Inheritance

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Class Employee (1/2)

```java
public class Employee {

  private final String name;
  private double salary;
  private static int lastId = 0;
  private int id;

  public Employee( String name , double salary ) {
    Employee.lastId++;
    this.id = lastId;
    this.name = name;
    this.salary = salary;
  }

  public void raiseSalary( double byPercent ) {
    double raise = salary*byPercent/100;
    salary += raise;
  }
```

Class Employee (2/2)

```java
  public void setSalary( double salary ) {
    this.salary = salary;
  }

  public double getSalary( ) {
    return this.salary;
  }

  public String getName() {
    return this.name;
  }

  public int getId() {
    return id;
  }
}
```

Extending a class

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}
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The keyword extends is used to indicate that a new class is defined that derives from an existing class.

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A subclass have more functionalities than their superclasses!

Defining and Inheriting Subclass Methods

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```
public class Manager extends Employee {
  private double bonus;
  ...
  public void setBonus(double bonus) {
    this.bonus = bonus;
  }
}
```

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  public void setBonus(double bonus) {
    this.bonus = bonus;
  }
}
```

On a Manager object we can invoke the setBonus but also all the methods defined in Employee:

```
Manager boss = new Manager( ... );
boss.setBonus(10000);
boss.raiseSalary(5);
```

Method Overriding

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```
public class Manager extends Employee {
  ...
  public double getSalary( ) {
    return super.getSalary()+this.bonus;
  }
  ...
}
```

Method Overriding

```
public class Employee {

  public boolean worksFor( Employee supervisor ) {
    ...
  }

}

public class Manager extends Employee {

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public class Manager extends Employee {

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    ...
  }

}
```

This is not overriding! A new method is defined!

Method Overriding

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public class Employee {

  public Employee getSupervisor( ) {
    ...
  }

}

public class Manager extends Employee {

  public Manager getSupervisor( ) {
    ...
  }

}
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Method Overriding

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This is overriding!

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public class Employee {

  public Employee getSupervisor( ) {
    ...
  }

}

public class Manager extends Employee {

  public Manager getSupervisor( ) {
    ...
  }

}
```

This is overriding!

The use of @Override is strongly recommended!

Subclass Construction

A subclass must invoke the appropriate constructor of its superclass to fill the `private` fields:

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```
public Manager( String name, double salary) {
  super(name,salary);
  this.bonus = 0;
}
```

Subclass Construction

A subclass must invoke the appropriate constructor of its superclass to fill the private fields:

```
public Manager( String name, double salary) {
  super(name,salary);
  this.bonus = 0;
}
```

If no super constructor is invoked, the superclass must have a default constructor that is called implicitly.

Superclass Assignment

It is legal to assign an object from a subclass to a variable whose type is a superclass:

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```
Manager boss = new Manager(...);
Employee empl = boss;
```

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Employee empl = boss;
```

Question: what happens when the following code is executed?

```
empl.getSalary();
```

The dynamic type of a receiver is used to select the method to invoke (dynamic method lookup)!

Example...

```
Employee[] staff = new Employee[...];
staff[0] = new Employee(...);
staff[1] = new Manager(...);
staff[2] = new Employee(...);
...
double sum = 0;
for (Employee e: staff) {
  sum += e.getSalary();
}
```

Example...

```
Employee[] staff = new Employee[...];
staff[0] = new Employee(...);
staff[1] = new Manager(...);
staff[2] = new Employee(...);
...
double sum = 0;
for (Employee e: staff) {
  sum += e.getSalary();
}
```

Thanks to dynamic method lookup, the right version of getSalary() is selected!

Cast

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Employee empl = new Manager(...);
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```
Employee empl = new Manager(...);
empl.setBonus(10000);
```

If really needed, we can use instanceof and explicit cast to access to methods of a subclass:

```
if (empl instanceof Manager) {
  Manager mgr = (Manager) empl;
  mgr.setBonus(10000);
}
```

Final methods

When a method is declared `final`, no subclass can override it:

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```
public class Employee {
  ...
  public final String getName() {
    return this.name;
  }
}
```

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An example of final method is the getClass method of Object.

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  public final String getName() {
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Modifier `final` can be applied also to classes to prevent others from subclassing:

Final methods

When a method is declared final, no subclass can override it:

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public class Employee {
  ...
  public final String getName() {
    return this.name;
  }
}
```

