Advanced Programming Methods

Lecture 1 – Java Basics

Course Overview

Object-oriented languages:

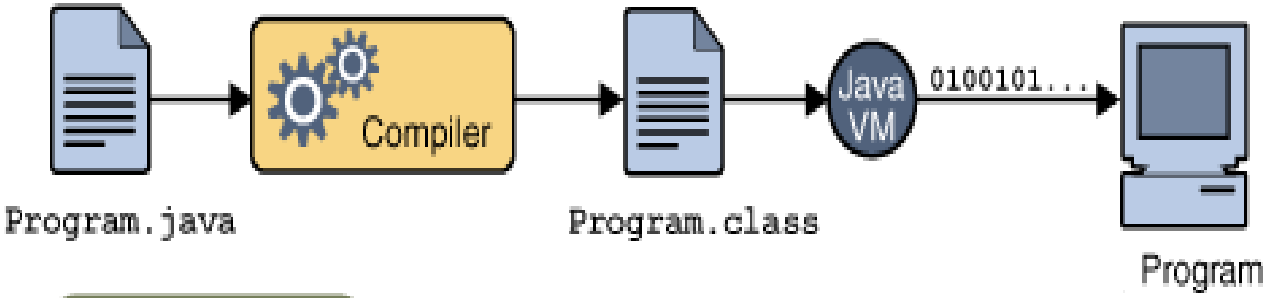
- Java (the first 10 lectures): Basics, Collections, IO, Functional Programming, Concurrency, XML, GUI, Metaprogramming

- C# (the last 3 lectures): Basics, Collections, IO

Java References

- Bruce Eckel, *Thinking in Java*
- The Java Tutorials, 2017.
  http://docs.oracle.com/javase/tutorial/index.html
- Java 9 API, 2017.
  https://docs.oracle.com/javase/9/docs/api/overview-summary.html

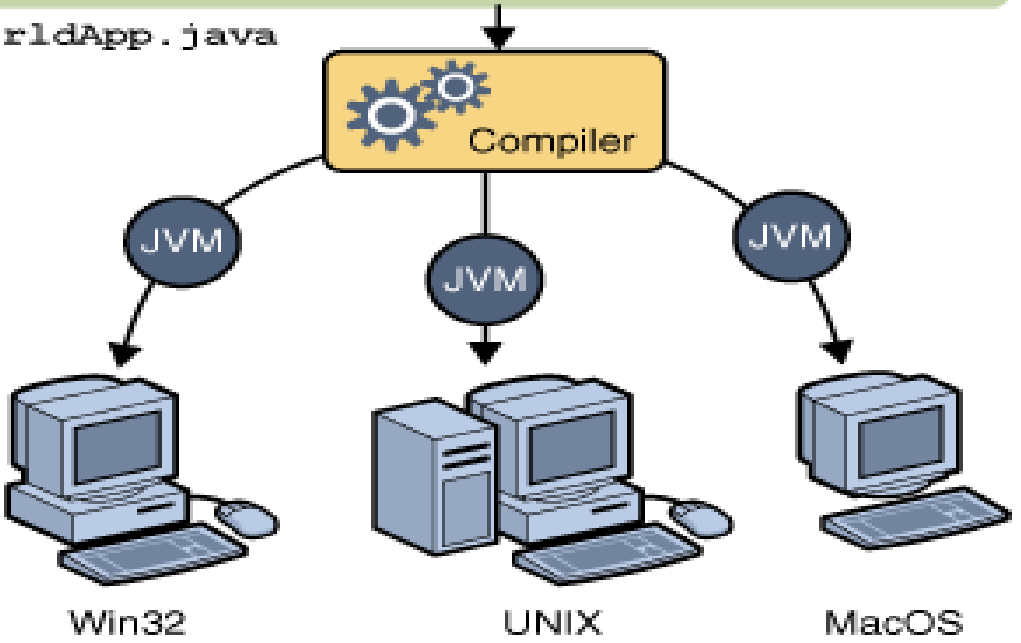
Java Technology



Java Program

```
class HelloWorldApp {
      public static void main(String[] args) {
            System.out.println("Hello World!");
      }
}
```

HelloWorldApp.java



Java Primitive Data Types

Variables Declaration:

```
type name_var1[=expr1][, name_var2[=expr2]…];
```

Primitive Data Types

Type	Nr. byte	Values	Default value
boolean	-	true, false	false
byte	1	-128 … +127	(byte)0
short	2	-2^{15} …$2^{15}-1$	(short)0
int	4	-2^{31} …$2^{31}-1$	0
long	8	-2^{63} …$2^{63}-1$	0L
float	4	IEEE754	0.0f
double	8	IEEE754	0.0d
char	2	Unicode 0, Unicode $2^{16}-1$	‘\u0000’ (null)

Primitive Data Types

Examples:

```
boolean gasit=true;
int numar=34, suma;
float eroare=0.45;
char litera='c';
litera='f';
litera=litera+1;
```

Java Comments

1. `// entire line`
2. `/* multiple`
   `lines */`
3. `/** used by documentation Javadoc tool`
   `multiple`
   `lines*/`

Obs: Comments canot be nested into strings.

```
/* … /*
*/ … */   NOT OK!
```

```
/* …
   //
   //
*/   OK!!
```

Java Constants

```
final type name [=value];
```

Examples:

a)
```
final int MAX=100;
```

b)
```
final int MAX;
…
MAX=100;
...
MAX=150; //error
```

One dimension Array

Array declaration

```
type[] name;
type name[];
```

Array allocation:

```
array_name=new type[dim]; //memory allocation
    //index  0 … dim-1
```

Accessing an array element: array_name`[index]`

Examples:

```
float[] vec;
vec=new float[10];
int[] sir=new int[3];
float tmp[];
tmp=vec;      //vec and tmp refer to the same array
```

One dimension Array

Built-in length: returns the array dimension.

```
int[] sir=new int[5];
int lung_sir=sir.length;  //lung=5;
sir[0]=sir.length;
sir.length=2;     //error

int[] y;
int lung_y=y.length;  //error, y was not created

double[] t=new double[0];
int lung_t=t.length;  //lung_t=0;
t[0]=2.3       //error: index out of bounds
```

the shortcut syntax to create and initialize an array:

```
int[] dx={-1,0, 1};
```

Rectangular multidimensional array

Declaration:

```
type name[][][]…[];
type[][][]…[] name;
```

Creation:

```
name=new type[dim1][dim2]…[dimn];
```

Accessing an element:

```
name[index1][index2]…[indexn];
```

Examples:

```
int[][] a;
a=new int[5][5];
a[0][0]=2;
int x=a[2][2];
```

Non-Rectangular Multidimensional Array

Examples:

```
int[][] a=new int[3][];
for(int i=0;i<3;i++)
    a[i]=new int[i+1];
int x=a.length;      //x=?
int y=a[2].length;   //y=?
```

Declaration+creation+initialization:

```
char[][] lit={{'a'},{'b'}};
int[][] b={{1,2},
           {2,5,8},
            {1}};
double[][] mat=new double[][]{{1.3, 0.5}, {2.3, 4.5}};
```

Char and String

```
char[] sir={'a','n','a'}; //comparison and printing
                          //is done character by character
sir[0]='A';
```

A constant Sequence of Chars :

```
"Ana are mere";           //object of type String
```

String class is immutable:

```
String s="abc";
s=s+"123";          //concatenating strings
String t=s;//t="abc123"
t+="12";            //t=?, s=?
```

String content can not be changed: `t[0]='A';`

```
char c=t.charAt(0);
```

```
method length(): int lun=s.length();
t.equals(s)
/*Returns true if and only if the argument is a String object that
represents the same sequence of characters as this object. */
compareTo(): int rez=t.compareTo(s)
/*Compares two strings lexicographically. Returns an integer indicating
whether this string is greater than (result is > 0), equal to (result is =
0), or less than (result is < 0) the argument.*/
```

