Advanced Programming Methods

Lecture 1 – Java Basics

Course Overview

Object-oriented languages:

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

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

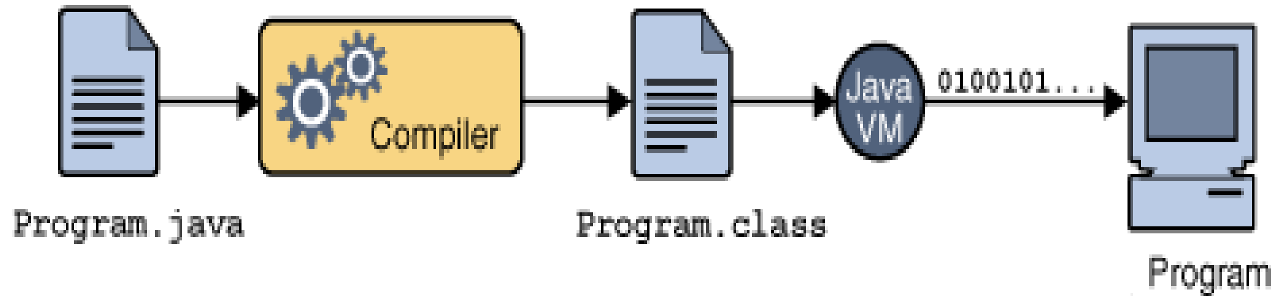
Java References

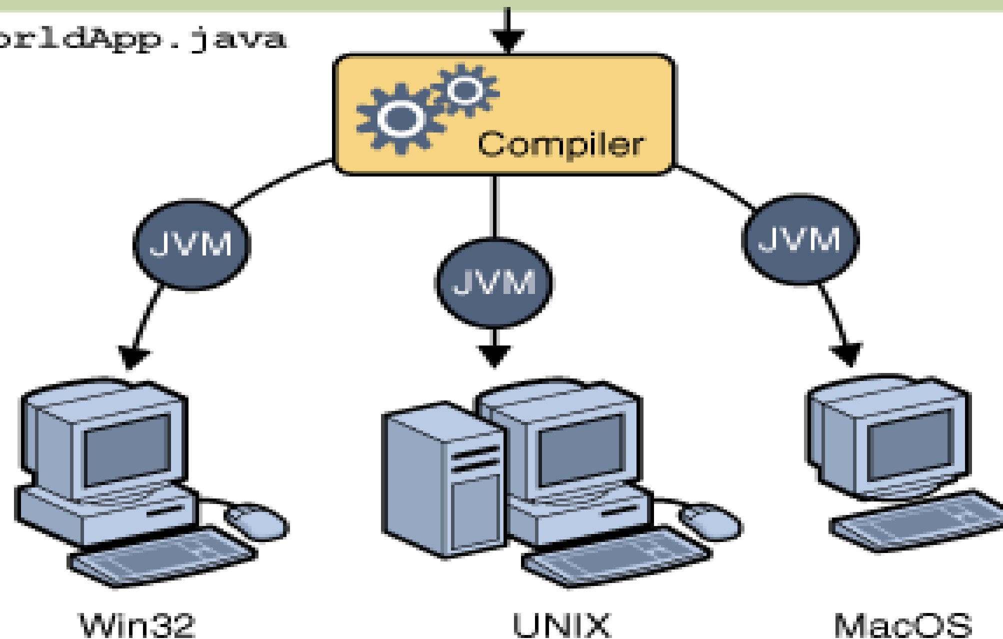
- Bruce Eckel, *Thinking in Java*

- The Java Tutorials, 2016.
  https://docs.oracle.com/javase/tutorial/

- Java 8 API, 2016.
  http://docs.oracle.com/javase/8/docs/api/

Java Technology





Java language

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)

Java Language

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
```

Array

Array with one dimension

```
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[dim_1][dim_2]…[dim_n];

Accessing an element:

name[$index_1$][$index_2$]…[$index_n$];

Examples:

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

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;
//...
}
```

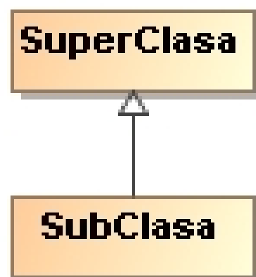
```
class Scrisoare{
  private String destinatar;
  private Adresa adresaDestinatar;
  private String expeditor;
  private Adresa adresaExpeditor
//...
}
```

Inheritance

- Using the keyword `extends`:

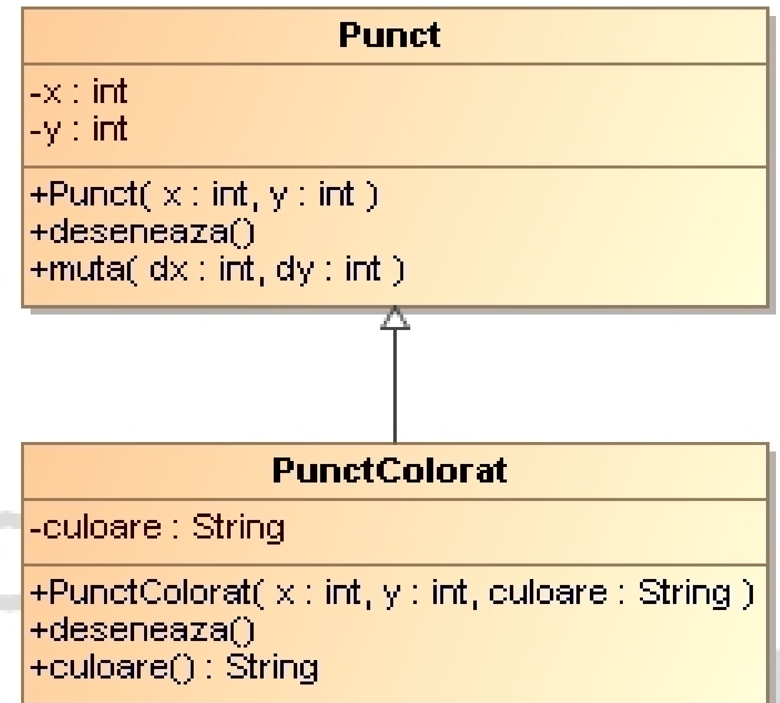
```
class NewClass extends ExistingClass{
    //...
}
```

- `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

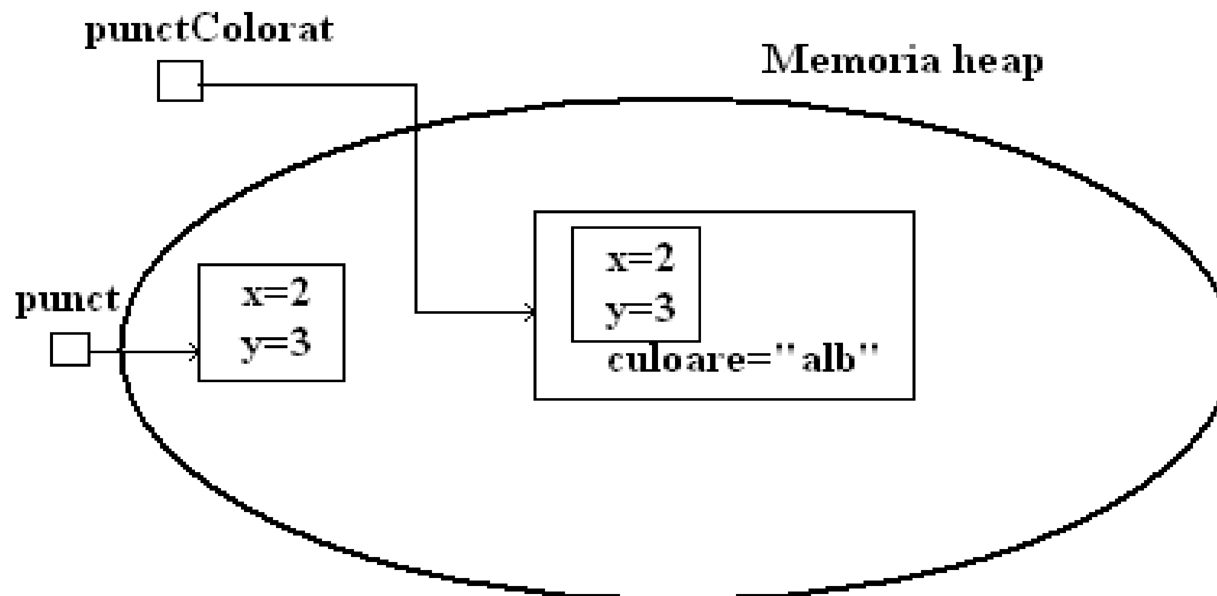
```
public class Punct{
  private int x,y;
  public Punct(int x, int y){
     this.x=x;
     this.y=y;
  }
  public void muta(int dx, int dy){
  //...
  }
  public void deseneaza(){
    //...
    }
}
public class PunctColorat extends Punct{
    private String culoare;
    public PunctColorat(int x, int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

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;
  }
  //...
}
```

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--;
  }
}
```

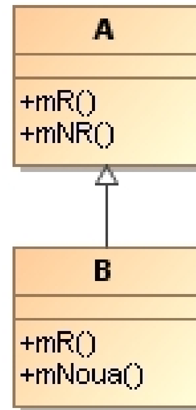
  - To call the overridden method (from the base class) from the overriding method (from the subclass).

```
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

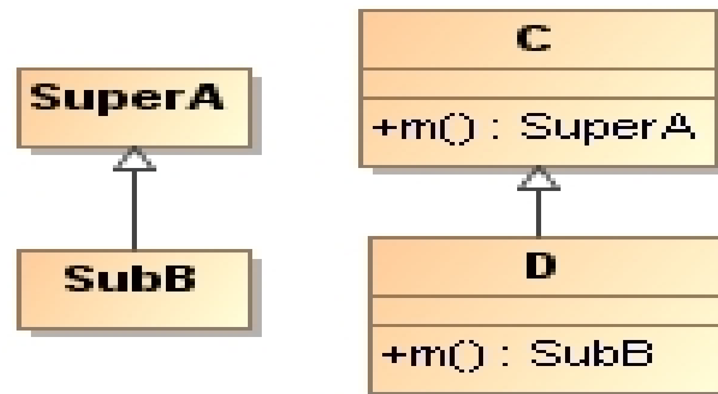
4. adnotation `@Override` (JSE >=5) in order to force a compile-time verification

```
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).

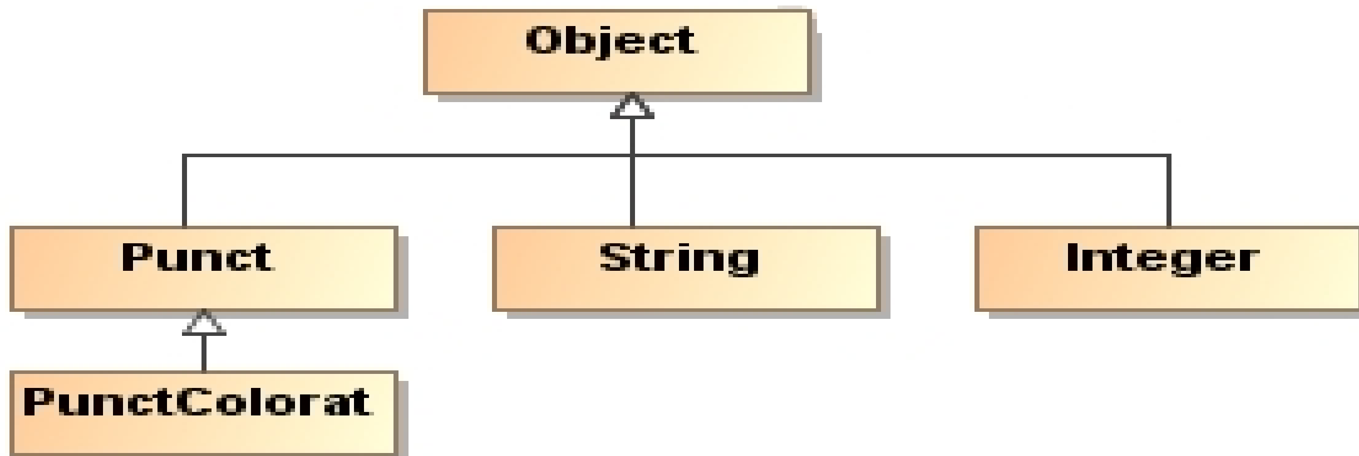
```
public class C{
  public SuperA m(){...}
}
public class D extends C{
  public SubB m(){...}
}
```



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

Object

```
+equals( o : Object ) : boolean
+toString() : String
+hashCode() : int
+notify()
+notifyAll()
+wait()
#clone() : Object
#finalize()
```

- `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.

