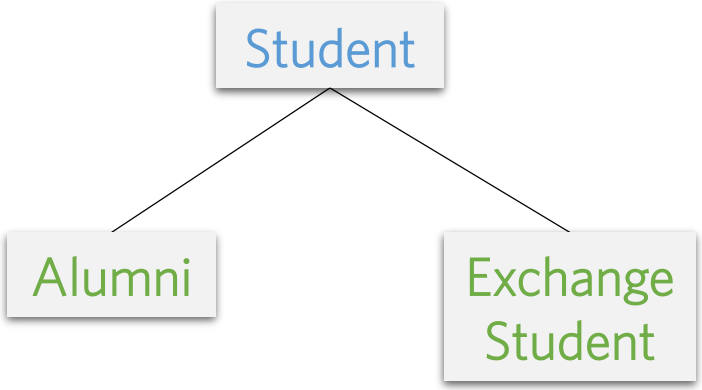
- Enables one object to inherit ***methods*** (*behavior)* and ***attributes*** from another object.
- For example, an `Alumni` class can `extend` a `Student` class:

```
public class Alumni extends Student      {
        int graduationYear;
        String jobTitle;
}
```

- `Alumni` *inherits* `name`, `age` & `getName` from `Student`.

Class Hierarchy

- This introduces subclasses and superclasses.
- A class that *inherits* from another class is called a subclass:
  - Alumni *inherits* from Student, and therefore Alumni is a subclass.
- The class that is *inherited* is called a superclass:
  - Student is *inherited*, and is the superclass.



Inheritance

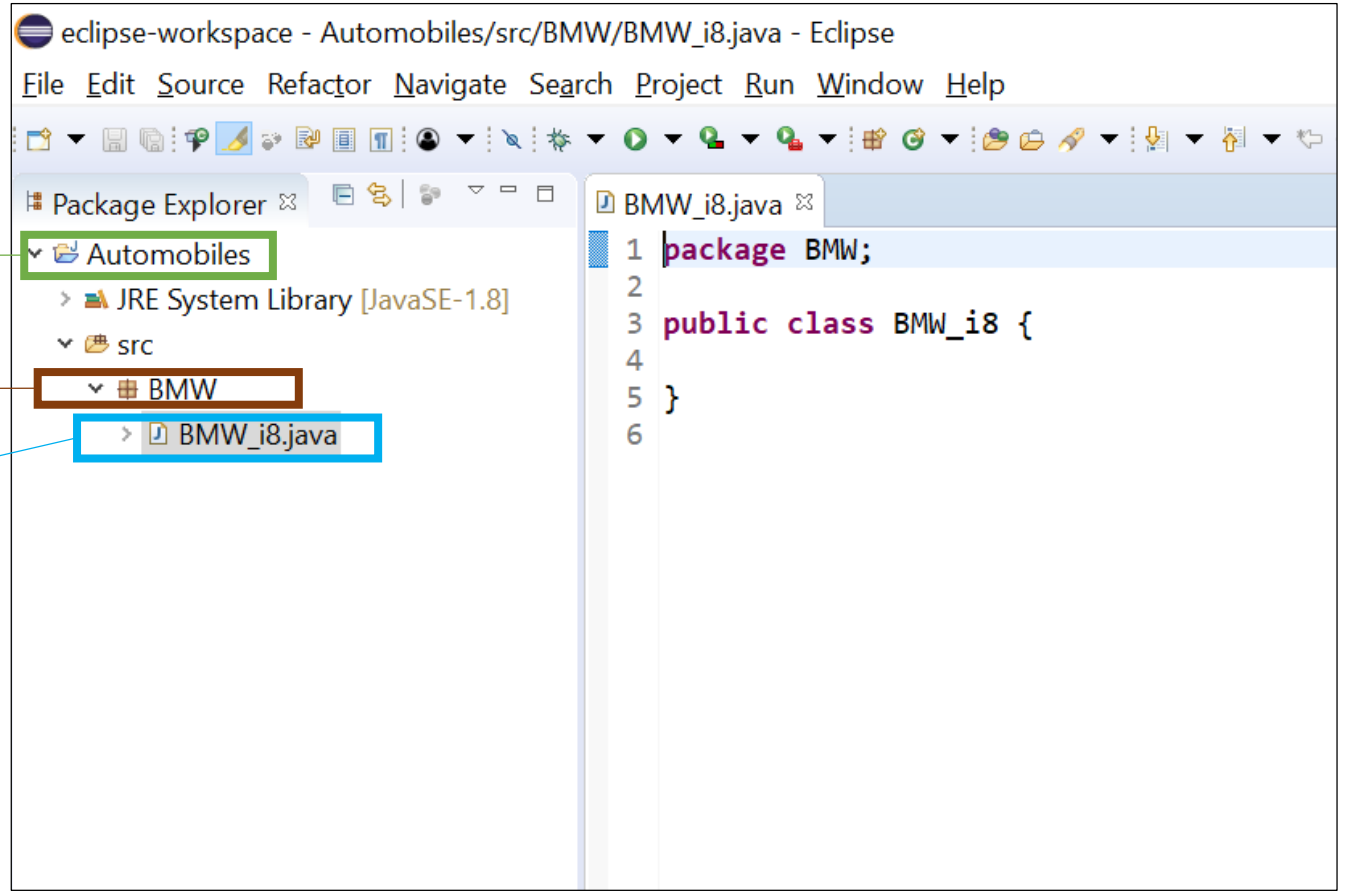
- Organizes related classes in a hierarchy:
  - This allows reusability and extensibility of common code
- Subclasses extend the functionality of a superclass
- Subclasses inherit all the methods of the superclass (***excluding constructors and privates***)
- Subclasses can **override** methods from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