Operators

arihtmetic: `+, -, *, /, %`

relational: `>, >=, <, <=, !=, ==`

increment/decrement: `++, --`

```
prefix:  int a=1;
     int b=++a; //a=2, b=2
postfix: int a=2;
     int b=a++; //a=3, b=2
```

assignment: `=, +=, -=, *=, /=`

conditional: `&&, ||, !`

`bitwise:` - shift `>>, <<, >>>,`

- conditional `&, |, ~ (not), ^ (exclusive or)`

ternary operator: `?:`

```
ex: logical_expr ? expr_1 : expr_2
 If logical_expr is TRUE then expr1 else expr2
```

Operators	Precedence (higher precedence on top, the same precedence on the same line)
1. Postfix	`expr++ expr--`
2. Unari	`++expr --expr +expr -expr ~ !`
3.	`* / %`
4.	`+ -`
5.	`<< >> >>>`
6.	`< > <= >= instanceof`
7.	`== !=`
8.	`&`
9.	`^`
10.	`|`
11.	`&&`
12.	`||`
13.	`? :`

Statements

Sequential Composition:

```
{
     instr1;
     instr2; …
}
```

Conditional:

```
if (logica_expr)
    instr;

if (logical_expr)
    instr1;
else
    instr2;
```

Obs: `logical_expr` is evaluated to `true or false`. Numerical values are not allowed.

Loop Statements

While statement:

```
while(logical_expr)
    instr
```

do-while statement:

```
do
    instr
while(logical_expr);
```

Obs: `Instr` is executed as long as `logical_expr is true.`

Loop Statement

FOR statement:

```
for(initialization;termination; step)
    instr
```

Obs: none of the `initialization, termination, step` are mandatory

```
int suma=0;
for(int i=1;i<10;i++)
   suma+=i;

for(int i=0,suma=0;i<10;i++)
        suma+=i;

    for(;;)
        // instruction
```

Enhanced FOR (EACH) statement

Syntax(JSE >=5):

```
for(Type elemName : tableName)
   instr;
```

```
int[] x={1, 4, 6, 9, 10};
for(int el:x)
  System.out.println(el);

for(int i=0;i<x.length;i++)
        System.out.println(x[i]);
```

Obs: Table elements cannot be modified by using enhanced for statement

```
 int[] x={1,4,6,10};
   for(int el:x){
      System.out.print(" "+el);
      el+=2;
   }
//1 4 6 10
   for(int e:x){
      System.out.print(" "+e);        //?
   }
```

Return statement:

```
return;
return value;
```

Break statement: terminates the execution of a loop

```
int[] x= { 2, 8, 3, 5, 12, 8, 62};
 int elem = 8;
boolean gasit = false;
 for (int i = 0; i < x.length; i++) {
            if (x[i] == elem) {
                gasit = true;
                break;
            }
    }
```

Continue statement

- skips the current iteration of a loop statement
- stops the execution of the loop instructions and forces the re-evaluation of the loop termination condition

```
int[] x= { 2, 8, 3, 5, 12, 8, 62};
int elem = 8;
int nrApar=0;
 for (int i = 0; i < x.length; i++) {
      if (x[i] != elem)
        continue;
      nrApar++;
}
```

Switch statement

```
switch(integral-selector) {
    case integral-value1 : statement; [break;]
    case integral-value2 : statement; [break;]
    case integral-value3 : statement; [break;]
    case integral-value4 : statement; [break;]
    case integral-value5 : statement; [break;]
    // ...
    default: statement;
}
```

Switch example

```
switch (luna) {
            case 1:
            case 3:
            case 5:
            case 7:
            case 8:
            case 10:
            case 12: nrZile = 31; break;
            case 4:
            case 6:
            case 9:
            case 11: nrZile = 30; break;
            case 2: if ( anBisect(an) )
                            nrZile = 29;
                    else
                            nrZile = 28;
                    break;
            default:
                System.out.println("Luna invalida");
        }
```

A simple Java program

```
//Test.java
    public class Test {
        public static void main(String[] args) {
            System.out.println("Hello");
            for(String el : args)
            System.out.println(el);
        }
    }
```

Compilation:

```
javac Test.java
```

Execution:

```
java Test

java Test ana 1 2 3
```

!!! You can use int value=Integer.parseInt(args[i]) in order to transform a string value into an int value.

Object-oriented programming Concepts

Class: represents a new data type

- Corresponds to an implementation of an ADT.

Object: is an instance of a class.

- The objects interact by messages.

Message: used by objects to communicate.

- A message is a method call.

Encapsulation(hiding)

- data (state)
- Operations (behaviour)

Inheritance: code reusing

Polymorphism – the ability of an entity to react differently depending on the context

Java Classes and Objects

- Class Declaration/Definition:

```
//ClassName.java
   [public] [final] class ClassName{
   [data (fields) declaration]
   [methods declaration and implementation]
   }
```

1. A class defined using `public` modifier it is saved into a file with the class name `ClassName.java.`
2. A file `.java` may contain multiple class definitions, but only one can be public.
3. Java vs. C++:
   - No 2 different files (.h, .cpp).
   - Methods are implemented when are declared.
   - A class declaration does not end with `;`

Java Classes and Objects

- Examples:

```
//Persoana.java
public class Persoana{
//...
}

// Complex.java
class Rational{
//...
}

class Natural{
//...
}

public class Complex{
//...
}
```

Java Classes and Objects

- Class Members (Fields) declaration:

```
... class ClassName{
    [access_modifier][static][final] Type name[=init_val];
}
```

`access_modifier` can be `public, protected, private`.

1. Class members can be declared anywhere inside a class.
2. Access modifier must be given for each field.
3. If the access modifier is missing, the field is visible inside the package (directory).

Java Classes and Objects

- Examples:

```
//Persoana.java
 public class Persoana{
    private String nume;
    private int varsta;
 //...
 }

 //Punct.java
 public class Punct{
 private double x;
 private double y;
 //...
 }
```

Java Classes and Objects

- Initializing fields
  - at declaration-site:

```
private double x=0;
```

  - in a special initialization block:

```
public class Rational{
        private int numarator;
        private int numitor;
        {
            numarator=0;
            numitor=1;
        }
        //...
}
```

  - in constructor.

Any field that is not explicitly initialized will take the default value of its type.

Constructors

- The constructor body is executed after the object memory space is allocated in order to initialize that space.

```
[...] class ClassName{
   [access_modifier] ClassName([list_formal_parameters]){
   //body
}
}
```

```
acces_modifier ∈ {public, protected, private}
```

```
list_formal_parameters takes the following form:
   Type1 name1[, Type2 name2[,...]]
```

1. The constructor has the same name as the class name (case sensitive).
2. The constructor does not have a return type.
3. For a class without any declared constructor, the compiler generates an implicit public constructor (without parameters).

Overloading Constructors

- A class can have many constructors, but they must have different signatures. .

```
//Complex.java
public class Complex{
  private double real, imag;

public Complex(){       //implicit constructor
 real=0;
  imag=0;
}

  public Complex(double real){
     this.real=real;
     imag=0;
  }

  public Complex(double real, double imag){ //...
   }

  public Complex(Complex c){ //...
   }
}
```

this

- It refers to the current (receiver) object.
- It is a reserved keyword used to refer the fields and the methods of a class.

```
//Complex.java
public class Complex{
  private double real, imag;
  //...
  public Complex(double real){
    this.real=real;
    imag=0;
  }

  public Complex(double real, double imag){
      this.real=real;
      this.imag=imag;
  }

  public Complex suma(Complex c){
  //...
  return this;
  }
}
```

Calling another constructor

- `this` can be used to call another constructor from a given constructor.

```
//Complex.java
public class Complex{
  private double real, imag;

 public Complex(){
  this(0,0);
  }

 public Complex(double real){
     this(real,0);
  }

public Complex(double real, double imag){
     this.real=real;
     this.imag=imag;
  }
  //...
 }
```

Calling another constructor

1. The call of another constructor must be the first instruction in the caller constructor.
2. The callee constructor cannot be called twice.
3. It is not possible to call two different constructors.
4. A constructor cannot be called from a method.

```
 //Punct.java
public class Punct{
   private int x, y;

   public Punct(){
     this(0,0);
   }

   public Punct(int x, int y){
       this.x=x;
       this.y=y;
   }

  public void muta(int dx, int dy){
       this(x+dx, y+dy);
   }
}
//Erorrs?
```