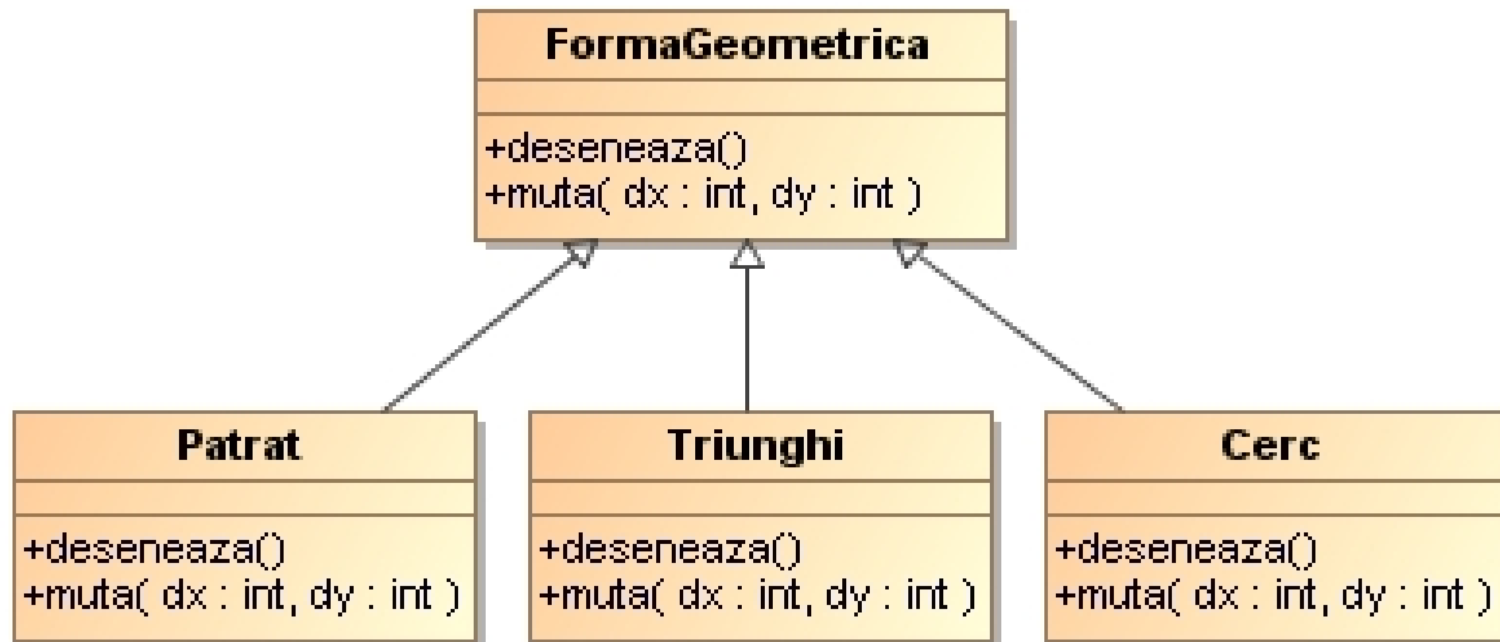
```
Punct p1=new Punct(2,3);
Punct p2=new Punct(2,3);
boolean egale=(p1==p2);   //false;
egale=p1.equals(p2);     //true, Punct must redefine equals
System.out.println(p1);   //toString is called
```

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 delared with the keyword **`abstract`**.

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

- *An abstract class may contain abstract methods*.
- An abstract class is defined using **`abstract.`**

```
[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;
}
```

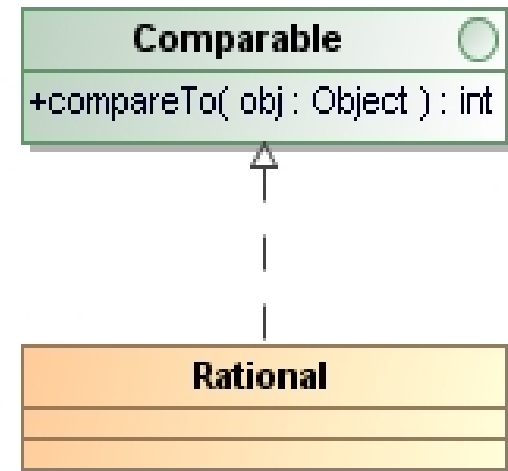
Interface implementation

- 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
  //...
}
```

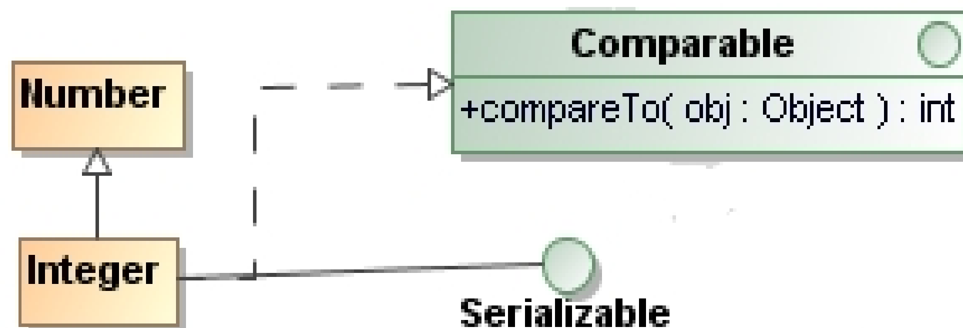
Inheritance and interfaces

- 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){
     //...
     }
}
```



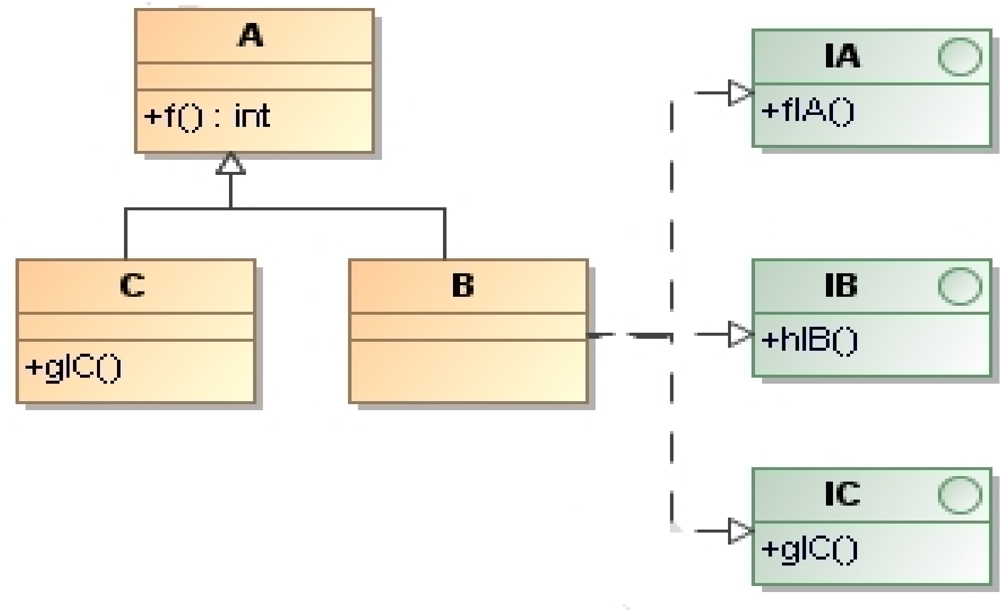
Variables of type interface

- 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

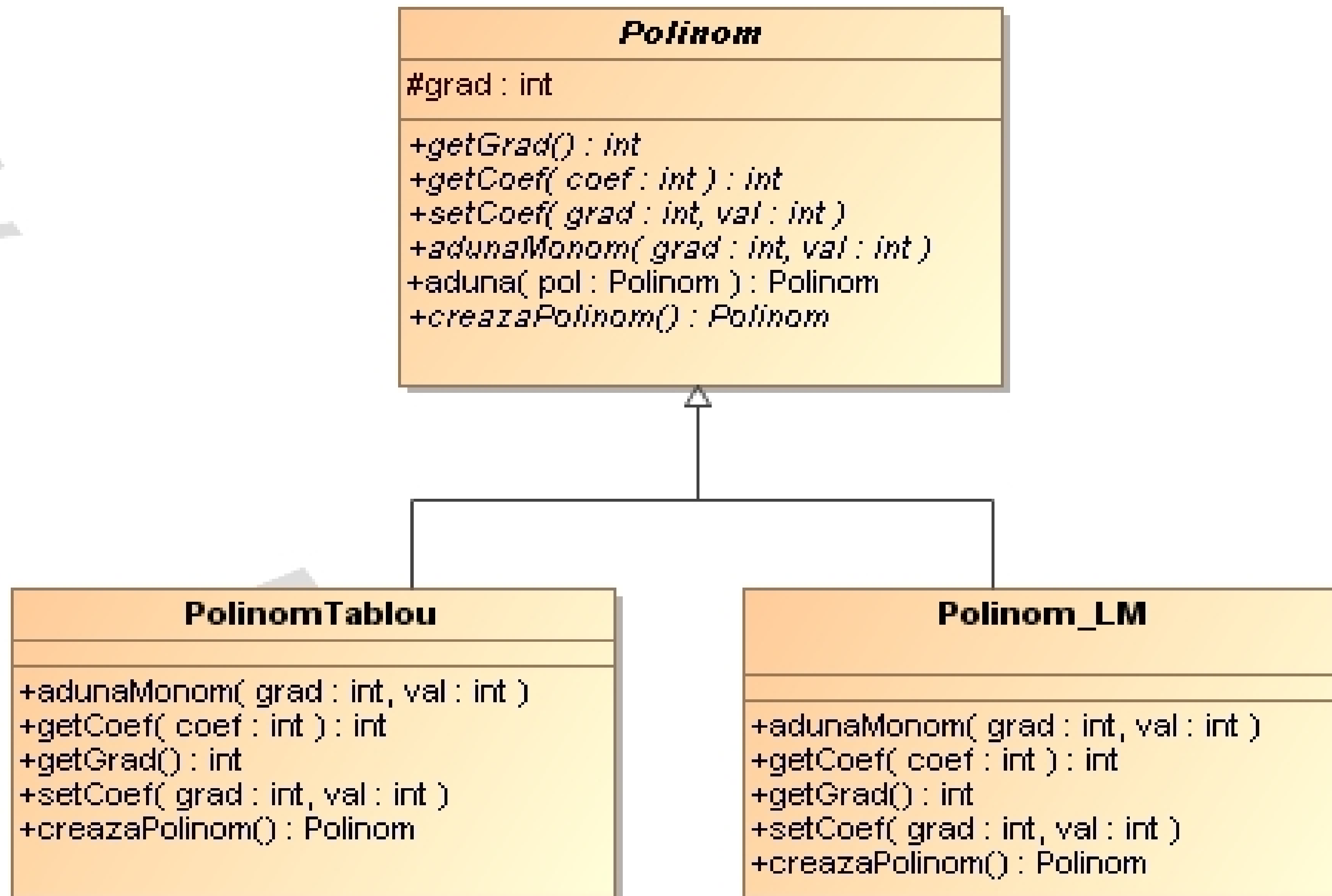
```
B b=new B();
IA ia=b; ia.fIA();

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

ic.f(); //?

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



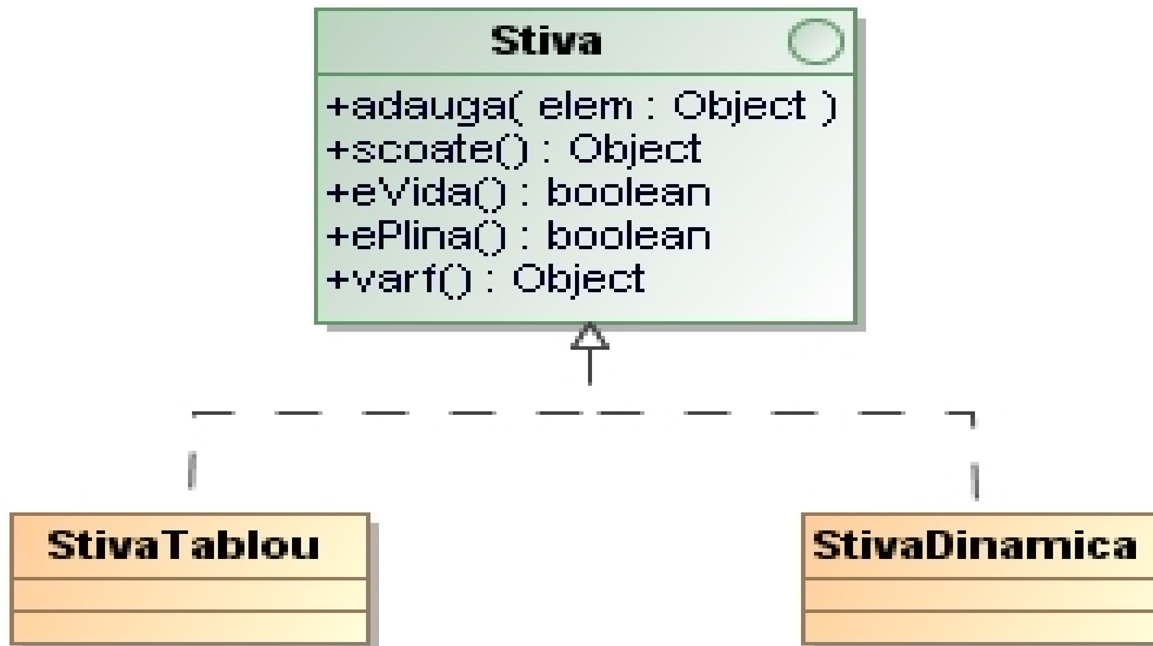
Abstract Class vs Interface

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 modifiiers 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();
   }
}
```