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Modifier final can be applied also to classes to prevent others from subclassing:

```
public final class Executive extends Manager {
  ...
}
```

Abstract Methods and Classes

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This method, and the class that contains it, are called abstract.

```
public abstract class Person {
  private final String name;

  public Person( String name ) {
    this.name = name;
  }

  public final String getName() {
    return name;
  }

  public abstract int getId();
}
```

Abstract Methods and Classes

```
public class Student extends Person {
  private final int id;

  public Student( int id, String name ) {
    super( name );
    this.id = id;
  }

  public final int getId() {
    return id;
  }


}
```

Protected Access

```
public class Employee {
  protected double salary;
  ...
}


public class Manager {
  ...

  public double getSalary() {
    return this.salary+this.bonus;
  }
  ...
}
```

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public class Employee {
  protected double salary;
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  public double getSalary() {
    return this.salary+this.bonus;
  }
  ...
}
```

Protected fields must be used with caution! Protected methods and constructor are more standard!

Inheritance and Default Methods

```
public interface Named {
  public String getName() { return ""; }
}

public class Person implements Named {
  ...
  public String getName() { return this.name; }
  ...
}

public class Student extends Person implements Named {
  ...
}
```

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  ...
}
```

In this case we have not a conflict! The class-win approach is used (to guarantee backward compatibility)!

Method Expressions

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```java
public class Worker {
  public void work() {
    for( int i=0 ; i<100; i++ ) {
      System.out.println("Working...");
    }
  }
}
```

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```

```java
public class ConcurrentWorker {
  public void work() {
    Thread t = new Thread(super::work);
    t.start();
  }
}
```

Object: The Cosmic Superclass!

Every Java class directly or indirectly extends the class Object:

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public class Employee { ... }
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is equivalent to

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- `boolean equals(Object other)`
- `int hashCode()`
- `Class<?> getClass()`
- `protected Object clone()`
- `protected void finalize ()`
- `wait, notify, notifyAll`

Method toString

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```
public class Employee {
  ...
  public String toString() {
    return getClass().getName()+"[name="+this.name+
      ",salary="+this.salary+"]";
  }
  ...
}
```

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  public String toString() {
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  }
  ...
}

public class Manager extends Employee {
  ...
  public String toString() {
    return super.toString()+"[bonus="+this.bonus+"]";
  }
  ...
}
```

Method equals

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Example:

```
public class Item {
  private String description;
  private double price;
  ...
  public boolean equals( Object other ) {
    if (this == other) return true;
    if (other == null) return false;
    if (getClass() != other.getClass()) return false;
    Item otherItem = (Item) other;
    return
      Objects.equals(this.description,otherItem.description)
      &&(this.price == other.price);
  }
}
```

Method equals (2)

```java
public class DiscountedItem extends Item {
  private double discount;
  ...
  public boolean equals( Object other ) {
    if (!super.equals(other)) return false;
    DiscountedItem otherItem = (DiscountedItem) other;
    return this.discount == otherItem.discount;
  }
}
```

Method hashCode

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Hash code algorithm for String:

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int hash = 0;
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Util method in class Objects:

```
public int hashCode() {
  return Objects.hash(description,price);
}
```

hashCode contract

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- Whenever it is invoked on the same object more than once during an execution of a Java application, the hashCode method must consistently return the same integer.
- If two objects are equal according to the equals(Object) method, then calling the hashCode method on each of the two objects must produce the same integer result.

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- It is transitive: for any non-null reference values `x`, `y`, and `z`, if `x.equals(y)` returns `true` and `y.equals(z)` returns `true`, then `x.equals(z)` should return `true`.

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- It is consistent: for any non-null reference values `x` and `y`, multiple invocations of `x.equals(y)` consistently return `true` or consistently return `false`, provided no information used in equals comparisons on the objects is modified.

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- It is transitive: for any non-null reference values `x`, `y`, and `z`, if `x.equals(y)` returns `true` and `y.equals(z)` returns `true`, then `x.equals(z)` should return `true`.
- It is consistent: for any non-null reference values `x` and `y`, multiple invocations of `x.equals(y)` consistently return `true` or consistently return `false`, provided no information used in equals comparisons on the objects is modified.
- For any non-null reference value `x`, `x.equals(null)` should return `false`.

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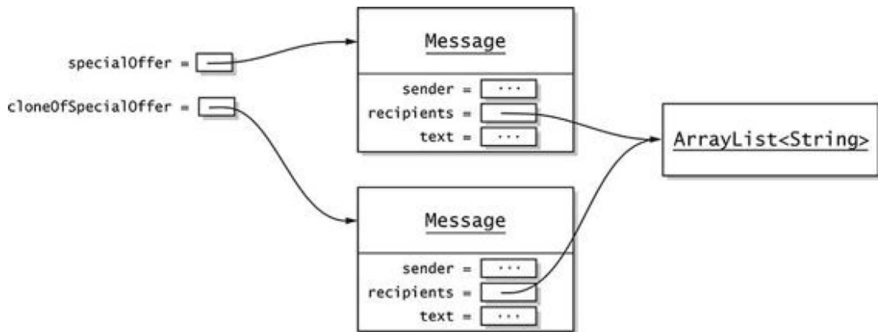
Method clone is used to make a clone. This method is declared protected so we can override it if needed.

The default implementation performs a shallow copy.

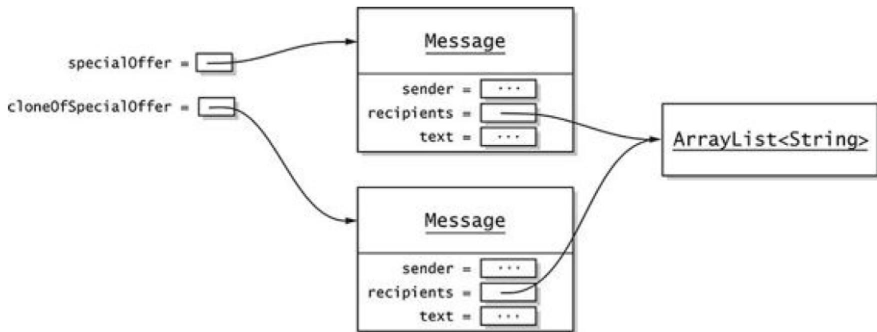
It only works for basic types:

```
public final class Message {
  private String sender;
  private ArrayList<String> recipients;
  private Strin text;
  ...
  public void addRecipient( String recipient ) { ... }
}
```

Cloning Objects



Cloning Objects



A deep copy is needed!

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When we implement a class, we have to decide whether:

1. We do not want to provide a clone method
2. The inherited clone method is acceptable
3. The clone method should make a deep copy

do nothing!

Cloning Objects

When we implement a class, we have to decide whether:

1. We do not want to provide a `clone` method

   do nothing!

2. The inherited `clone` method is acceptable

   Implement interface `Cloneable`!

3. The `clone` method should make a deep copy

   Override method `clone`!

Enumerations

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public enum Size { SMALL, MEDIUM, LARGE, EXTRA_LARGE; }
```

Elements of an enumeration can be compared with the == operator (there is only one instance of each case).

Method `toString` by default provides the name of the enumerated object (e.g. "SMALL").

Enumerations

The method valueOf can be used to build an element of the enumeration from string:

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Size[] allValues = Size.values();
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Method original can be used to get the position of an instance in the enum declaration.

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```
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```

Method original can be used to get the position of an instance in the enum declaration.

Any enumerate type E implements Comparable<E>, the comparison is performed via original values.

Constructors, Methods, and Fields

If needed we can add constructors, methods, and fields to an enumeration type:

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```
public enum Size {
  SMALL("S"), MEDIUM("M"), LARGE("L"), EXTRA_LARGE("XL");

   private String abbreviation;

   Size(String abbreviation) {
     this.abbreviation = abbreviation;
   }

   public String getAbbreviation() { return abbreviation; }

}
```

Bodies of Instances

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```
public enum Opertion {
  ADD {public int eval(int arg1,int arg2) {return arg1+arg2;}

  SUB {public int eval(int arg1,int arg2) {return arg1-arg2;}

  MUL {public int eval(int arg1,int arg2) {return arg1*arg2;}

  DIV {public int eval(int arg1,int arg2) {return arg1/arg2;}

   public abstract int eval(int arg1, int arg2);
}
```

To be continued...