Creating objects

- Operator **`new:`**

```
Punct p=new Punct();   //the parentheses are compulsory
Complex c1=new Complex();
Complex c2=new Complex(2.3);
Complex c3=new Complex(1,1.5);

Complex cc; //cc=null, cc does not refer any object
cc=c3;      //c3 si cc refer to the same object in the memory
```

1. The objects are created into the heap memory.
2. The operator new allocates the memory for an object;

Defining methods

```
[...] class ClassName{
   [access_modifier] Result_Type methodName([list_formal_param]){
       //method body
   }
}
```

`access_modifier ∈ {public, protected, private}`

`list_formal_param` **takes the form** `Type1 name1[, Type2 name2[, ...]]`

`Result_Type` poate can be any primitiv type, reference type, array, or `void.`

1. If the access_modifier is missing, that method can be called by any class defined in that package (director).
2. If the return type is not `void,` then each execution branch of that method must end with the statement `return.`

Defining methods

```
//Persoana.java
public class Persoana{
   private byte varsta;
   private String nume;
   public Persoana(){
      this(“”,0);
   }
   public Persoana(String nume, byte varsta){
    this.nume=nume;
    this.varsta=varsta;
   }
   public byte getVarsta(){
      return varsta;
   }
   public void setNume(String nume){
    this.nume=nume;
   }
   public boolean maiTanara(Persoana p){//...
   }
}
```

Overloading methods

- A class may contain multiple methods with the same name but with different signature. A signature = return type and the list of the formal parameters

```
public class Complex{
  private double real, imag;
  // constructors ...
  public void aduna (double real){
   this.real+=real;
   }
   public void aduna(Complex c){
       this.real+=c.real;
       this.imag+=c.imag;
   }
   public Complex aduna(Complex cc){
   this.real+=cc.real;
   this.imag+=cc.imag;
   return this;
   }
}
//Erorrs?
```

- Java does not allow the operators overloading.
- Class String has overloaded operators `+` and `+=`.

```
String s="abc";
     String t="EFG";
     String r=s+t;
     s+=23;
     s+=' ';
     s+=4.5;
//s="abc23 4.5";
//r="abcEFG"
```

- Destructor: In Java there is no any destructor.
  - The garbage collector deallocates the memory .

Objects as Parameters

- Objects can be formal parameters for the methods

- A method can return an object or an array of objects.

```
public class Rational{
private int numarator, numitor;
//Constructors ...

public void aduna(Rational r){
//...
}
public Rational scadere(Rational r){
//...
}

}
```

Passing arguments

- Primitive type arguments (boolean, int, byte, long, double) are **passed by value**. Their values are copied on the stack.
- Arguments of reference type are **passed by value**. A reference to them is copied on the stack, but their content (fields for objects, locations for array) can be modified if the method has the rights to accces them.

1. There is not any way to change the passing mode(like & in C++).

```
class Parametrii{
    static void interschimba(int x, int y){
        int tmp=x;
        x=y;
        y=tmp;
  }
  public static void main(String[] args) {
        int x=2, y=4;
        interschimba(x,y);
        System.out.println("x="+x+" y="+y);   //?
    }
}
```

Passing arguments

```
class B{
    int val;
    public B(int x){
        this.val=x;
    }
    public String toString(){
        return ""+val;
    }
     static void interschimba(B x, B y){
        B tmp=x;
        x=y;
        y=tmp;
        System.out.println("[Interschimba B] x="+x+" y="+y);
    }
    public static void main(String[] args) {
        B bx=new B(2);
        B by=new B(4);
        System.out.println("bx="+bx+" by="+by);
        interschimba(bx,by);
        System.out.println("bx="+bx+" by="+by);   //?
     }
}
```

Passing arguments

```
class B{
    int val;
    public B(int x){
        this.val=x;
    }
    public String toString(){
        return ""+val;
    }
     static void interschimbaData(B x, B y){
        int tmp=x.val;
        x.val=y.val;
        y.val=tmp;
        System.out.println("[InterschimbaData] x="+x+" y="+y);
    }
    public static void main(String[] args) {
        B bx=new B(2);
        B by=new B(4);
        System.out.println("bx="+bx+" by="+by);
        interschimbaData(bx,by);
        System.out.println("bx="+bx+" by="+by);   //?
     }
}
```

Array of objects

- Each array element must be allocated and intialized.

```
public class TablouriObiecte {
   static void genereaza(int nrElem, Complex[] t){
        t=new Complex[nrElem];
        for(int i=0;i<nrElem;i++)
            t[i]=new Complex(i,i);
   }
   static Complex[] genereaza(int nrElem){
        Complex[] t=new Complex[nrElem];
        for(int i=0;i<nrElem;i++)
            t[i]=new Complex(i,i);
        return t;
   }
   static void modifica(Complex[] t){
        for(int i=0;i<t.length;i++)
            t[i].suma(t[i]);
   }
//...
```

Array of objects

```
  static Complex suma(Complex[] t){
        Complex suma=new Complex(0,0);
        for(int i=0; i<t.length;i++)
            suma.aduna(t[i]);
        return suma;
    }
   public static void main(String[] args) {
        Complex[] t=genereaza(3);
        Complex cs=suma(t);
        System.out.println("suma "+cs);
        Complex[] t1=null;
        genereaza(3,t1);
        Complex cs1=suma(t1);
        System.out.println("suma "+cs1);
        modifica(t);
        System.out.println("suma dupa modificare "+suma(t));

    }
}
```

The methods toString and equals

```
public class Complex{
    private double real, imag;
    public Complex(double re, double im){
      //...
    }
    public String toString(){
        if (imag>=0)
            return "("+real+"+"+imag+"i)";
        else
            return "("+real+imag+"i)";
    }

    public boolean equals(Object obj){
        if (obj instanceof Complex){
            Complex c=(Complex)obj;
             return (real==c.real) && (imag==c.imag);
        }
        return false;
    }
//...
}
```

Static methods

- Are declared using the keyword **`static`**
- **They are shared by all class instances**

```
public class Complex{
    private double real, imag;
    public Complex(double re, double im){
     //...
    }
    public static Complex suma(Complex a, Complex b){
        return new Complex(a.real+b.real, a.imag+b.imag);
    }
//...
}
```

Static methods

- They are called using the class name:

```
Complex a,b;
//... initialization a and b
Complex c=Complex.aduna(a, b);
```

1. A static method cannot use those fields (or call those methods) which are not static. It can use or call only the static members.

Static fields

```
public class Natural{
   private long val;
  public static long MAX=232.... //2^63-1
 //....
}
public class Produs {
    private static long counter;
    private final long id=counter++;
    public String toString(){
        return ""+id;
    }
   //....
```

Static fields are shared by all class instances. They are allocated only once in the memory.