Advanced Programming Methods

Lecture 2 – Java Exceptions, Generics and Collections

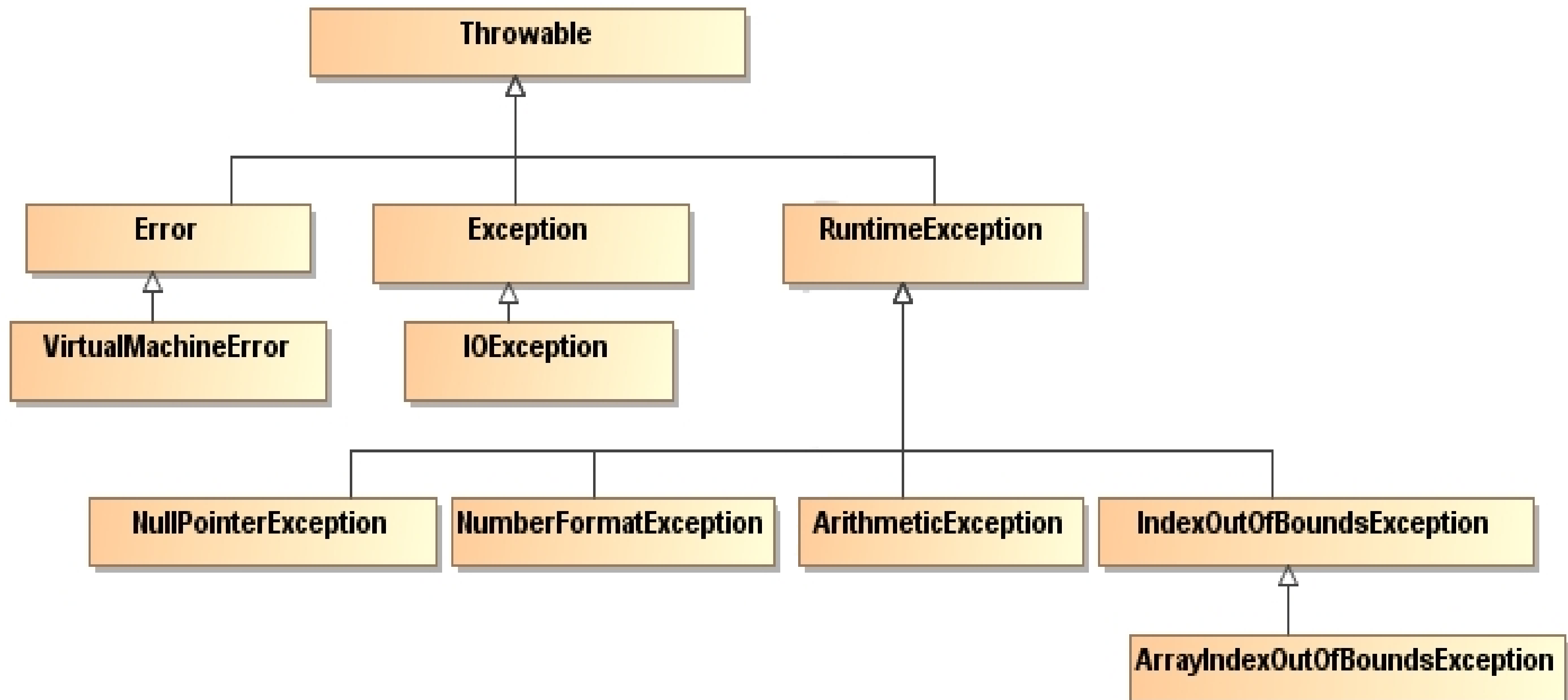
Content

1. **Java Exceptions**
2. **Java Generics**
3. **Java Collections**

JAVA EXCEPTIONS

Java Exceptions

Three types of exceptions:Errors(external to the application), Checked Exceptions(subject to try-catch), and Runtime Exceptions(correspond to some bugs)



Example 1

Program for ax+b=0, where a, b are integers.

```
class P1{
 public static void main(String args[]){
      int a=Integer.parseInt(args[0]);    //(1)
      int b=Integer.parseInt(args[1]);    //(2)
      if (b % a==0)                    //(3)
      System.out.println("Solutie "+(-b/a));           //(4)
      else
        System.out.println("Nu exista solutie intreaga"); //(5)
    }
}
java P1 1 1 //-1
java P1 0 3 //exception, divide by 0
            //Lines 4 or 5 are not longer executed
```

Example 1

Java VM creates the exception object corresponding to that abnormal situation and throws the exception object to those program instructions that generates the abnormal situation.

Thrown exception object can be caught or can be ignored (in our example the program P1 ignores the exception)

```
Exception in thread "main" java.lang.ArithmeticException: / by zero
 at P1.main(P1.java:13)
```

Catching exceptions

Using try-catch statement:

```
try{
  //code that might generates abnormal situations
}catch(TipExceptie numeVariabila){
  //treatment of the abnormal situation
}
```

Execution Flow:

- If an abnormal situation occurs in the block try(), JVM creates an exception object and throws it to the block catch.
- If no abnormal situation occurs, try block normally executes.
- If the exception object is compatible with one of the exceptions of the catch blocks then that catch block executes

Example 2

```
class P2{
    public static void main(String args[]){
     try{
      int a=Integer.parseInt(args[0]);    //(1)
      int b=Integer.parseInt(args[1]);    //(2)
      if (b % a==0)                //(3)
        System.out.println("Solutie "+(-b/a));    //(4)
      else
        System.out.println("Nu exista solutie intreaga"); //(5)
     }catch(ArithmeticException e){
        System.out.println("Nu exista solutie");  //(6)
     }
    }
}
java P2 1 1 //Solutie -1
java P2 0 3 // Nu exista solutie
            // (1), (2), (3), (6) are executed
```

Multiple catch clauses

```
try{
  //code with possible errors
}catch(TipExceptie1 numeVariabila1){
  //instructions
}catch(TipExceptie2 numeVariabila2){
  //instructions
}...
catch(TipExceptien numeVariabilan){
  // instructions
}
```

Example 3

```
class P3{
    public static void main(String args[]){
     try{
      int a=Integer.parseInt(args[0]);    //(1)
      int b=Integer.parseInt(args[1]);    //(2)
      if (b % a==0)               //(3)
        System.out.println("Solutie "+(-b/a));     //(4)
      else
        System.out.println("Nu exista solutie intreaga"); //(5)
     }catch(ArithmeticException e){
        System.out.println("Nu exista solutie");  //(6)
     }catch(ArrayIndexOutOfBoundsException e){
        System.out.println("java P3 a b");      //(7)
     }    }
}
java P3 1 1 //Solution -1
java P3 0 3 // Nu exista solutie
            // (1), (2), (3), (6) are executed
java P3 1  //java P3 a b
```

Nested try statements

```
class P4{
  public static void main(String args[]){
    try{
      int a=Integer.parseInt(args[0]);    //(1)
      int b=Integer.parseInt(args[1]);    //(2)
      try{
         if (b % a==0)                //(3)
          System.out.println("Solutie "+(-b/a));          //(4)
         else
          System.out.println("Nu exista solutie intreaga"); //(5)
      }catch(ArithmeticException e){
          System.out.println("Nu exista solutie");  //(6)
      }
      }catch(ArrayIndexOutOfBoundsException e){
        System.out.println("java P4 a b");      //(7)
       } }}
java P4 1 1 //Solutie -1
java P4 0 3 // Nu exista solutie
java P4 1  //java P4 a b
```

Nested try statements

```
try{
 //...
  try{
    //...
  }catch(TipExceptie_ii numeVar_ii){
   //...
   }
}catch(TipExceptie_1 numeVar_1){
  //instructiuni
}catch(TipExceptie_n numeVar_n){
  // ...
   try{
    //...
   }catch(TipExceptie_in numeVar_in){
   //...
   }
}
```

Finally clause

The finally clause is executed in any situation:

```
try{
  //...
}catch(TipExceptie1 numeVar1){
  //instructiuni
}[catch(TipExceptien numeVarn){
  // ...
}]
[finally{
  //instructiuni
}]
```

Finally Clause

```
A
try{
   B
}catch(TipExceptie nume){
    C
}finally{
  D
}
E
```

Block D executes:

- After A and B (before E) if no exception occurs in B. (A, B, D, E)
- After C, if an exception occurs in B and that exception is caught (A, a part of B, C, D, E).
- Before exit from the method:
  - » An exception occurs in B, but is not caught (A, a part of B, D).
  - » An exception occurs in B, it is caught but a return exists in C (A, a part of B, C, D).
  - » If a return exists in B (A, B, D).

Finally Clause

```
public void writeElem(int[] vec) {
    PrintWriter out = null;
    try {
        out = new PrintWriter(new FileWriter(“fisier.txt"));
         for (int elem:vec)
             out.print(" "+elem);
    } catch (IOException e) {
         System.err.println("IOException: "+e);
    }finally{
         if (out != null)
             out.close();
    }
}
```

General form of Try statement

```
try{
  //code with possible errors
}[catch(TipExceptie1 e1){
  //...
}]
//...
[catch(TipExceptien en){
   //...
}]
[finally{
  //instructions
 }]
```

Defining exception classes

- By deriving from class `Exception:`

```
public class ExceptieNoua extends Exception{
  public ExceptieNoua(){}
  public ExceptieNoua(String mesaj){
    super(mesaj);
  }
}
```

Exceptions Specification

- Use keyword `throws` in method signatures:

```
public class ExceptieNoua extends Exception{}

public class A{
  public void f() throws ExceptieNoua{
    //...
  }
}
```

- Many exceptions can be specified (their order does not matter):

```
public class Exceptie1 extends Exception{}
public class B{
  public int g(int d) throws ExceptieNoua, Exceptie1{
    //...
 }
}
```

Throwing exceptions

- Statement `throw :`

```
public class B{
  public int  g(int d)  throws ExceptieNoua,Exceptie1{
    if (d==3)
        return 10;
    if (d==7)
         throw new ExceptieNoua();
    if (d==5)
         throw new Exceptie1();
    return 0;
  }
  //...
}
```

- Statement throw throws away the exception object and the method execution is interrupted.
- All exceptions thrown inside a method must be specified in the method signature.

Calling a method having exceptions

- use try-catch to treat the exception:

```
public class C{
  public void h(A a){
    try{
      a.f();
    }catch(ExceptieNoua e){
      System.err.println(" Exceptie "+e);
    }
  }
}
```

- Throwing away an uncaught exception (uncaught exception must be specified in the signature):

```
public class C{
  public void t(B b) throws ExceptieNoua {
    try{
      int rez=b.g(8);
    }catch(Exceptie1 e){          //only Exceptie1 is caught
      System.err.println(" Exceptie "+e);
    }
  }
}
```

Exception specification

- The subclass constructor must specified all the base class constructor (explicitly or implicitly called) in its signature.
- The subclass constructor may add new exceptions to its signature.

```
public class A{
  public A() throws Exceptie1{
  }
  public A(int i){ }
  //...
}

public class B extends A{
  public B() throws Exceptie1{   }
  public B(int i){
    super(i);
  }
  public B(char c) throws Exceptie1, ExceptieNoua{
  }
  //...
}
```

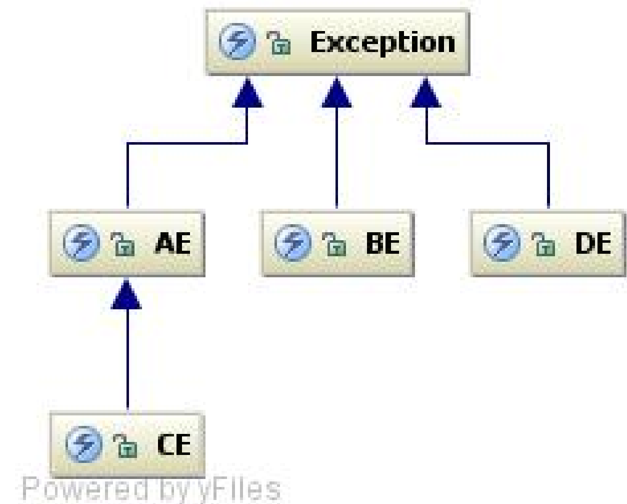
Exceptions and method overriding

- An overriding method may declare a part of the exceptions of the overridden method.
- An overriding method may add only new exceptions which are inherited from the overridden method exceptions
- The same rules are applied for the interfaces.

```
public class AA {
    public void f() throws Exceptie1, Exceptie2{ }
    public void g(){ }
    public void h() throws Exceptie1{  }
}

public class BB extends AA{
    public void f() throws Exceptie1{ }  //Exceptie2 is not declared
    public void g() throws Exceptie2{ }  //not allowed
    public void h() throws Exceptie3{ }
}
public class Exceptie3 extends Exceptie1{...}
```

Exceptions and method overriding

```
public class A {
    public void f() throws AE, BE {}
    public void g() throws AE{}
}

public class B extends A{
    public void g(){}
    public void f() throws AE, BE, CE{}
    public void f() throws AE, BE, DE{}
    public void g() throws DE{}
}
//?
```



Exceptions order in catch clauses

- The order of catch clauses is important since the JVM selects the first catch clause on which the try block thrown exception matches.
- An exception A matches an exception B if A and B have the same class or A is a subclass of B.

```
public class C {
  public void g(B b){
    try{
        b.f();
    } catch(Exception e){...

    } catch (CE ce) { ...
    } catch (AE ae) {...
    } catch (BE be) {...
    }
  }
}
```

```
public class C {
  public void g(B b){
    try{
        b.f();
    } catch (CE ce) { ...
    } catch (AE ae) {...
    } catch (BE be) {...
    } catch(Exception e){...
    }
  }
}
```

Lost exceptions

```
public class C {
    public void g(B b){
        try{
            b.f();
        }
        catch (CE ce) { }  //At least an error message must be printed
        catch (AE ae) { }
        catch (BE be) { }
    }
}
```

Re-throwing an exception

- A caught exception can be re-thrown

```
public class C {
 public int h(A a) throws Exceptie4, BE {
        try {
            a.f();
        } catch (BE be) {
            System.out.println("Exceptie rearuncata "+be);
            throw be;
        } catch (AE ae) {
            throw new Exceptie4("mesaj", ae);
        }
        return 0;
    }
}
public class Exceptie4 extends Exception {
    public Exceptie4() { }
    public Exceptie4(String message) {
        super(message);
    }
    public Exceptie4(String message, Throwable cause) {
        super(message, cause);
    }
}
```

Exception class

- Constructors:
  - `Exception()`
  - `Exception(String message)`
  - `Exception(String message, Throwable cause)`
  - `Exception(Throwable cause)`
- Methods:
  - `getCause(): Throwable`
  - `getMessage(): String`
  - `printStackTrace()`
  - `printStackTrace(PrintStream s)`

```
public class C {
 public int h(A a) throws BE {
        try {
            a.f();
        } catch (BE be) {
            System.out.println("Exceptie rearuncata "+be.getMessage());
            throw be;
        } catch (AE ae) {
            ae.printStackTrace();
        }
        return 0;
    }
}
```

Unchecked Exceptions

- Checked exceptions are those which are derived from class `Exception`
- Exceptions may be derived from class `RuntimeException`. They are named *unchecked exceptions*.

```
public class ExceptieNV extends RuntimeException{
    public ExceptieNV() { }
    public ExceptieNV(String message) {
     super(message);
    }
}
```

- Uncheked Exceptions must not be declared in the method signature.

- Unchecked Exceptions are used only for the abnormal situations that can not be solved (the recovering cannot be done).