Java Workspace Hierarchy

Project name

Package name

Class name



Access Control

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

- Attributes:

```
public String name;
```

- Methods:

```
protected String getName() { … }
```

- Constructers

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

Access Control

- Access modifiers include:
  - Public
  - Protected
  - Private

Access Control

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  - Public
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  - Private

Access Control

- Access modifiers include:
  - 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 Ahmad = new Student();
                Ahmad.setName("Ahmad");
        }
}
```

Access Control

- Access modifiers include:
  - Public
  - **Protected**
  - Private

Access Control

- Access modifiers include:
  - Protected:
    - You can use this only in the following
      - Same class as the variable,
      - Any subclasses of that class,
      - Or classes in the same package.
    - A package is a group of related classes that serve a common purpose.

Access Control

- Access modifiers include:
  - Public
  - Protected
  - Private

Access Control

- Access modifiers include:
  - Private:

    Restricted even further than a protected variable: you can use it **only in the same class**:

```
public class Student {
        …
        private void setName(String newName) {
                this.name = newName;
        }
        public Student(String name) {
                setName(name);
        }
}
public class Test {
        public static void main(String[] args) {
                Student Ahmad = new Student();
                Ahmad.setName("Ahmad");        // Not accessible anymore!
        }
}
```

Object & Class Variables

- Each `Student` object has its own `name`, `age`, etc...
  - `name` and `age` are examples of **Object Variables**.
- When an attribute should describe an **entire class** of objects instead of a specific object, we use **Class Variables** (or **Static Variables**).

Object & Class Variables

- A **Class Variable** Example:

```
public class Student {
        public static String University= “CMU”;
}


public class Test() {
        public static void main(String[] args) {
                Student Ahmad = new Student();
                String uni = Ahmad.University;
        }
}
```

Object & Class Variables

- A **Class Variable** Example:

```
public class Student {
        public static String University= “CMU”;
}


public class Test() {
        public static void main(String[] args) {
                String uni = Student.University;
        }
}
```

Encapsulation

- Encapsulation is **restricting access to an object's components**.
- How can we change or access `name` now?:

```
public class Student {
        private String name;
        private int age;



        }
}

Student Ahmad = new Student();
```

Encapsulation

- Encapsulation is **restricting access to an object's components**.
- Using **getters** and **setters**:

```
public class Student {
        private String name;
        private int age;
        public void setName(String newName) {
                this.name = newName;
        }
}

Student Ahmad = new Student();

Ahmad.setName("Ahmad");
```

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
- Example:

```
public void changeDate(int year) {
    // process date change
}

public void changeDate(int year, int month) {
    // process date change
}
```

Overloading Methods

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

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

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

Overloading Methods

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

```
public void changeDate(int year) {
    // process date change
}

public void changeDate(int month) {
    // process date change
}
```

Overloading Methods

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

```
public void changeDate(int year) {
    // process date change
}

public void changeDate(int month) {
    // process date change
}
```

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

Overriding Methods

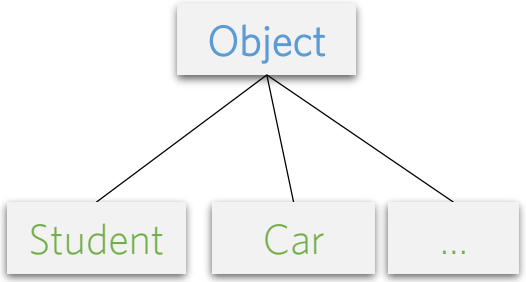
- Example:

```
public class Parent {
    public int someMethod() {
            return 3;
    }
}

public class Child extends Parent {

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

Overriding Methods



- 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 Methods

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

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

}
```

Overriding Methods

- Example: 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.name == this.name);
            }
    }

}
```

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

- 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* 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

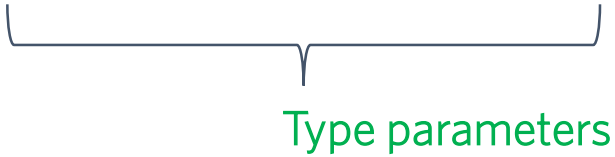
- Consider this non-generic **Box** class:

```
public class Box {
        private Object object;
        public void set(Object object) {
                this.object = object;
        }
        public Object get() {
                return object;
        }
}
```

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*:

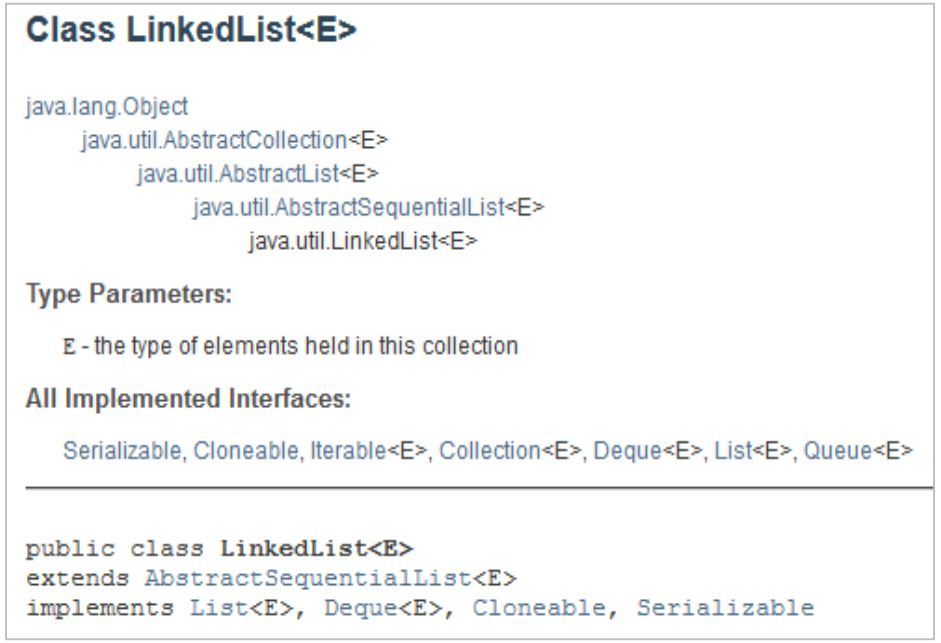
```
public class Box<T> {
        // T stands for "Type"
        private T t;
        public void set(T t) {
                this.t = t;
        }
        public T get() {
                return t;
        }
}
```

- 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
- 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
```

*The data-type passed as parameter to a collection's constructor can not be of the type *Object,* the unknown type *?, or a primitive data-type*. The data-type must be a Class.

Why Generic Functions?

- Consider writing a method that takes an array of objects, a collection, and puts all objects in the array into the collection

```
static void fromArrayToCollection(Object[] arr, Collection<?> coll) {
    for (Object o : arr) {
        coll.add(o); // compile-time error
    }
}
```

```
static <T> void fromArrayToCollection(T[] a, Collection<T> c) {
    for (T o : a) {
        c.add(o); // Correct
    }
}
```

← Generic Method

ArrayList Class

- Is a subclass of Collection
- Implements a resizable array
- Provides methods for array manipulation
- Generic or parameterized
- Declaration and Instantiation:

```
ArrayList<ClassName> arrayListName = new ArrayList<ClassName>();
ArrayList<Student>   students = new ArrayList<Student>();
```

ArrayList Methods

- Add, Get, Set, Clear, Remove, Size, IsEmpty, Contains, IndexOf, LastIndexOf, AsList etc.
- Basic Iterator:

```
for (int i = 0; i < arrayListName.size(); i++) {
    // Get object at index i
    ClassName obj = arrayListName.get(i)
    // Process obj …
}
```

- Advanced Iterator:

```
for (ClassName obj : arrayListName)  {
    // Process obj
}
```

Generic Classes with Wildcards

- Wildcards **<?>** denote "*unknown*" or "*any*" type (resembles **<T>**)

```
public void summAll(ArrayList<? extends Number> listOfNumbers) {}
```