Static fields

- Initialization:
  - At declaration site:

```
public static long MAX=2000;
```

  - In a special intialization block

```
public class Natural {
        public  static long MAX;
 static {
    MAX=2000;
 }
```

If a static field is not intialized, it will take the default value of its type:

```
private static long counter; //0
```

Code reusing

- *Composing*: The new class consists of instance objects of the existing classes

- *Inheritance*: A new class is created by extending an existing class (new fields and methods are added to the fields and methods of the existing class)

Composing

The new class contains fields which are instance objects of the existing classes.

```
class Adresa{
 private String nr, strada, localitate, tara;
 private long codPostal;
//...
}
```

```
class Persoana{
  private String nume;
  private Adresa adresa;
  private String cnp;
//...
}
```

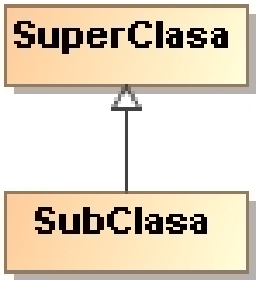
```
class Scrisoare{
  private String destinatar;
  private Adresa adresaDestinatar;
  private String expeditor;
  private Adresa adresaExpeditor
//...
}
```

Inheritance

- Using the keyword `extends:`

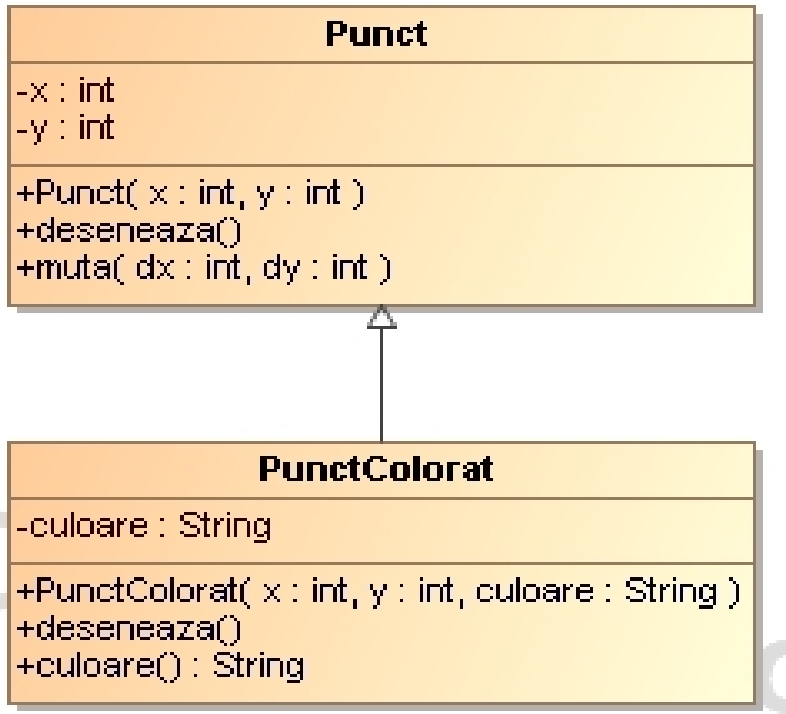
```
class NewClass extends ExistingClass{
    //...
}
```

- `NewClass` is called subclass,or child class or derived class.
- `ExistingClass` is called superclass, or parent class, or base class.
- Using inheritance, `NewClass` will have all the members of the class `ExistingClass`. However, `NewClass` may either redefine some of the methods of the class `ExistingClass` or add new members and methods.
- UML notation:



Inheritance

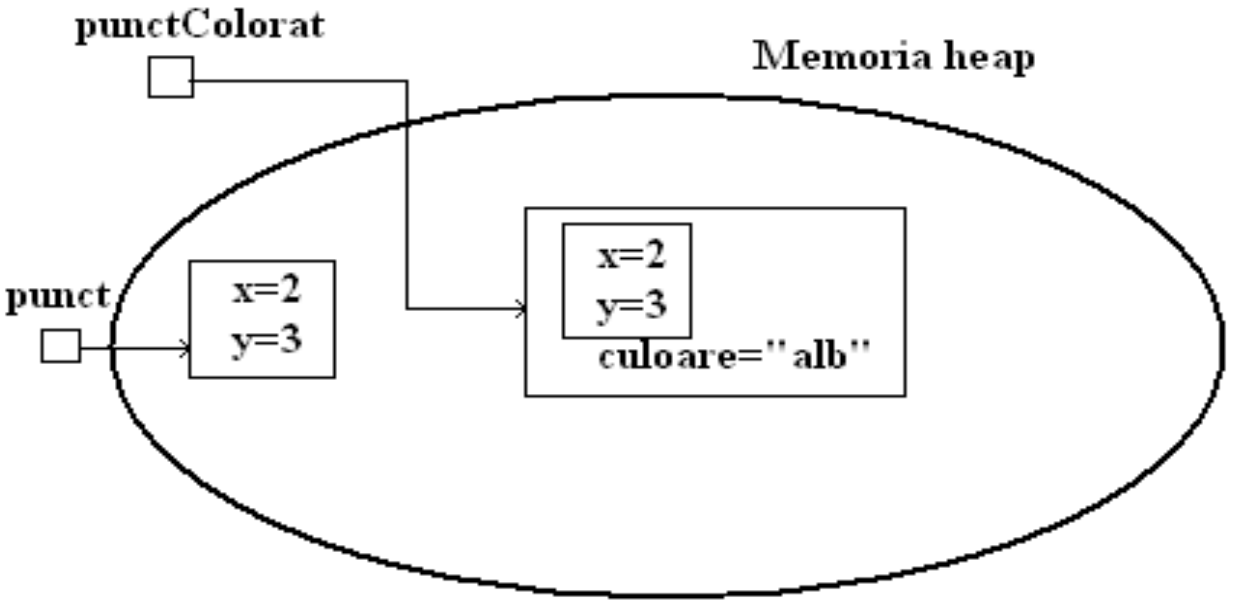
```
public class Punct{
  private int x,y;
  public Punct(int x, int y){
     this.x=x;
     this.y=y;
  }
  public void muta(int dx, int dy){
  //...
  }
  public void deseneaza(){
     //...
     }
}
public class PunctColorat extends Punct{
     private String culoare;
     public PunctColorat(int x, int y, String culoare){...}
     public void deseneaza(){...}
     public String culoare(){...}
}
```



Inheritance

- Notions
  - `deseneaza` is an overridden method.
  - `muta` is an inherited method.
  - `culoare` is a new added method.
- Heap memory:

```
Punct punct =new Punct(2,3);
PunctColorat punctColorat=new PunctColorat(2,3,"alb");
```



Method overloading

- A subclass may overload a method from the base class.
- An instance object of a subclass may call all the overloaded methods including those from the superclass.

```
public class A{
  public void f(int h){ //...
  }
  public void f(int i, char c){ //...
  }
}
```

```
public class B extends A{
  public void f(String s, int i){
    //...
  }
}
```

```
B b=new B();
b.f(23);
b.f(2, 'c');
b.f("mere",5);
```

Calling the superclass constructors

- A constructor of a subclass can call a constructor of the base class.
- It is used the keyword **super**.
- The call of the base class must be the first instruction of the subclass constructor.

```
public class Persoana{
  private String nume;
  private int varsta;
  public Persoana(String nume, int varsta){
    this.nume=nume;
    this.varsta=varsta;
  }
  //...
}
public class Angajat extends Persoana{
  private String departament;
  public Angajat(String nume, int varsta, String departament){
    super(nume, varsta);
    this.departament=departament;
  }
  //...
}
```

Fields initialization

- The initialization order:
  1. Static fields.
  2. Non-static fields which are initialized at the declaration site.
  3. The other fields are intialized with their types default values.
  4. The constructor is executed

Fields initialization

```
public class Produs{
  static int contor=0;        //(1)
  private String denumire;    //(2)
  private int id=contor++;    //(3)
  public Produs(String denumire){ //(4)
    this.denumire=denumire;
  }
  public Produs(){            //(5)
    denumire="";
  }
  //...
}

Produs prod=new Produs();         // (1), (3), (2), (5)

Produs prod2=new Produs("mere"); //?
```

Fields initialization and inheritance

- First the base class fields are initialized and then those of the derived class
- In order to initialize the base class fields the default base class constructor is called by default. If the base class does not have a default constructor, each constructor of the derived class must call explicitly one of the base class constructors.

```
public class Punct{
  private int x,y;
  public Punct(int x, int y){
     this.x=x;
     this.y=y;
  }
}
public class PunctColorat extends Punct{
  private String culoare;
  public PunctColorat(int x, int y, String culoare){
    super(x,y);
    this.culoare=culoare;
  }
}
```

The keyword super

- It is used in the followings:
  - To call a constructor of the base class.
  - To refer to a member of the base class which has been redefined in the subclass.

```
public class A{
  protected int ac=3;
     //...
}
```

```
public class B extends A{
  protected int ac=3;
  public void f(){
    ac+=2;  super.ac--;
  }
}
```