JAVA GENERICS

Generics

- Parameterized types
- Started with Java 1.5
- Different than C++ templates
  - It does not generate a new class for each parameterized type
  - The constraints can be imposed on the type variables of the parameterized types.
- Motivation:

```
Stiva s=new Stiva();     //stack of Object
s.push("Ana");
s.push(new Persoana("Ana", 23));
Persoana p1 =(Persoana)s.pop();
Persoana p2 =(Persoana)s.pop();
  //correct at compile-time, error at execution time
```

Generic Class declaration

```
[access_mode] class ClassName <TypeVar1[, TypeVar2[, ...]] >{
    TypeVar1 field1;
   [declarations of fields]
   [declarations and definitions of methods]
}
```

Obs:

Type variables must be upper letters(for example E for element, K for key, V for value, T, U, S ...).

```
public class Stiva<E>{
  private class Nod<T>{
    T info;
    Nod<T> next;
    Nod(){info=null; next=null;}
    Nod(T info, Nod next){
         this.info=info;
          this.next=next;
     }
   }//class Nod
  Nod<E> top;
  //...
}
```

Object creation

```
public class Test{
  public static void main(String[] args){
    Stiva<String> ss=new Stiva<String>();
    ss.push("Ana");
    ss.push("Maria");
    ss.push(new Persoana("Ana", 23));    //error at compile-time
    String elem=ss.pop();            //NO CAST

   Stiva<Persoana> sp=new Stiva<Persoana>();
   sp.push(new Persoana("Ana", 23));
   sp.push(new Persoana("Maria", 10));

   Dictionar<String, String> dic=new Dictionar<String, String>();
   dic.add("abc", "ABC");
   dic.add(23, "acc");  //error at compile-time
   dic.add("acc", 23);  //error la compile-time
  }
}
```

Object creation

Type variables can be instantiated only with reference types. Primitive types: int, byte, char, float, double,.... are not allowed. Therefore the corresponding reference types are used.

```
Stiva<int> si=new Stiva<int>();
//error at compile-time

Stiva<Integer> si=new Stiva<Integer>();
```

primitive types	Corresponding reference types
boolean	Boolean
byte	Byte
short	Short
int	Integer
long	Long
float	Float
double	Double

Autoboxing

- Java 1.5
- Autoboxing: automatic conversion of a value of a primitive type to an object instance of a corresponding reference type when an object is expected, and vice-versa when a primitive value is expected.

```
Stiva<Integer> si=new Stiva<Integer>();
si.push(23);         //autoboxing
si.push(new Integer(23));
int val=si.pop();

Character ch = 'x';
char c = ch;
```

Continuation in Lecture 3

Generic methods

- Methods with type variables

```
 class ClassName[<TypeVar ...>]{
[access_mod] <TypeVar1[, TypeVar2[,...]]> TypeR nameMethod([list_param]){
  }
  //...
}
```

Obs:

- Static methods cannot use the type variables of the class.
- A generic method can contain type variables different than those used by the generic class.
- A generic method can be defined in a non-generic class.

Generic methods

```
public class GenericMethods {
   public <T> void f(T x) {
      System.out.println(x.toString());
  }

   public static <T> void copy(T[] elems, Stiva<T> st) {
         for(T e:elems)
              st.push(e);
  }

}
```

Calling a generic method

- The compiler automatically infers the types which instantiate the type variables when a generic method is called.

```
public class A {
   public <T> void print(T x) {
      System.out.println(x);
  }

  public static void main(String[] args) {
    A a=new A();
    a.print(23);
    a.print(“ana”);
    a.print(new Persoana(“ana”,23));
  }
}
```

Calling a generic method

- The instantiations of the type vars are explicitly given:
  - Instance method:

```
a.<Integer>print(3);
a.<Persoana>print(new Persoana(“Ana”,23));
```

  - Static method :

```
NameClass.<Typ>nameMethod([parameters]);
//...
Integer[] ielem={2,3,4};
Stiva<Integer> st=new Stiva<Integer>();
GenericMethods.<Integer>copy(ielem, st);
//
```

  - Non-static method in a class:

```
this.<Typ>nameMethod([parameters]);
class A{
   public <T> void print(T x){...}
   public void g(Complex x){
     this.<Complex>print(x);
   }
}
```

Generic arrays

- Cannot be created using new:

```
T[] elem=new T[dim]; //error at compile time
```

but we can use:

```
T[] elem=(T[])new Object[dim];   //warning at compile-time
```

- Alternatives:
  - Using `Array.newInstance`

```
import java.lang.reflect.Array;
public class Stiva <E>{
    private E[] elems;
    private int top;
    @SuppressWarnings("unchecked")
    public Stiva(Class<E> tip) {
       elems= (E[])Array.newInstance(tip, 10);
       top=0;
    }
   //...
}
Stiva<Integer> si=new Stiva<Integer>(Integer.class);
```

  - Using `ArrayList` instead of array.

Generic arrays

- Use an array of Object, but read operation requires an explicit cast:

```
public class Stiva <E>{
    private Object[] elems;
    private int top;
    public Stiva() {
     elems=new Object[10];
        top=0;
    }
    public void push(E elem){
        elems[top++]=elem;
    }
    @SuppressWarnings("unchecked")
    public E pop(){
        if (top>0)
            return (E)elems[--top];
        return null;
    }
  //...
}
```

Erasure

- Java does not create a new class for each new instantiation of the type variables in case of the generic classes.
- The compiler erases all type variables and replaces them with their upper bounds (usually Object) and explicit casts are inserted when it is necessary

```
public class A {
  public String f (Integer ix){
    Stiva<String> st=new Stiva<String>();
    Stiva sts=st;
    sts.push(ix);
    return st.top();
  }
}
```

```
public class A {
  public String f (Integer ix){
    Stiva st=new Stiva();
    Stiva sts=st;
    sts.push(ix);
    return (String)st.top();
  }
}
```

compilation

- Reason: backward compatibility with the non-generic Java versions
- The generic class is not recompiled for each new instantiation of the type variables like in C++.

Bounds

```
public class ListOrd<E> {
    private class Nod<E>{
        E info;
        Nod<E> nxt;
        public Nod(){ info=null; nxt=null; }
        private Nod(E info, Nod<E> nxt) { this.info = info; this.nxt = nxt; }
        private Nod(E info) { this.info = info; nxt=null; }
    }
    private Nod<E> head;
    public ListOrd(){ head=null;}
    public void add(E elem){
        if (head==null){
            head=new Nod<E>(elem);
            return;
        }
        if (/*compare elem to head.info*/){
            head=new Nod<E>(elem,head);
        }else {...}
    }
}
```

Bounds

- Type variables can have constraints (namely bounds) using `extends`.

```
T extends E    //T is the type E or is a subtype of E.
```

- General form of the constraint:

  `T extends [C &] I`$_1$ `[& I`$_2$ `&...& I`$_n$`]`

  T inherits the class C and implements the interfaces I_1, ... I_n.

- At compile-time T is replaced by the first element from the constraint expression:

```
T extends C          //T is replaced by C
 T extends C & I1 & I2   //T is replaced by C
 T extends I1 & I2       //T is replaced by I1
 T extends I1            //T is replaced by I1
 T             //T is replaced by Object
```

- If T has constraints then through T we can call any method from the class and interfaces specified as bounds.

Bounds

```
public interface Comparable<E>{
   int compareTo(E e);
}
public class ListOrd<E extends Comparable<E>> {
    private class Nod<E>{...}
    private Nod<E> head;
    public ListOrd(){ head=null;}
    public void add(E elem){
        if (head==null){
            head=new Nod<E>(elem);
            return;
        }
        if (elem.compareTo(head.info)<0){
            head=new Nod<E>(elem,head);
        }else {...}
    }
     public E retElemPoz(int poz){
        //...
     }
}
```

Wildcards

```
ListOrd<String> ls=new ListOrd<String>();
ListOrd<Object> lo=ls; //ASSUME this is CORRECT
lo.add(23);
String s=ls.retElemPoz(0);  //ERROR
```

Obs:

If `SB` is a subtype of `T` and `G` is a generic container class then `G<SB>` is not a subtype of `G<T>`.

```
void printLista(ListOrd<Object> lo){
   for(Object o:lo)
    System.out.println(o);
}
...
  ListOrd<String> ls=new ListOrd<String>();
  ls.add("mere");
  ls.add("pere");
  printLista(ls);        //error at compile-time
```

We use ? to denote any type (or unknown type)

Wildcards

```
void printLista(ListOrd<?> lo){
   for(Object o:lo)
    System.out.println(o);
}
```

Obs:

1. When we use `?`, the elements can be considered to be of type `Object` (upper bound).
2. When we use `?` to declare an instance, the instance elements cannot be read or write, the only allowed operation is to read Object and to write null.

```
ListOrd<String> ls=new ListOrd<String>();
ls.add("mere");
ls.add("pere");
ListOrd<?> ll=ls;
ll.add("portocale");     //error
ll.update(1, "struguri");//error
Object el=ll.retElemPoz(0);
```

Bounded Wildcards

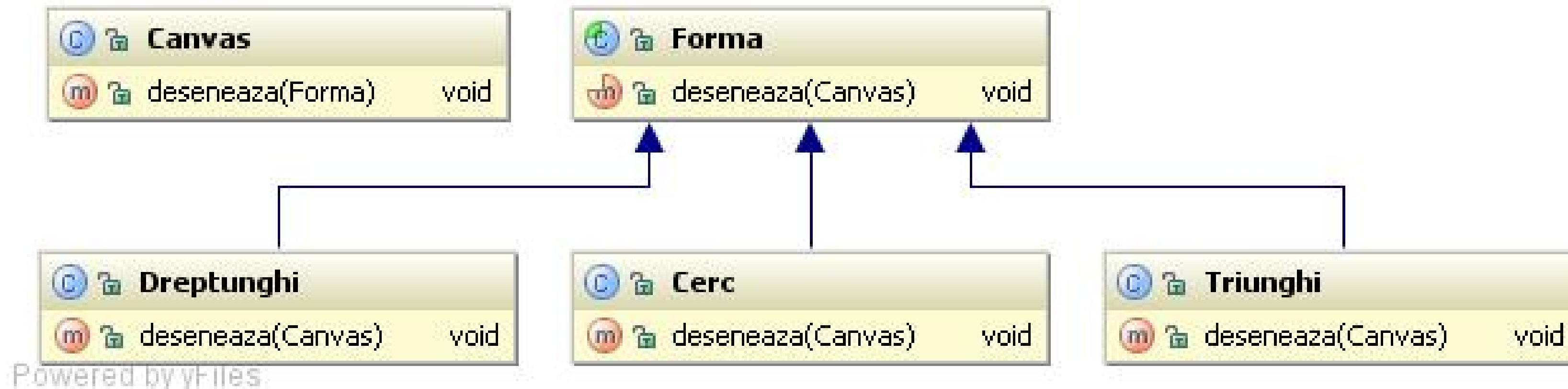
We can specify bounds for ?:

- Upper bound by `extends`: `? extends C` or `? extends I`
- Lower bound by `super`: `? super C (any superclass of C)`

1. Upper bound means that we can read elements of the type (or of superclass of the type) given by the upper bound.
2. Lower bound means that we can write elements of type (or of subclasses of the type) given by the lower bound.

```
ListOrd<Angajat> la=new ListOrd<Angajat>();
la.add(new Angajat(...));
ListOrd<? extends Persoana> lp=la;
lp.add(new Angajat(...));  //error at compile time
Persoana p=lp.retElemPoz(0);
lp.retElemPoz(0).getNume();
ListOrd<? super Angajat> linf=la;
linf.add(new Angajat(...));  //correct
```

Bounded Wildcards




```
public class Canvas {
   public void deseneaza(Forma f){ f.deseneaza(this); }
   public void deseneaza(ListOrd<Forma> lf){
     for(Forma f: lf)
        f.deseneaza(this);
   }
}
//...
Canvas c=new Canvas();
ListOrd<Cerc> lc=new ListOrd<Cerc>();
c.deseneaza(lc);     //error at compile time
```

Bounded Wildcards

```
public class Canvas {
   public void deseneaza(Forma f){ f.deseneaza(this); }
  public void deseneaza(ListOrd<? extends Forma> lf){
    for(Forma f: lf)
       f.deseneaza(this);
   }
}
//...
Canvas c=new Canvas();
ListOrd<Cerc> lc=new ListOrd<Cerc>();
c.deseneaza(lc);  //correct
ListOrd<? extends Forma> ll=lc;
ll.add(new Cerc());      //error at compile time;
```

JAVA COLLECTIONS

Java Collections Framework (JCF)

A *collection* is an object that maintains references to others objects

JCF is part of the `java.util` package and provides:

Interfaces

- Each defines the operations and contracts for a particular type of collection (List, Set, Queue, etc)
- Idea: when using a collection object, it's sufficient to know its interface

Implementations

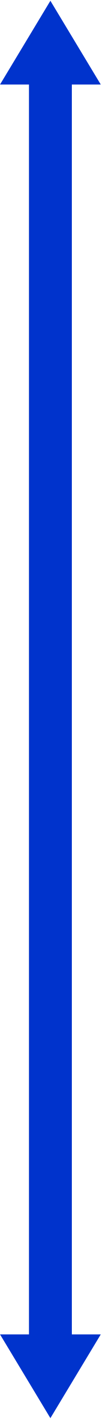
- Reusable classes that implement above interfaces (e.g. LinkedList, HashSet)

Algorithms

- Useful polymorphic methods for manipulating and creating objects whose classes implement collection interfaces
- Sorting, index searching, reversing, replacing etc.

Interfaces

Generalisation



A special Collection that cannot contain duplicates.

Root interface for operations common to all types of collections

Stores mappings from keys to values

Collection

Map

Set

List

Queue

SortedMap

SortedSet

Specialises collection with operations for FIFO and priority queues.

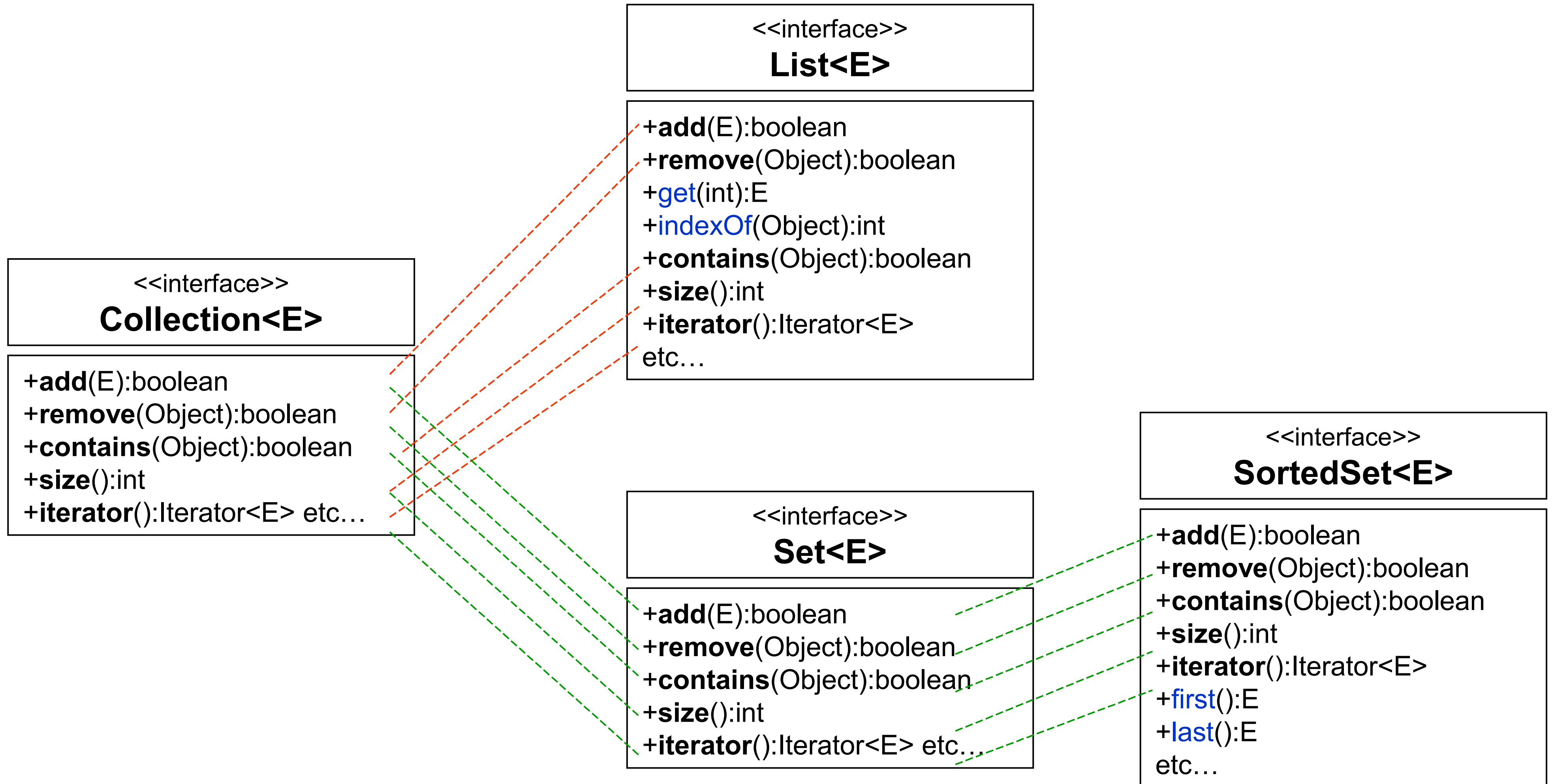
Special map in which keys are ordered

Stores a sequence of elements, allowing indexing methods

Special Set that retains ordering of elements.

Specialisation

Expansion of contracts



The Collection Interface

- The Collection interface provides the basis for List-like collections in Java. The interface includes:

boolean add(Object)
boolean addAll(Collection)
void clear()
boolean contains(Object)
boolean containsAll(Collection)
boolean equals(Object)
boolean isEmpty()
Iterator iterator()
boolean remove(Object)
boolean removeAll(Collection)
boolean retainAll(Collection)
int size()
Object[] toArray()
Object[] toArray(Object[])

List Interface

- Lists allow duplicate entries within the collection
- Lists are an ordered collection much like an array
  - Lists grow automatically when needed
  - The list interface provides accessor methods based on index
- The List interface extends the Collections interface and add the following method definitions:

```
void add(int index, Object)
boolean addAll(int index, Collection)
Object get(int index)
int indexOf(Object)
int lastIndexOf(Object)
ListIterator listIterator()
ListIterator listIterator(int index)
Object remove(int index)
Object set(int index, Object)
List subList(int fromIndex, int toIndex)
```

Set Interface

- The Set interface also extends the Collection interface but does not add any methods to it.
- Collection classes which implement the Set interface have the add stipulation that Sets CANNOT contain duplicate elements
- Elements are compared using the equals method
- NOTE: exercise caution when placing mutable objects within a set. Objects are tested for equality upon addition to the set. If the object is changed after being added to the set, the rules of duplication may be violated.

SortedSet Interface

- SortedSet provides the same mechanisms as the Set interface, except that SortedSets maintain the elements in ascending order.
- Ordering is based on natural ordering (Comparable) or by using a Comparator.

java.util.**Iterator<E>**

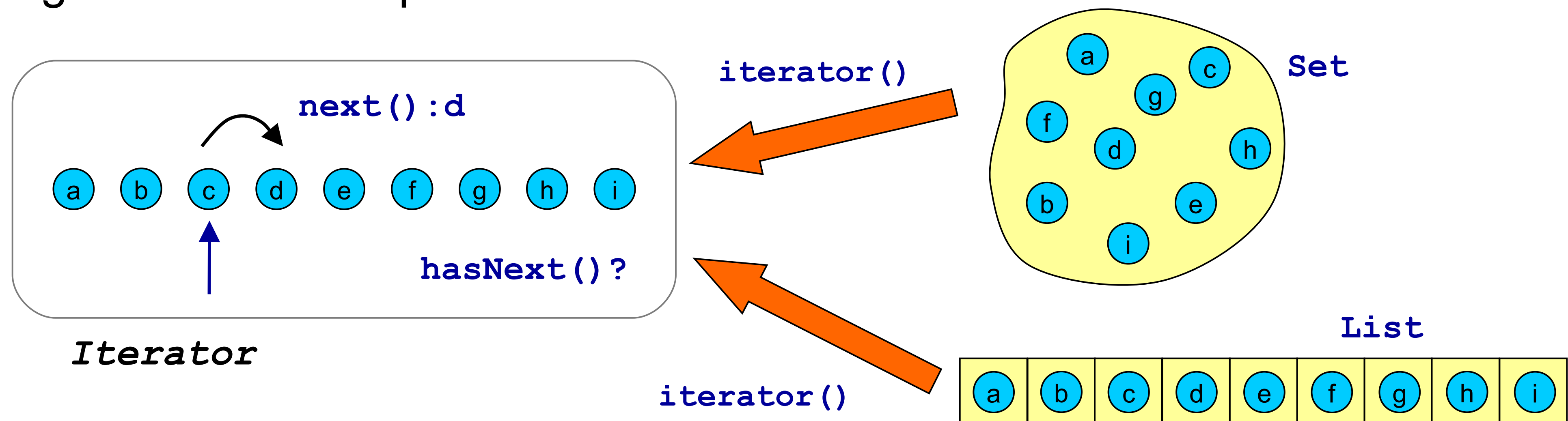
Think about typical usage scenarios for Collections

Retrieve the list of all patients

Search for the lowest priced item

More often than not you would have to traverse every element in the collection – be it a List, Set, or your own datastructure

Iterators provide a generic way to traverse through a collection regardless of its implementation



Using an `Iterator`

Quintessential code snippet for collection iteration:

```
public void list(Collection<T> items) {
  Iterator<T> it = items.iterator();
  while(it.hasNext()) {
    Item item = it.next();
    System.out.println(item.toString());
  }
}
```

<<interface>>
Iterator<E>

+**hasNext**():boolean
+**next**():E
+**remove**():void

Design notes:

- Above method takes in an object whose class implements Collection
  - List, ArrayList, LinkedList, Set, HashSet, TreeSet, Queue, MyOwnCollection, etc
- We know any such object can return an Iterator through method iterator()
- We don't know the exact implementation of Iterator we are getting, but **we don't care**, as long as it provides the methods next() and hasNext()
- Good practice: **Program to an interface!**

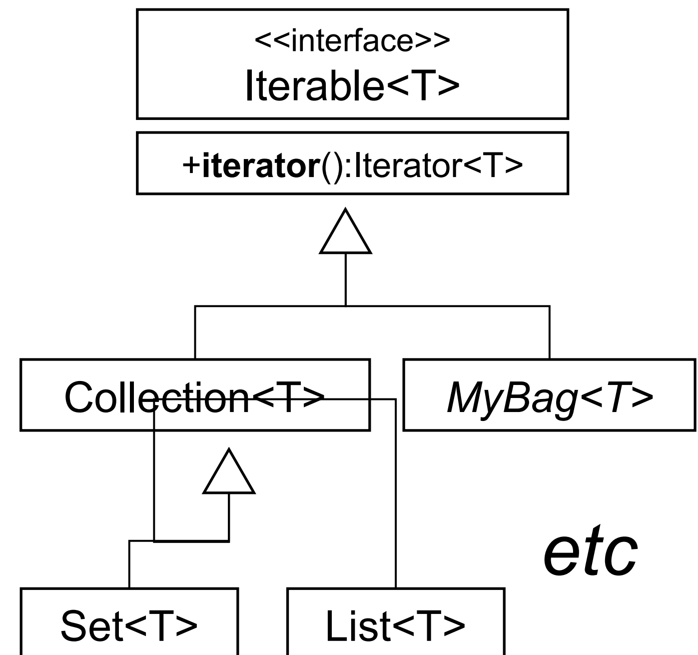
java.lang.**Iterable<T>**

```
for (Item item : items) {
  System.out.println(item);
}
```

=

```
Iterator<Item> it = items.iterator();
while(it.hasNext()) {
  Item item = it.next();
  System.out.println(item);
}
```

- This is called a **“for-each”** statement
  - For each **`item`** in **`items`**
- This is possible as long as items is of type **`Iterable`**
  - Defines single method **`iterator()`**
- **`Collection`** (and hence all its subinterfaces) implements **`Iterable`**
- You can do this to your own implementation of **`Iterable`** too!
  - To do this you may need to return your own implementation of **`Iterator`**



java.util.**Collections**

Offers many very useful utilities and algorithms for manipulating and creating collections

Sorting lists

Index searching

Finding min/max

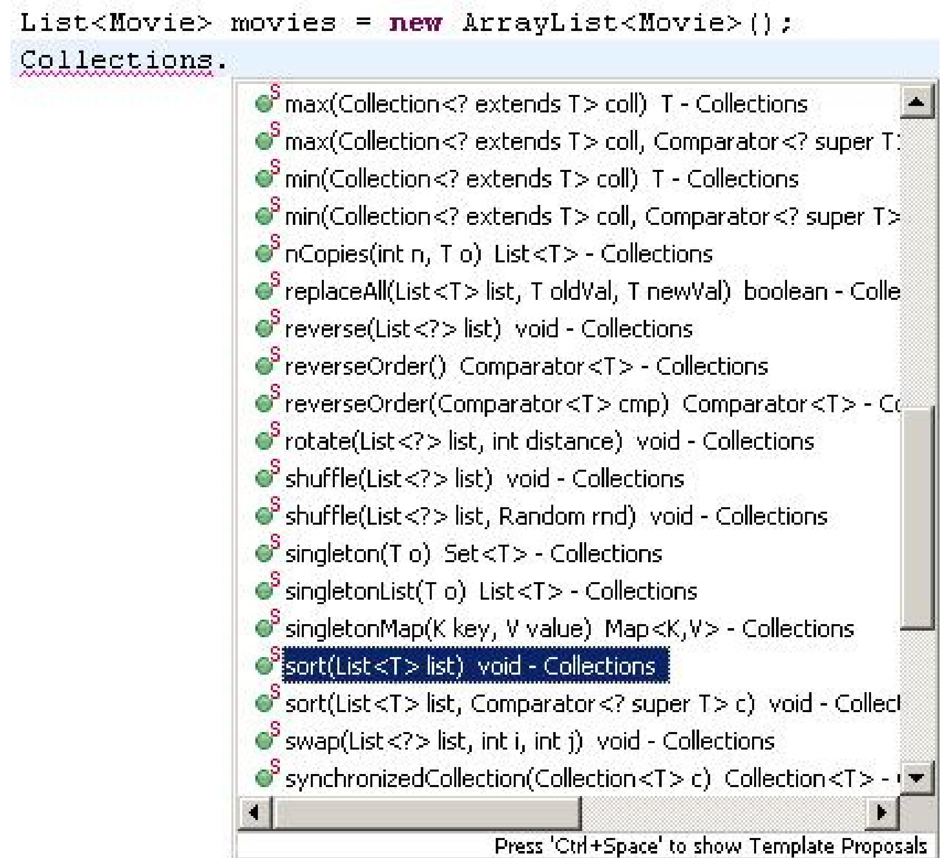
Reversing elements of a list

Swapping elements of a list

Replacing elements in a list

Other nifty tricks

Saves you having to implement them yourself → **reuse**

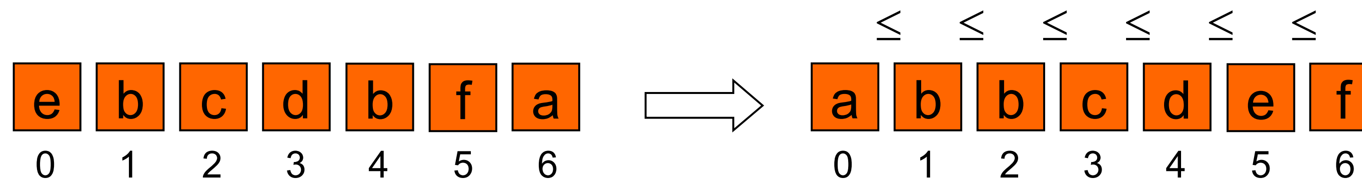


Comparable and Comparators

- You will have noted that some classes provide the ability to sort elements.
  - How is this possible when the collection is supposed to be de-coupled from the data?
- Java defines two ways of comparing objects:
  - The objects implement the Comparable interface
  - A Comparator object is used to compare the two objects
- If the objects in question are Comparable, they are said to be sorted by their "natural" order.
- Comparable object can only offer one form of sorting. To provide multiple forms of sorting, Comparators must be used.