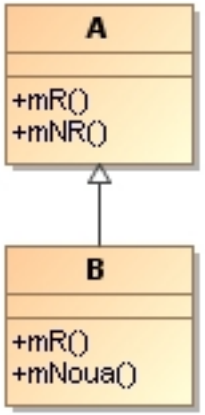
  - To call the overridden method (from the base class) from the overriding method (from the subclass).

```
public class Punct{
  //...
  public void deseneaza(){
    //...
  }
}
```

```
public class PunctColorat extends Punct{
  private String culoare;
  public void deseneaza(){
    System.out.println(culoare);
    super.deseneaza();
  }
}
```

Method overriding

- A derived class may override methods of the base class



- Rules:
  1. The class `B` overrides the method `mR` of the class `A` if `mR` is defined in the class B with the same signature as in the class `A`.
  2. For a call `a.mR()`, where `a` is an object of type `A`, it is selected the method `mR` which correspond to the object referred by `a`.

```
A a=new A();
a.mR();     //method mR from A
a=new B();
a.mR();     //method mR from B
```

  3. The methods which are not overridden are called based on the variable type.

Method overriding

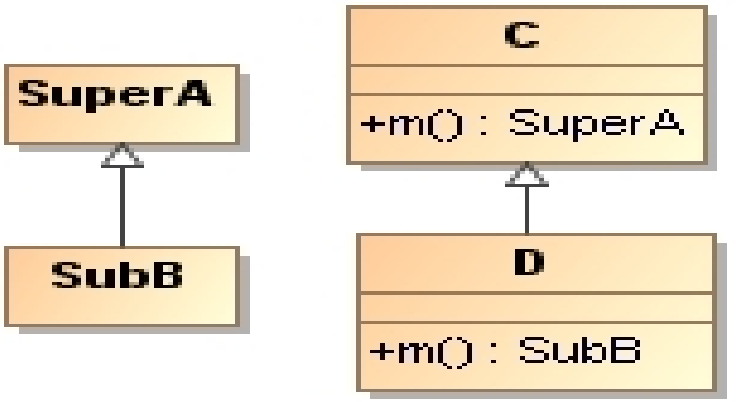
4. adnotation `@Override` (JSE >=5) in order to force a compile-time verification

```
public class A{
  public void mR(){
    //...
  }
}
```

```
public class B extends A{
  @Override
  public void mR(){
  }
}
```

4. The return type of an overriding method may be a subtype of the return type of the overridden method from the base class (*covariant return type*). (JSE>=5).

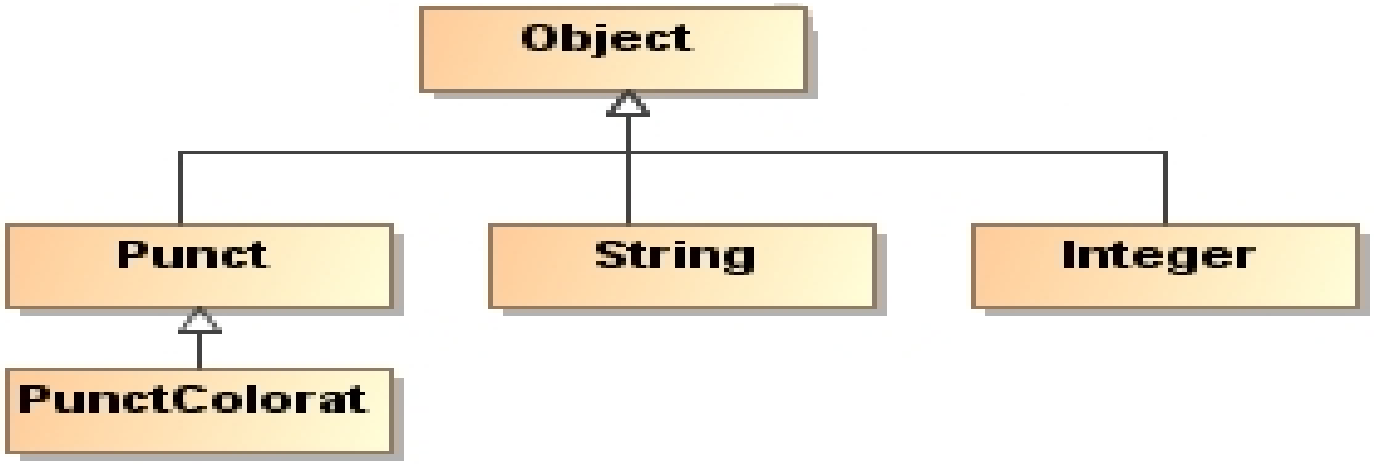
```
public class C{
  public SuperA m(){...}
}
public class D extends C{
  public SubB m(){...}
}
```



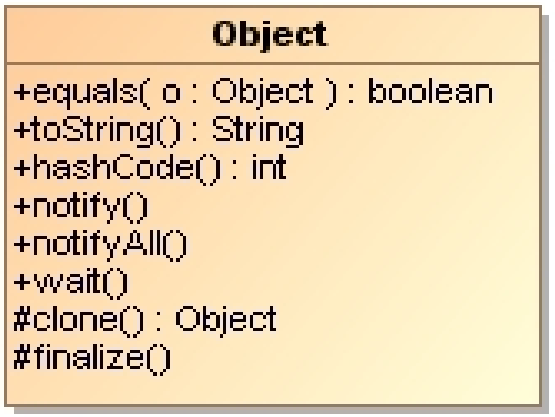
The class Object

- It is the top of the java classes hierarchy.
- By default Object is the parent of a class if other parent is not explicitly defined

```
public class Punct{
  //...
}
public class PunctColorat extends Punct{
  //...
}
```



Class Object - methods



- `toString`() is called when a String is expected
- `equals`() is used to check the equality of 2 objects. By default it compares the references of those 2 objects.

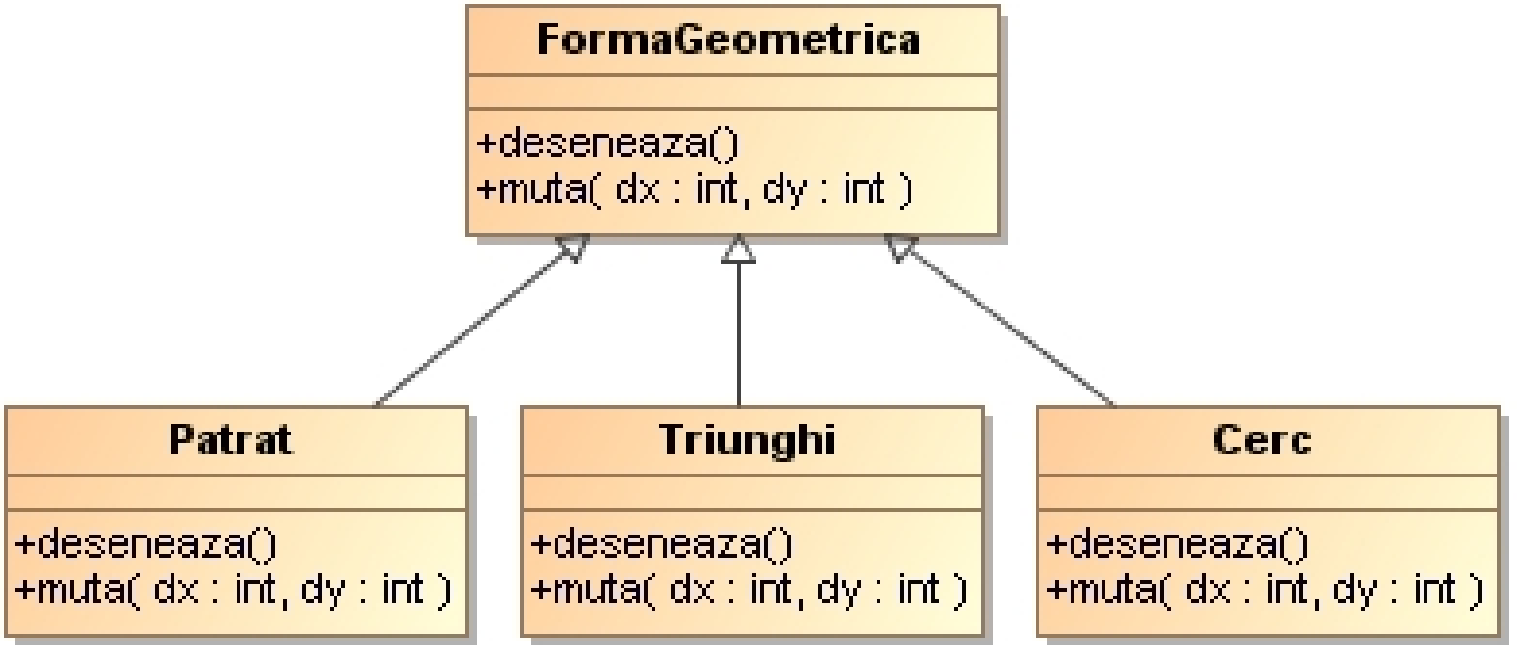
```
Punct p1=new Punct(2,3);
Punct p2=new Punct(2,3);
boolean egale=(p1==p2);   //false;
egale=p1.equals(p2);     //true, Punct must redefine equals
System.out.println(p1);   //toString is called
```

Class Object - methods

```
public class Punct {
    private int x,y;
    public Punct(int x, int y) {
        this.x = x;
        this.y = y;
    }
    @Override
    public boolean equals(Object obj) {
        if (! (obj instanceof Punct))
            return false;
        Punct p=(Punct)obj;
        return (x==p.x)&& (y==p.y);
    }

    @Override
    public String toString() {
        return ""+x+' '+y;
    }
    //...
}
```

Polymorphism

- The ability of an object to have different behaviors according to the context.
- 3 types of polymorphism:
  - ad-hoc: method overloading.
  - Parametric: generics types.
  - inclusion: inheritance.



Polymorphism

- *early binding*: the method to be executed is decided at compile time
- *late binding*: the method to be executed is decided at execution time
- Java uses late binding to call the methods. However there is an exception for static methods and final methods.

```
void deseneaza(FormaGeometrica fg){
   fg.deseneaza();
}

//...
FormaGeometrica fg=new Patrat();
deseneaza(fg);   //call deseneaza from Patrat
fg=new Cerc();
deseneaza(fg);   //call deseneaza from Cerc
```

Polymorphic collections

```
public FiguraGeometrica[] genereaza(int dim){
   FiguraGeometrica[] fg=new FiguraGeometrica[dim];
     Random rand = new Random(47);
     for(int i=0;i<dim;i++){
      switch(rand.nextInt(3)) {
    case 0: fg[i]= new Cerc(); break;
    case 1: fg[i]= new Patrat(); break;
    case 2: fg[i]= new Triunghi(); break;
              default:
     }
   }
    return fg;
}

public void muta(FiguraGeometrica[] fg){
  for(FiguraGeometrica f: fg)
     f.muta(3,3);
}
```

Abstract classes

- An abstract method is declared but not defined. It is declared with the keyword **`abstract`**.

```
[modificator_acces] abstract ReturnType nume([list_param_formal]);
```

- *An abstract class may contain abstract methods*.

```
[public] abstract class ClassName {
     [fields]
     [abstract methods declaration]
     [methods declaration and implementation]
}

public abstract class Polinom{
  //...
   public abstract void aduna(Polinom p);
}
```

Abstract classes

1. An abstract class cannot be instantiated.

```
Polinom p=new Polinom();
```

2. If a class contains at least one abstract method then that class must be abstract.
3. A class can be declared abstract without having any abstract method.
4. If a class extends an abstract class and does not define all the abstract methods then that class must also be declared abstract.

```
public abstract class A{
  public A(){}
  public abstract void f();
  public abstract void g(int i);

}
```

```
public abstract class B extends A{
  private int i=0;
  public void g(int i){
   this.i+=i;
  }
}
```

Java interfaces

- Are declared using keyword `interface.`

```
public interface InterfaceName{
    [methods declaration];
}
```

1. Only method declaration, no method implementation
2. No constructors
3. All declared methods are implicitly public.
4. It may not contain any method declaration.
5. It may contain fields which by default are `public`, `static` and constant (`final`).

```
public interface LuniAn{
 int IANUARIE=1, FEBRUARIE=2, MARTIE=3, APRILIE=4, MAI=5,
    IUNIE=6, IULIE=7, AUGUST=8, SEPTEMBRIE=9, OCTOMBRIE=10, NOIEMBRIE=11,
      DECEMBRIE=12;
}
```

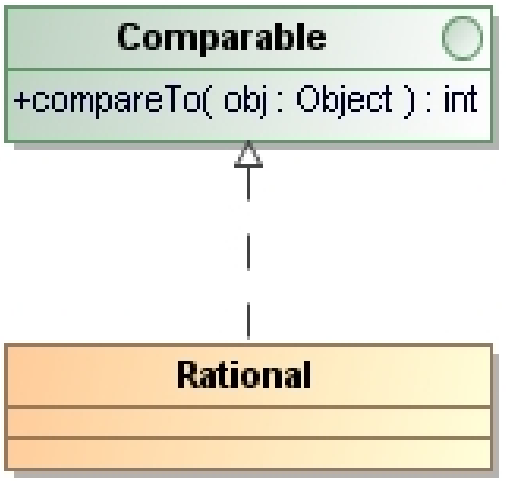
Interface implementation

- A class can implement an interface, using `implements`.

```
[public] class ClassName implements InterfaceName{
    [interface method declarations]
    //other definitions
}
```

1. The class must implement all the interface methods

```
public interface Comparable{
     int compareTo(Object o);
}
public class Rational implements Comparable{
  private int numarator, numitor;
  //...
  public int compareTo(Object o){
  //...
  }
}
```



Extending an interface

- An interface can inherit one or more interfaces

```
[public] interface InterfaceName extends Interface1[, Interface2[, ...]
    ]{
   [declaration of new methods]

}
```

1. Multiple inheritance.

```
public interface A{
  int f();
}
public interface B{
  double h(int i);
}
public interface C extends A, B{
  boolean g(String s);
}
```

Collisions

```
interface I1 {
  void f();
}
interface I2 {
  int f(int i);
 }
interface I3 {
  int f();
}

interface I6 extends I1, I2{}
interface I4 extends I1, I3 {}  //error
```

Implementing multiple interfaces

- A class can implement multiple interfaces.

```
[public] class ClassName implements Interface1, Interface2, ...,
     Interfacen{
  //...
}
```

- The class must implement the methods from all interfaces.It may occur collisions between methods declared in different interfaces

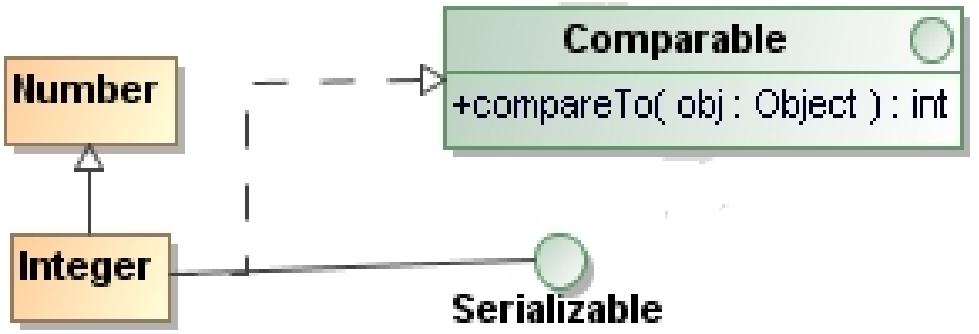
```
class C2 implements I1, I2 {
     public void f() {}
     public int f(int i) { return 1; }
     //overloading
}
class CC implements I1, I3{  //error at compile-time
  //...
}
```