Collections.sort()

Java's implementation of merge sort – ascending order



- What types of objects can you sort? Anything that has an **ordering**
- Two sort() methods: sort a given List according to either 1) *natural ordering* of elements or an 2) externally defined ordering.

1)
```
public static <T extends Comparable<? super T>> void sort(List<T> list)
```

2)
```
public static <T> void sort(List<T> list, Comparator<? super T> c)
```

- Translation:
  1. Only accepts a List parameterised with type implementing Comparable
  2. Accepts a List parameterised with any type as long as you also give it a Comparator implementation that defines the ordering for that type

java.lang.**Comparable<T>**

A **generic interface** with a single method: **`int compareTo(T)`**

Return 0 if this = other

Return **any +'ve integer** if this > other

Return **any –'ve integer** if this < other

Implement this interface to define **natural ordering** on objects of type T

```
public class Money implements Comparable<Money> {
  ...
  public int compareTo( Money other ) {
    if( this.cents == other.cents ) {
      return 0;
    }
    else if( this.cents < other.cents ) {
      return -1;
    }
    else {
      return 1;
    }
  }
```

```
m1 = new Money(100,0);
m2 = new Money(50,0);
m1.compareTo(m2) returns 1;
```

A more concise way of doing this? (hint: 1 line)

```
return this.cents - other.cents;
```

Natural-order sorting

```
List<Money> funds = new ArrayList<Money>();
funds.add(new Money(100,0));
funds.add(new Money(5,50));
funds.add(new Money(-40,0));
funds.add(new Money(5,50));
funds.add(new Money(30,0));

Collections.sort(funds);
System.out.println(funds);

List<CD> albums = new ArrayList<CD>();
albums.add(new CD("Street Signs","Ozomatli",2.80));
//etc...
Collections.sort(albums);
```

What's the output?
[-40.0,
5.50,
5.50,
30.0,
100.0]

CD does not implement a Comparable interface

```
public static <T extends Comparable<? super T>> void sort(List<T> list)
```

java.util.**Comparator<T>**

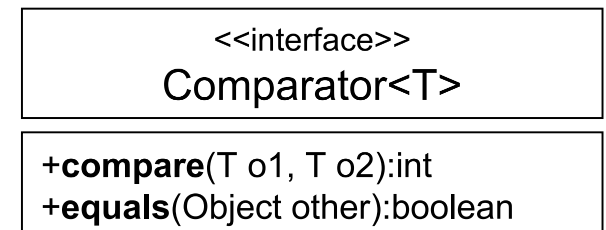
Useful if the type of elements to be sorted is not Comparable, or you want to define an alternative ordering

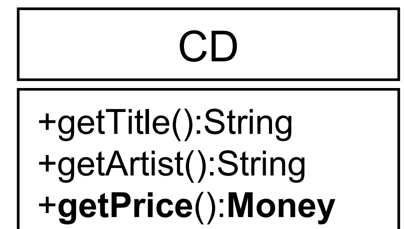
Also a generic interface that defines methods **`compare(T,T)`** and **`equals(Object)`**

Usually only need to define **`compare(T,T)`**

Define ordering by CD's getPrice() → **Money**

Note: PriceComparator implements a Comparator para-meterised with **`CD`** → **`T`** "becomes" **`CD`**






```
public class PriceComparator
implements Comparator<CD> {
  public int compare(CD c1, CD c2) {
    return c1.getPrice().compareTo(c2.getPrice());
  }
}
```

Comparator and Comparable going hand in hand ☺

Comparator sorting

```
List<CD> albums = new ArrayList<CD>();
albums.add(new CD("Street Signs","Ozomatli",new Money(3,50)));
albums.add(new CD("Jazzinho","Jazzinho",new Money(2,80)));
albums.add(new CD("Space Cowboy","Jamiroquai",new Money(5,00)));
albums.add(new CD("Maiden Voyage","Herbie Hancock",new Money(4,00)));
albums.add(new CD("Here's the Deal","Liquid Soul",new Money(1,00)));

Collections.sort(albums, new PriceComparator());
System.out.println(albums);
```

Note, in sort(), Comparator overrides natural ordering

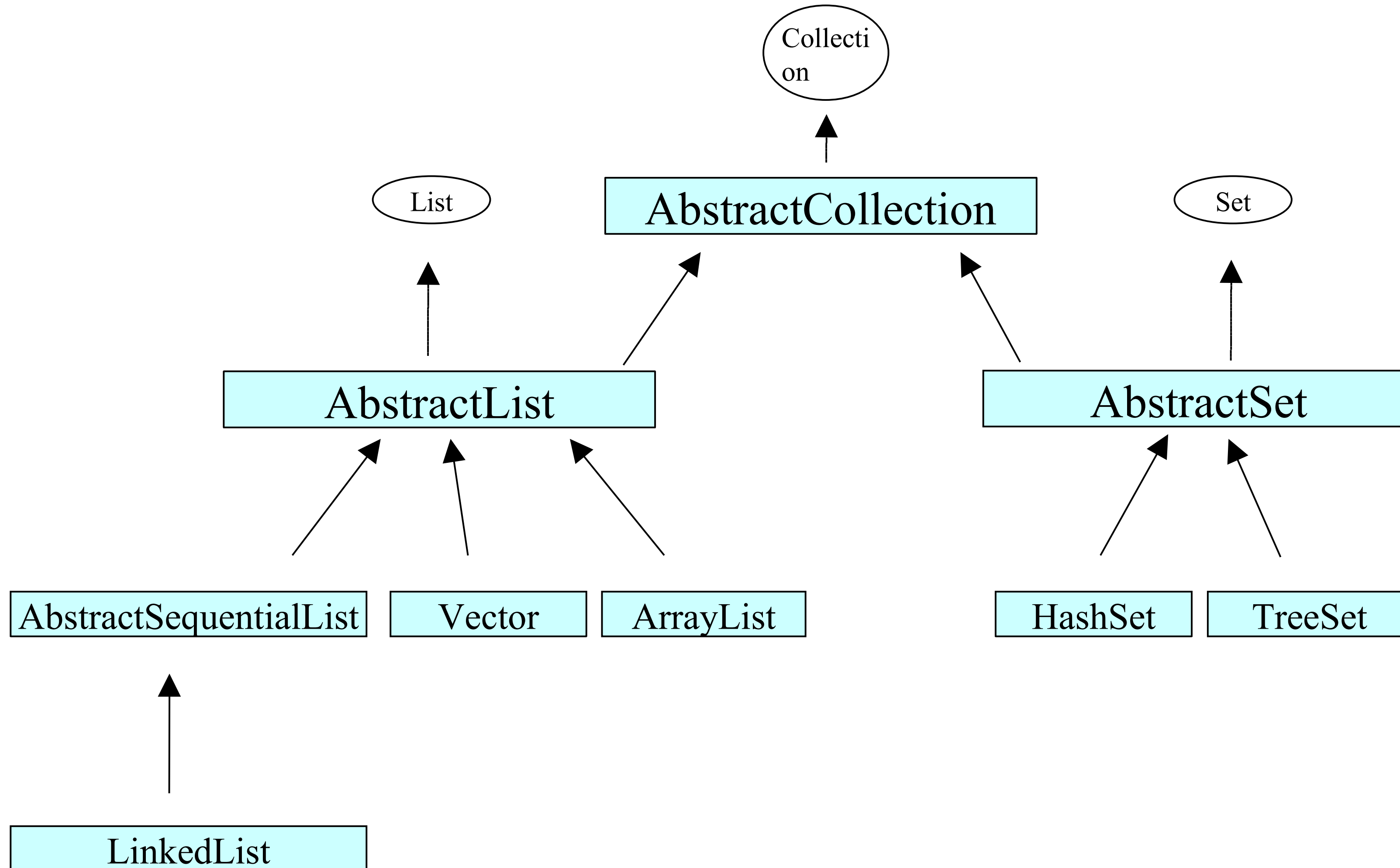
i.e. Even if we define natural ordering for CD, the given comparator is still going to be used instead

(On the other hand, if you give **`null`** as Comparator, then natural ordering is used)

```
public static <T> void sort(List<T> list, Comparator<? super T> c)
```

The Class Structure

- The Collection interface is implemented by a class called AbstractCollection. Most collections inherit from this class.



Lists

- Java provides 3 concrete classes which implement the list interface
  - Vector
  - ArrayList
  - LinkedList
- Vectors try to optimize storage requirements by growing and shrinking as required
  - Methods are synchronized (used for Multi threading)
- ArrayList is roughly equivalent to Vector except that its methods are not synchronized
- LinkedList implements a doubly linked list of elements
  - Methods are not synchronized

Sets

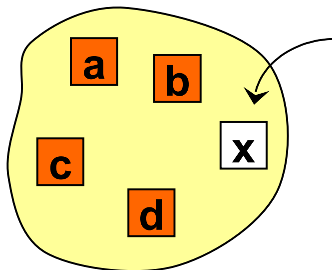
- Java provides 2 concrete classes which implement the Set interface
  - HashSet
  - TreeSet
- HashSet behaves like a HashMap except that the elements cannot be duplicated.
- TreeSet behaves like TreeMap except that the elements cannot be duplicated.
- Note: Sets are not as commonly used as Lists

Set<E>

Mathematical Set abstraction – contains **no duplicate** elements
i.e. no two elements e1 and e2 such that e1.equals(e2)

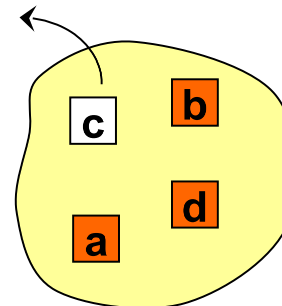
add(x)
→*true*

add(b)
→*false*



remove(c)
→*true*

remove(x)
→*false*

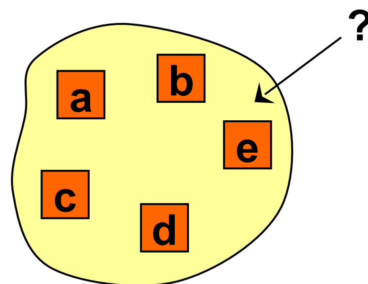


<<interface>>
Set<E>

+**add**(E):boolean
+**remove**(Object):boolean
+**contains**(Object):boolean
+**isEmpty**():boolean
+**size**():int
+**iterator**():Iterator<E> etc…

contains(e)
→true

contains(x)
→*false*



isEmpty()
→*false*

size()
→*5*

<<interface>>
SortedSet<E>

+first():E
+last():E
etc…

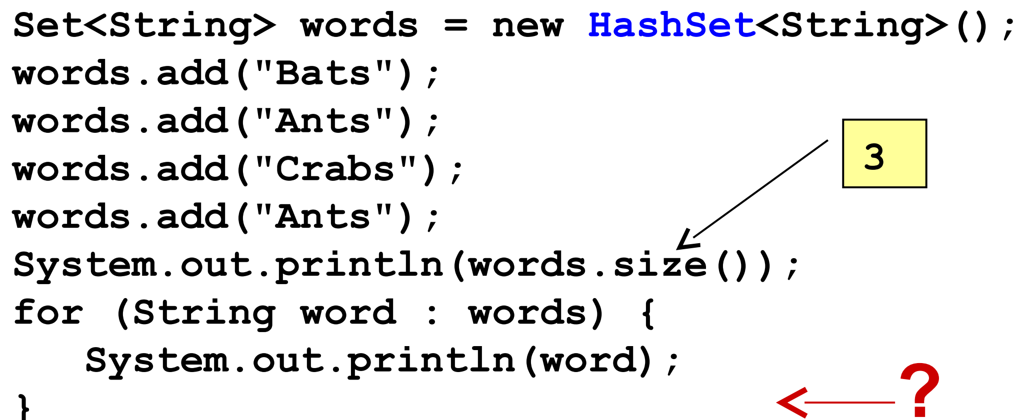
HashSet<E>

- Typically used implementation of Set.
- Hash? Implemented using HashMap (later)
- Parameterise Sets just as you parameterise Lists
- Efficient (constant time) insert, removal and contains check – all done through hashing
- x and y are duplicates if x.equals(y)
- How are elements ordered? Quiz:

<<interface>>
Set<E>

+**add**(E):boolean
+**remove**(Object):boolean
+**contains**(Object):boolean
+**size**():int
+**iterator**():Iterator<E> etc…

HashSet<E>



a) Bats, Ants, Crabs
b) Ants, Bats, Crabs
c) Crabs, Bats, Ants
d) Nondeterministic

TreeSet<E> (**SortedSet<E>**)

If you want an ordered set, use an implementation of a SortedSet: TreeSet

What's up with "Tree"? Red-black tree

Guarantees that all elements are ordered (sorted) at all times

`add()` and **`remove()`** preserve this condition

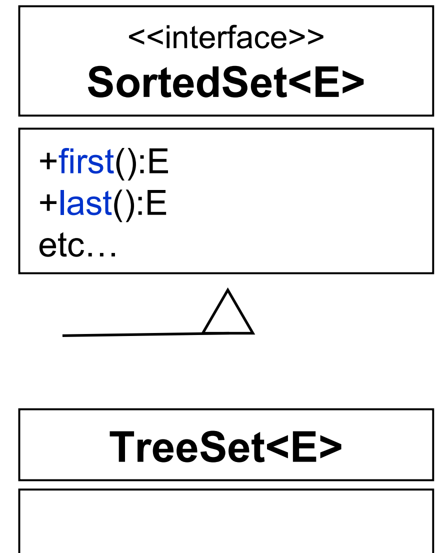
`iterator()` always returns the elements in a specified order

Two ways of specifying ordering

Ensuring elements have natural ordering (**`Comparable`**)