Inheritance and interfaces

- A class can inherit one class but can implement multiple interfaces

```
[public] class NumeClasa extends SuperClasa implements Interfata1,
     Interfata2, ..., Interfatan{
  //...
}
```

```
Example:
 public class Integer extends Number implements Serializable, Comparable{
     //...
     public int compareTo(Object o){
     //...
     }
}
```



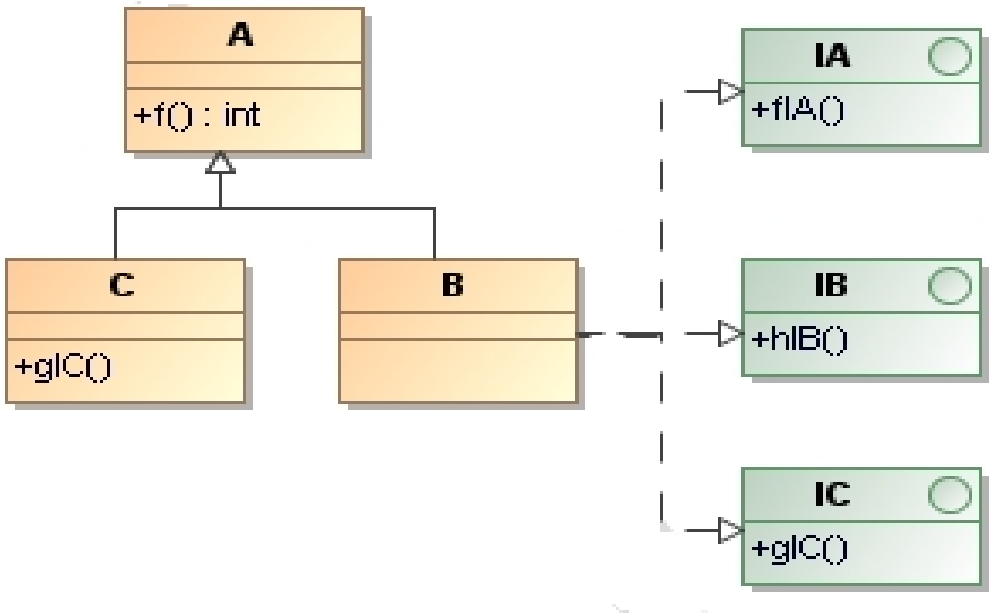
Variables of type interface

- An interface is a referrence type
- It is possible to declare variables of type interface. These variables can be initialized with objects instances of classes which implement that interface. Through those variables only interface methods can be called

```
public interface Comparable{
  //...
}
public class Rational implements Comparable{
  //...
}
Rational r=new Rational();
Comparable c=r;
Comparable cr=new Rational(2,3);
cr.compareTo(c);
c.aduna(cr); //ERROR!!
```

Variable of type interface

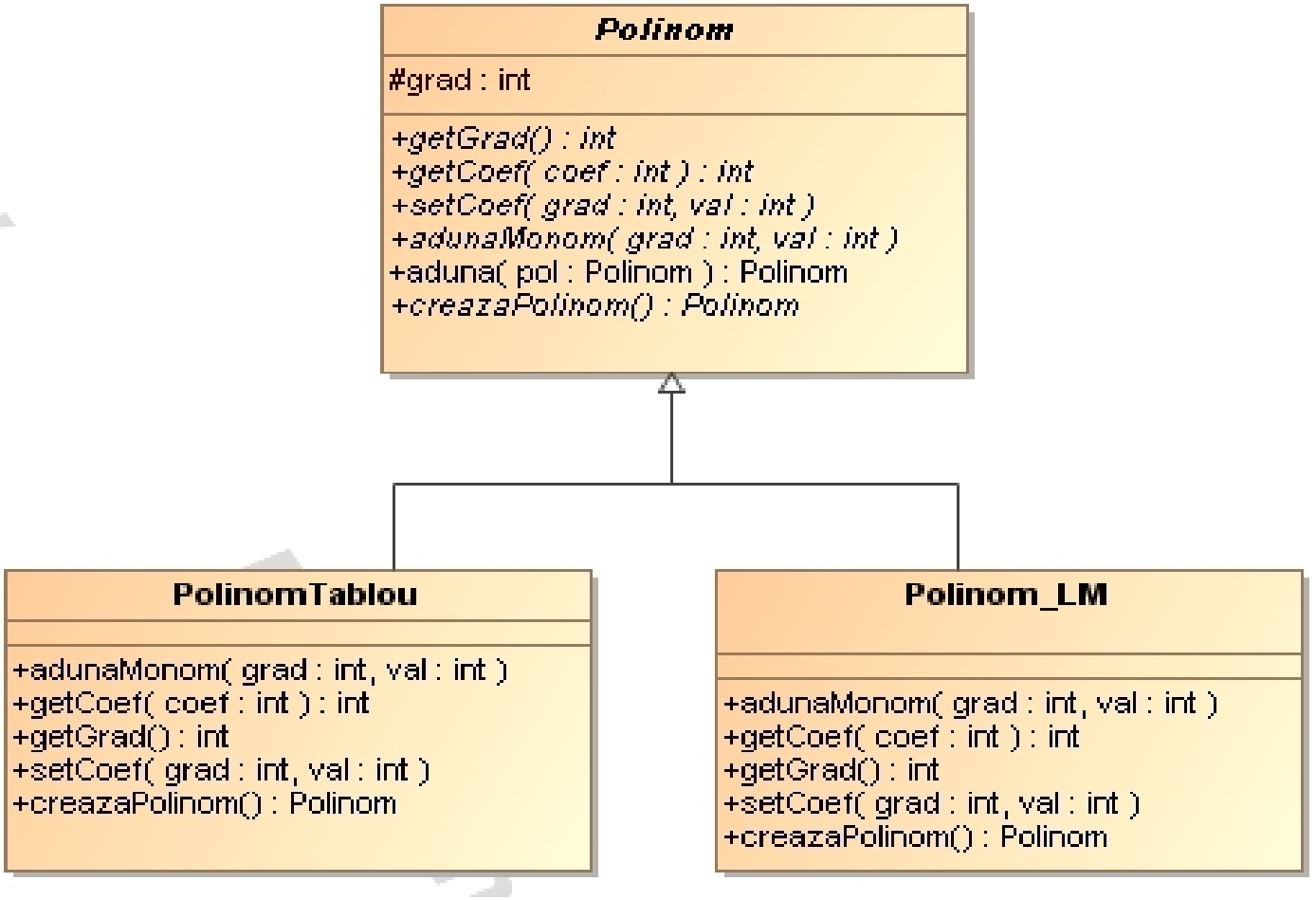
```
B b=new B();
IA ia=b; ia.fIA();

IB ib=b; ib.hIB();
IC ic=b; ic.gIC();

ic.f(); //?

C c=new C();
IC ic=c;
ic.gIC();//?
```