Giving a **`Comparator<E>`** to the constructor

Caution: TreeSet considers x and y are duplicates if x.compareTo(y) == 0 (or compare(x,y) == 0)



TreeSet construction

```
Set<String> words = new TreeSet<String>();
words.add("Bats");
words.add("Ants");
words.add("Crabs");
for (String word : words) {
   System.out.println(word);
}
```

String has a **natural ordering**, so empty constructor

What's the output?
Ants; Bats; Crabs

- But CD doesn't, so you must pass in a Comparator to the constructor

```
Set<CD> albums = new TreeSet<CD>(new PriceComparator());
albums.add(new CD("Street Signs","O",new Money(3,50)));
albums.add(new CD("Jazzinho","J",new Money(2,80)));
albums.add(new CD("Space Cowboy","J",new Money(5,00)));
albums.add(new CD("Maiden Voyage","HH",new Money(4,00)));
albums.add(new CD("Here's the Deal","LS",new Money(2,80)));
System.out.println(albums.size());
for (CD album : albums) {
   System.out.println(album);
}
```

What's the output?
4
Jazzinho; Street; Maiden; Space

The Map Interface

- The Map interface provides the basis for dictionary or key-based collections in Java. The interface includes:

void clear()
boolean containsKey(Object)
boolean containsValue(Object)
Set entrySet()
boolean equals(Object)
Object get(Object)
boolean isEmpty()
Set keySet()
Object put(Object key, Object value)
void putAll(Map)
boolean remove(Object key)
int size()
Collection values()

Maps

- Java provides 3 concrete classes which implement the map interface
  - HashMap
  - WeakHashMap
  - TreeMap
- HashMap is the most commonly used Map.
  - Provides access to elements through a key.
  - The keys can be iterated if they are not known.
- WeakHashMap provides the same functionality as Map except that if the key object is no longer used, the key and it's value will be removed from the Map.
- A Red-Black implementation of the Map interface

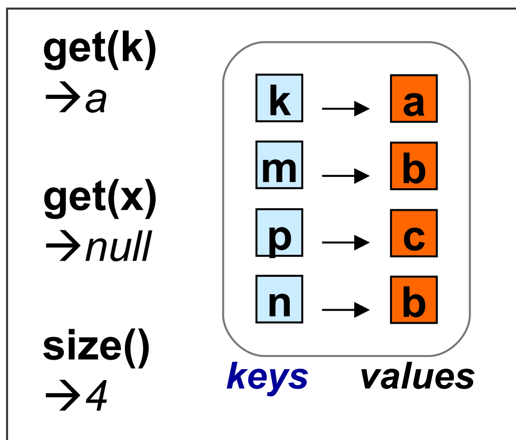
Map<K,V>

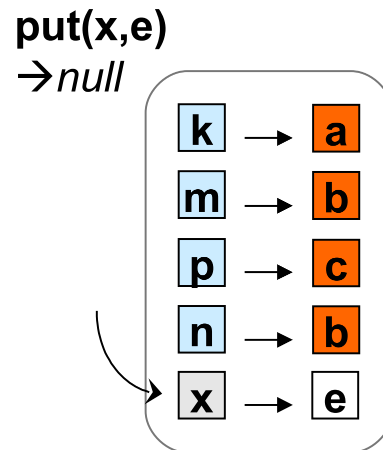
Stores mappings from (unique) keys (type `K`) to values (type `V`)

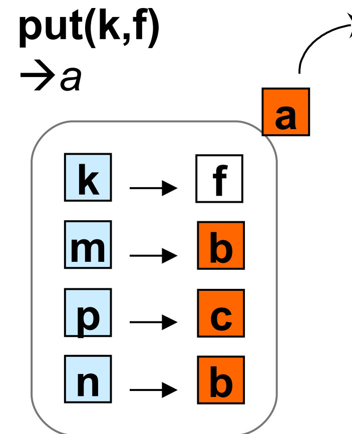
See, you can have more than one type parameters!

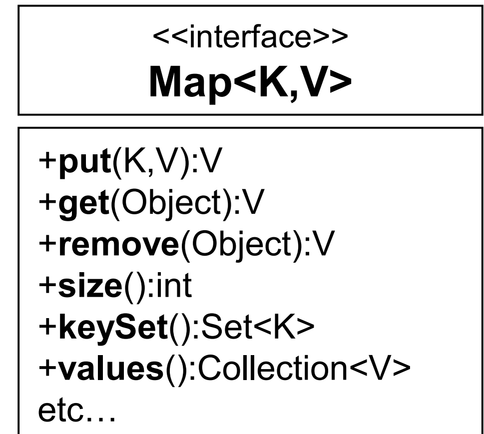
Think of them as "arrays" but with objects (keys) as indexes

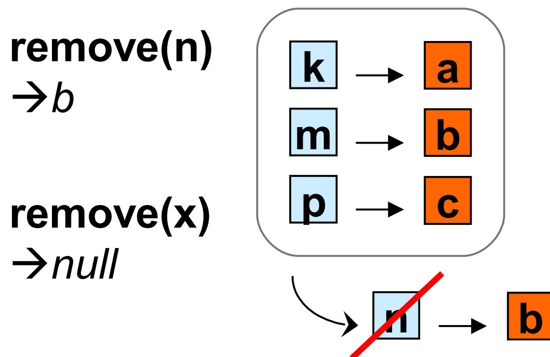
Or as "directories": e.g. `"Bob"` → `021999887`

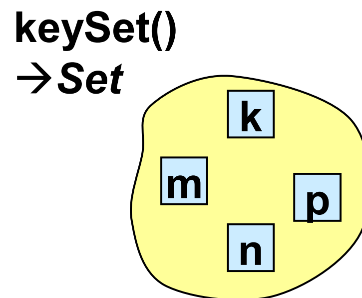


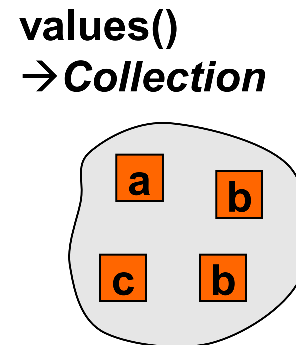


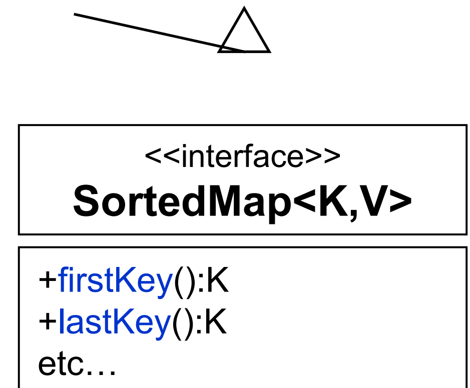




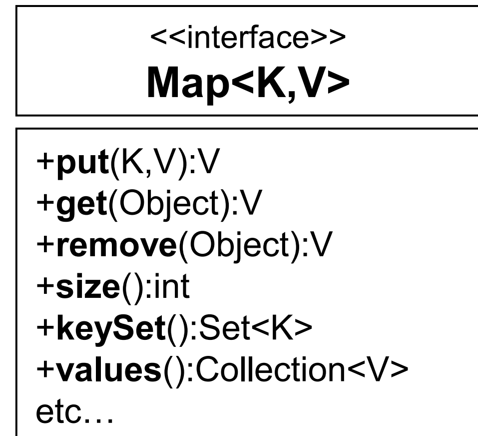








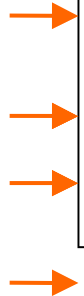
HashMap<K,V>



keys are hashed using `Object.hashCode()`
i.e. no guaranteed ordering of keys

`keySet()` returns a `HashSet`

`values()` returns an unknown Collection



```
Map<String, Integer> directory
                  = new HashMap<String, Integer>();
directory.put("Mum", new Integer(9998888));
directory.put("Dad", 9998888);
directory.put("Bob", 12345678);
directory.put("Edward", 5553535);
directory.put("Bob", 1000000);
System.out.println(directory.size());
for (String key : directory.keySet()) {
  System.out.print(key+"'s number: ");
  System.out.println(directory.get(key));
}
System.out.println(directory.values());
```

"autoboxing"

4 or 5?

`Set<String>`

What's Bob's number?

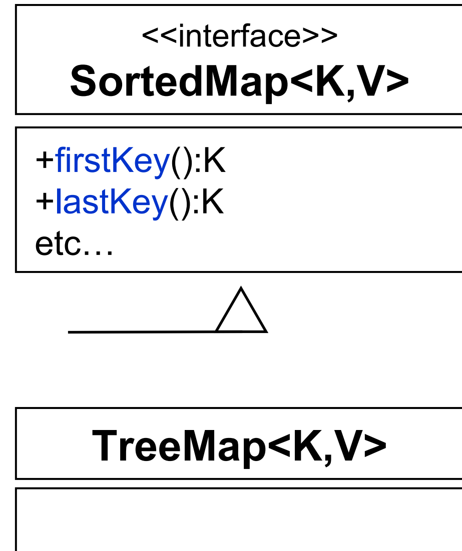
TreeMap<K,V>

Guaranteed ordering of keys (like TreeSet)

In fact, TreeSet is implemented using TreeMap ☺

Hence **`keySet()`** returns a **`TreeSet`**

`values()` returns an unknown Collection – ordering depends on ordering of **keys**



Empty constructor → natural ordering

```
Map<String, Integer> directory
                  = new TreeMap<String, Integer>();
directory.put("Mum", new Integer(9998888));
directory.put("Dad", 9998888);
directory.put("Bob", 12345678);
directory.put("Edward", 5553535);
directory.put("Bob", 1000000);
System.out.println(directory.size());
for (String key : directory.keySet()) {
  System.out.print(key+"'s #: ");
  System.out.println(directory.get(key));
}
System.out.println(directory.values());
```

4

Loop output?

```
Bob's #: 1000000
Dad's #: 9998888
Edward's #: 5553535
Mum's #: 9998888
```

?

TreeMap with Comparator

As with TreeSet, another way of constructing TreeMap is to give a Comparator → necessary for non-Comparable keys

```
Map<CD, Double> ratings
              = new TreeMap<CD, Double>(new PriceComparator());
ratings.put(new CD("Street Signs","O",new Money(3,50)), 8.5);
ratings.put(new CD("Jazzinho","J",new Money(2,80)), 8.0);
ratings.put(new CD("Space Cowboy","J",new Money(5,00)), 9.0);
ratings.put(new CD("Maiden Voyage","H",new Money(4,00)), 9.5);
ratings.put(new CD("Here's the Deal","LS",new Money(2,80)), 9.0);

System.out.println(ratings.size());
for (CD key : ratings.keySet()) {
  System.out.print("Rating for "+key+": ");
  System.out.println(ratings.get(key));
}
System.out.println("Ratings: "+ratings.values());
```

4

Ordered by key's price

Depends on key ordering

Most Commonly Use Methods

- While it is a good idea to learn and understand all of the methods defined within this infrastructure, here are some of the most commonly used methods.

- For Lists:
  - add(Object), add(index, Object)
  - get(index)
  - set(index, Object)
  - remove(Object)

- For Maps:
  - put(Object key, Object value)
  - get(Object key)
  - remove(Object key)
  - keySet()

Which class should I use?

- You'll notice that collection classes all provide the same or similar functionality. The difference between the different classes is how the structure is implemented.
  - This generally has an impact on performance.
- Use Vector
  - Fast access to elements using index
  - Optimized for storage space
  - Not optimized for inserts and deletes
- Use ArrayList
  - Same as Vector except the methods are not synchronized. Better performance
- Use linked list
  - Fast inserts and deletes
  - Stacks and Queues (accessing elements near the beginning or end)
  - Not optimized for random access

Which class should I use?

- Use Sets
  - When you need a collection which does not allow duplicate entries
- Use Maps
  - Very Fast access to elements using keys
  - Fast addition and removal of elements
  - No duplicate keys allowed
- When choosing a class, it is worthwhile to read the class's documentation in the Java API specification. There you will find notes about the implementation of the Collection class and within which contexts it is best to use.

Collections and Fundamental Data Types

- Note that collections can only hold Objects.
  - One cannot put a fundamental data type into a Collection
- Java has defined "wrapper" classes which hold fundamental data type values within an Object
  - These classes are defined in java.lang
  - Each fundamental data type is represented by a wrapper class
- The wrapper classes are:

  Boolean
  Byte
  Character
  Double
  Float
  Short
  Integer
  Long

Wrapper Classes

- The wrapper classes are usually used so that fundamental data values can be placed within a collection
- The wrapper classes have useful class variables.
  - Integer.MAX_VALUE, Integer.MIN_VALUE
  - Double.MAX_VALUE, Double.MIN_VALUE, Double.NaN, Double.NEGATIVE_INFINITY, Double.POSITIVE_INFINITY
- They also have useful class methods

  Double.parseDouble(String) - converts a String to a double

  Integer.parseInt(String) - converts a String to an integer

Continuation from Lecture 1

Note: The attendance at seminars and labs is available online at

https://docs.google.com/spreadsheets/d/1-n1aJooRGoGqD2XTJmbj9Cri5DWNzKeE2Y7oDWZ5rZ0/edit?ts=57f7528a#gid=0

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--;
  }
}
```

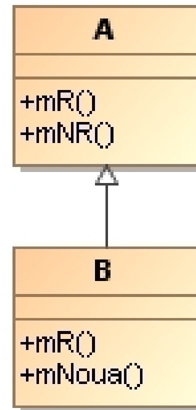
  - To call the overridden method (from the base class) from the overriding method (from the subclass).