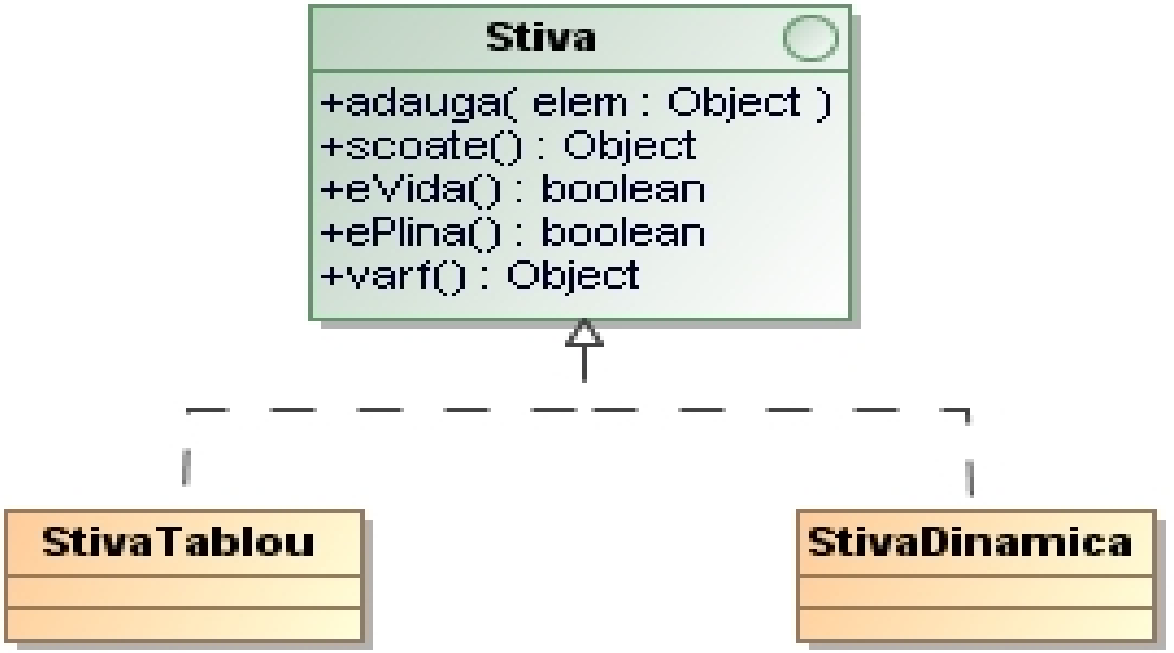
Abstract Class vs Interface

Public, protected, private methods	only public methods.
Have fields	Can have only static and final fields
Have constructors	No constructors.
It is possible to have no any abstract method.	It is possible to have no any methods
Both do not have instance objects	

Abstract classes vs Interfaces



Abstract Classes vs Interfaces



Packages

- Groups classes and interfaces
- Name space management

- ex. package `java.lang` contains the classes `System, Integer, String`, etc.
- A package is defined by the instruction `package:`

```
//structuri/Stiva.java
package structuri;
public interface Stiva{
   //...
}
```

Obs:

1. `package` must be the first instruction of the java file
2. The file is saved in the folder `structuri` (case-sensitive).

```
//structuri/liste/Lista.java
package structuri.liste;     //folder structuri/liste/Lista.java
public interface Lista{
   //...
}
```

Packages

- Compilation:

if the file Stiva.java is in the folder

```
C:\users\maria\java\structuri
```

the current folder must be:

```
C:\users\maria\java
```

```
C:\users\maria\java> javac structuri/Stiva.java
C:\users\maria\java> javac structuri/liste/Lista.java
```

File `.class` **is saved in the same folder.**

```
C:\users\maria\java\structuri\Stiva.class
C:\users\maria\java\structuri\liste\Lista.class
```

Package

- Using the class

```
package structuri.liste;
public class TestLista{
  public static void main(String args[]){
    Lista li=...
  }
}
```

Compilation:

```
C:\users\maria\java> javac structuri/liste/TestLista.java
```

Running:

```
C:\users\maria\java> java structuri.liste.TestLista
```

Using the classes declared in the packages

```
// structuri/ArboreBinar.java
package structuri;
public class ArboreBinar{
  //...
}
```

- The classes are referred using the following syntax:

```
  [pac1.[pac2.[...]]]NumeClasa
//TestStructuri.java
public class TestStructuri{
  public static void main(String args[]){
    structuri.ArboreBinar ab=new structuri.ArboreBinar();
    //...
  }
}
```

Using the classes declared in the packages

- Instruction `import`:
  - one class:

```
import pac1.[pac2.[...]]NumeClasa;
```

  - All the package classes, but not the subpackages:

```
import pac1.[pac2.[...]]*;
```

- A file may contain multiple import instructions. They must be at the beginning before any class declaration.

```
//structuri/Heap.java
package structuri;
public class Heap{
  //...
}
//Test.java
//fara instructiuni import
public class Test{
  public static void main(String args[]){
    structuri.ArboreBinar ab=new structuri.ArboreBinar();
    structuri.Heap hp=new structuri.Heap();
  }}
```

Using the classes declared in the packages

```
//Test.java
import structuri.ArboreBinar;
public class Test{
  public static void main(String args[]){
    ArboreBinar ab=new ArboreBinar();
    structuri.Heap hp=new structuri.Heap();
  }
}
//Test.java
import structuri.*;
import structuri.liste.*;
public class Test{
  public static void main(String args[]){
    ArboreBinar ab=new ArboreBinar();
    Heap hp=new Heap();
    Lista li=new Lista();
  }
}
```

Package+import

- The instruction `package` must be before any instruction `import`

```
//algoritmi/Backtracking.java
package algoritmi;
import structuri.*;

public class Backtracking{
  //...
}
```

- The package `java.lang` is implicitly imported by the compiler.

Static import

- Starting with version 1.5

```
import static pac1.[pac2.[. ...]]NumeClasa.MembruStatic;
import static pac1.[pac2.[...]]NumeClasa.*;
```

- Allow to use static members of class `NumeClasa` without using the class name.

```
package utile;
public class EncodeUtils {
    public static String encode(String txt){...}
    public static String decode(String txt){...}
}
//Test.java
import static utile.EncodeUtils.*;
public class Test {
    public static void main(String[] args) {
        String txt="aaa";
        String enct=encode(txt);
        String dect=decode(enct);
        //...
    }
}
```

Anonymous package

```
//Persoana.java
public class Persoana{...}

//Complex.java
class Complex{...}

//Test.java
public class Test{
  public static void main(String args[]){
    Persoana p=new Persoana();
    Complex c=new Complex();
    //...
  }
}
```

If a file `.java` does not contain the instruction `package`, all the file classes are part of anonymous package.

Name Collision

```
// unu/A.java
package unu;
public class A{
  //...
}
```

```
// doi/A.java
package doi;
public class A{
  //...
}
```

```
//Test.java
import unu.*;
import doi.*;
public class Test{
  public static void main(String[] args){
    A a=new A();  //compilation error
    unu.A a1=new unu.A();
    doi.A a2=new doi.A();
  }
}
```

Access modifiers

- 4 modifiers for the class members:
  - `public:` access from everywhere
  - `protected:` access from the same package and from subclasses
  - `private:` access only from the same class
  - `:` access only from the same package
- Classes (excepting inner classes) and interfaces can be public or nothing.

Access modifiers

```
// structuri/Nod.java
package structuri;
class Nod{
   private Nod urm;
   public Nod getUrm(){...}
   void setUrm(Nod p){...}
  //...
}
```

```
// structuri/Coada.java
package structuri;
public class Coada{
   Nod cap;
   Coada(){ cap.urm=null;}
   Coada(int i){...}
  //...
}
```

```
//Test.java
import structuri.*;
class Test{
  public static void main(String args[]){
      Coada c=new Coada();
      Nod n=new Nod();     //class is not public
      Coada c2=new Coada(2);   //constructor is not public
 }
}
```

Access modifiers

```
package unu;
public class A{
  A(int c, int d){...}
  protected A(int c){...}
  public A(){...}
  protected void f(){...}
  void h(){...}
}
```

```
package unu;
class DA extends A{
   DA(int c){ super(c);}
}
```

```
package doi;
import unu.*;
class DDA extends A{
  DDA(int c){super(c);}
  DDA(int c, int d) {super(c,d);}
  protected void f(){
    super.h();
  }
}
```

Protected

- The fields and methods which are declared `protected` are visible inside the class, inside the derived classes and inside the same package.

```
public class Persoana{
  private String nume;
  private int varsta;
  public Persoana(String nume, int varsta){
    this.nume=nume;
    this.varsta=varsta;
  }
  //...
}
public class Angajat extends Persoana{
  private String departament;
  public Angajat(String nume, int varsta, String departament){
    this.nume=nume;
    this.varsta=varsta;
    this.departament=departament;
  }
  //...
}
```

Protected

```
public class Persoana{
  protected String nume;
  protected int varsta;
  public Persoana(String nume, int varsta){
    this.nume=nume;
    this.varsta=varsta;
  }
  //...
}
public class Angajat extends Persoana{
  protected String departament;
  public Angajat(String nume, int varsta, String departament){
    this.nume=nume;
    this.varsta=varsta;
    this.departament=departament;
  }
  //...
}
```