```
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

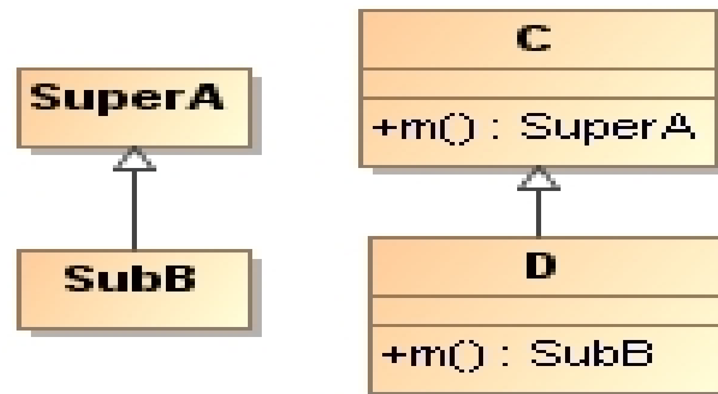
4. adnotation `@Override` (JSE >=5) in order to force a compile-time verification

```
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).

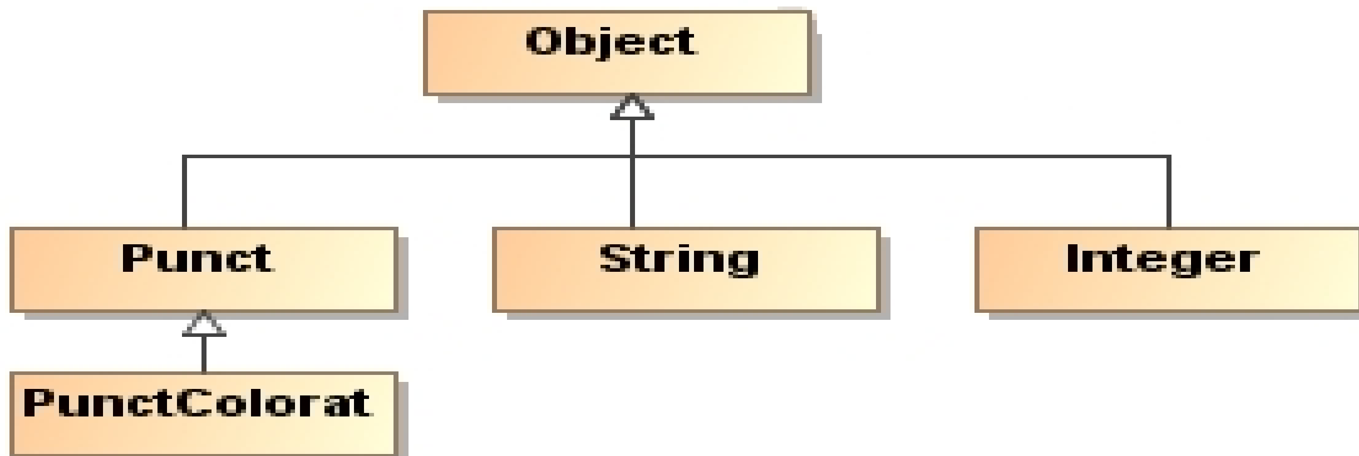
```
public class C{
  public SuperA m(){...}
}
public class D extends C{
  public SubB m(){...}
}
```



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

```
Object
+equals( o : Object ) : boolean
+toString() : String
+hashCode() : int
+notify()
+notifyAll()
+wait()
#clone() : Object
#finalize()
```

- `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.

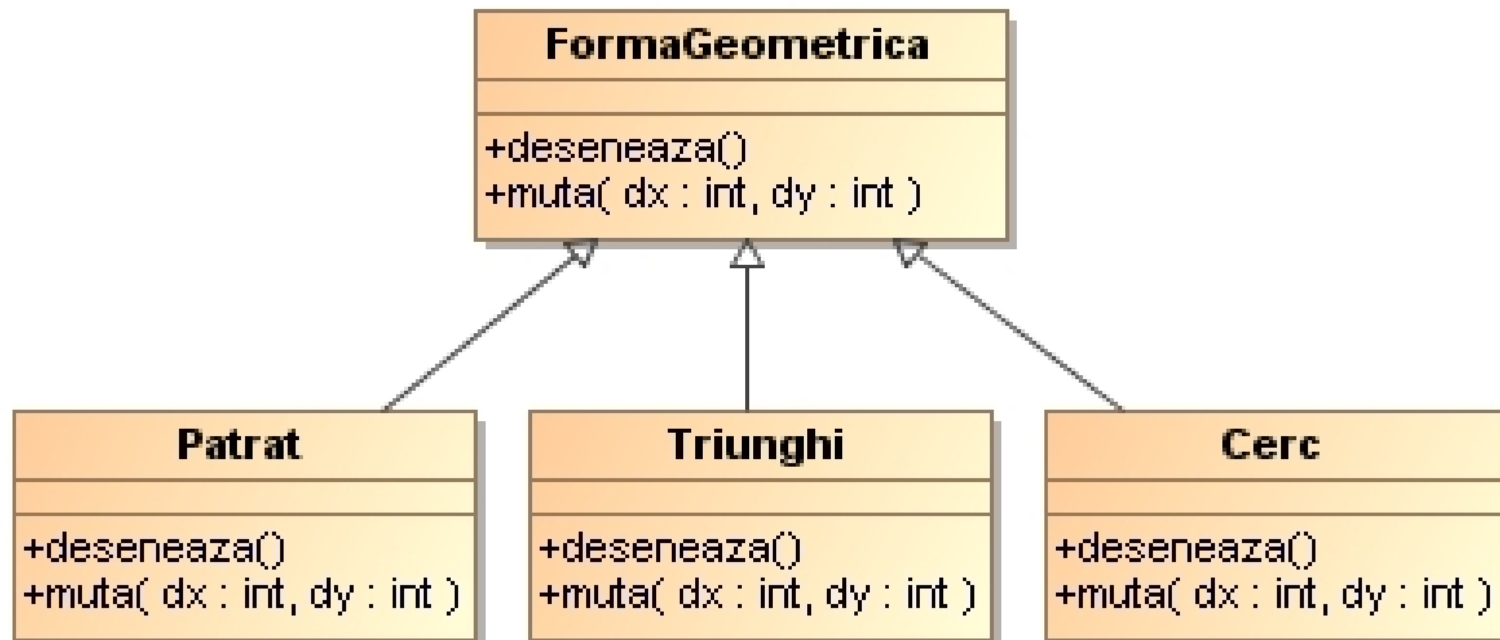
```
Punct p1=new Punct(2,3);
Punct p2=new Punct(2,3);
boolean egale=(p1==p2);   //false;
egale=p1.equals(p2);     //true, Punct must redefine equals
System.out.println(p1);   //toString is called
```

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*.
- An abstract class is defined using **abstract.**

```
[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;
}
```

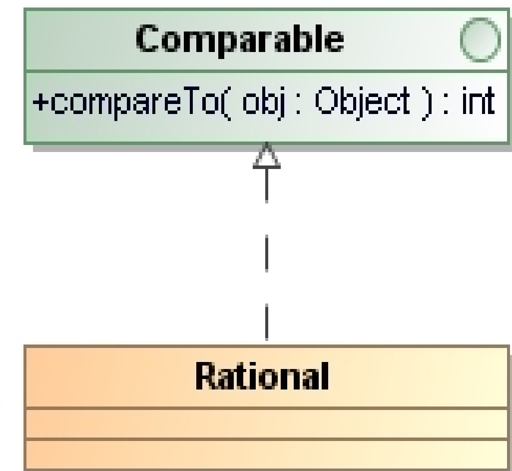
Interface implementation

- 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

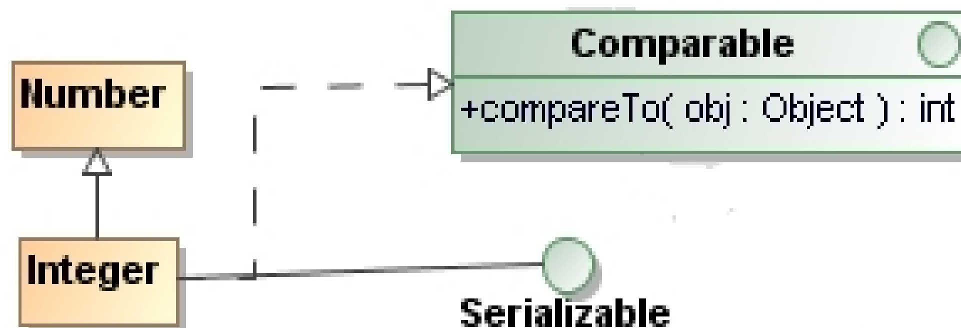
```
class C2 implements I1, I2 {
     public void f() {}
     public int f(int i) { return 1; }
     //overloading
}
class CC implements I1, I3{  //error at compile-time
  //...
}
```

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){
     //...
     }
}
```



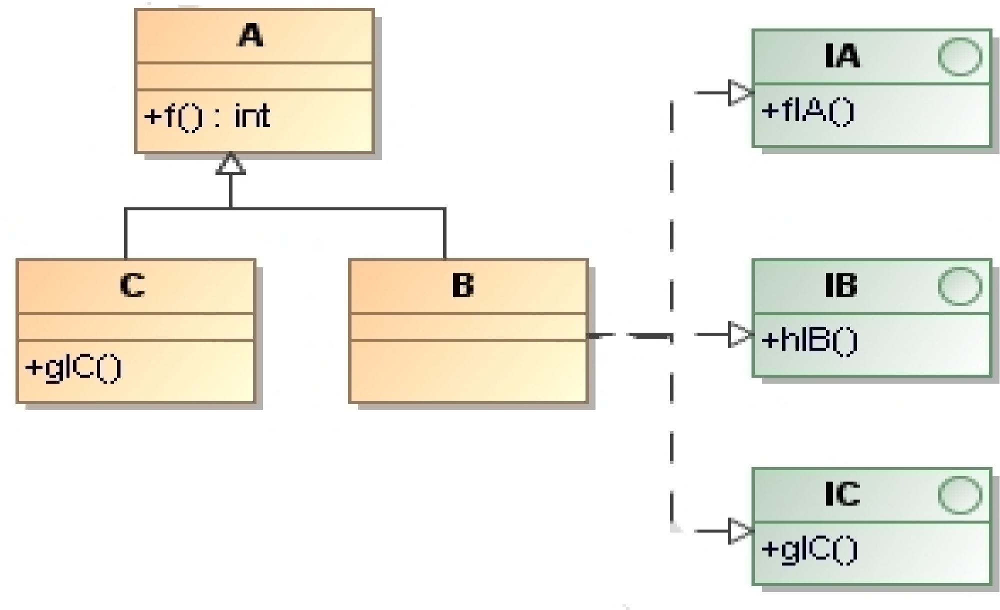
Variables of type interface

- An interface is a reference 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

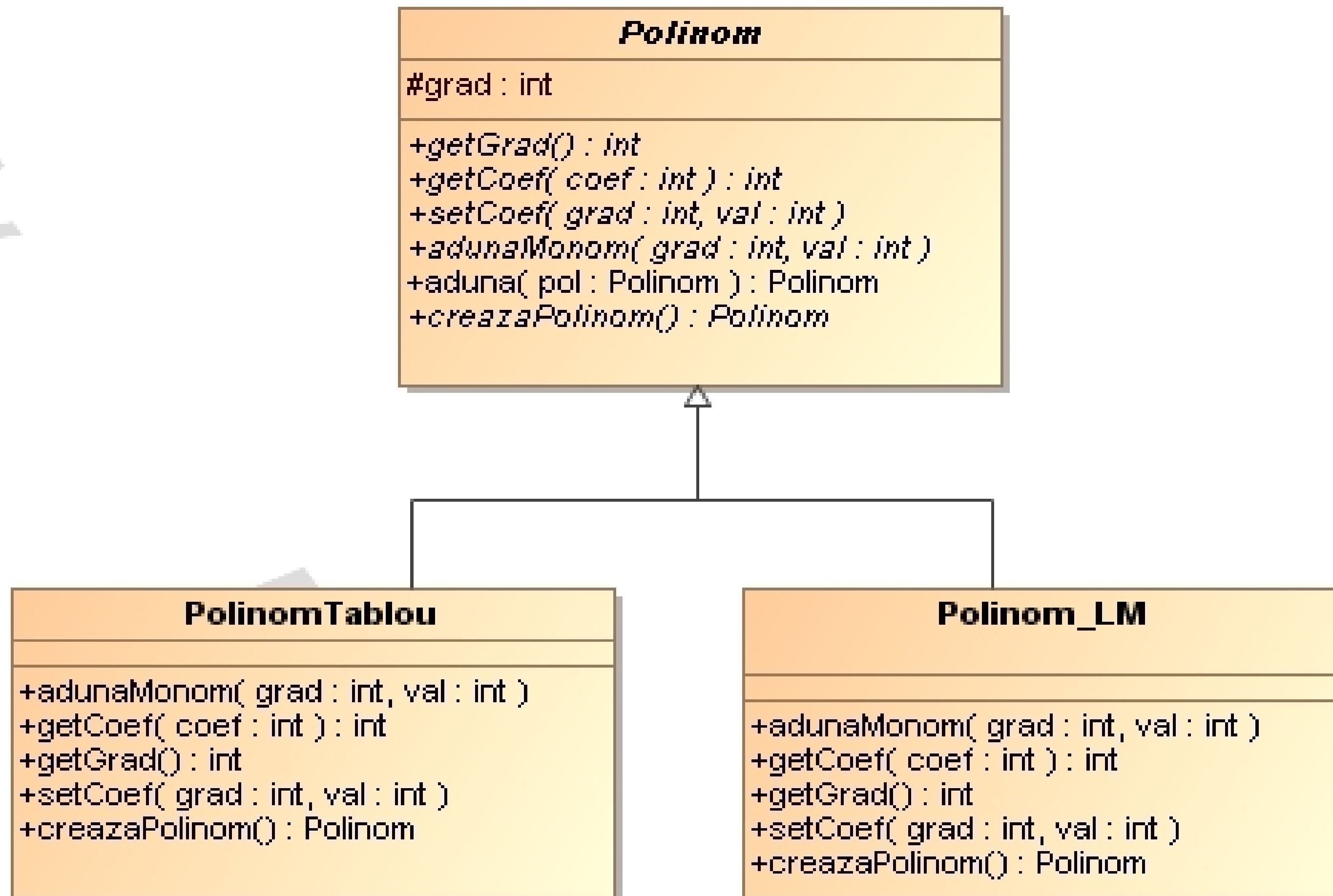
```
B b=new B();
IA ia=b; ia.fIA();

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

ic.f(); //?

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



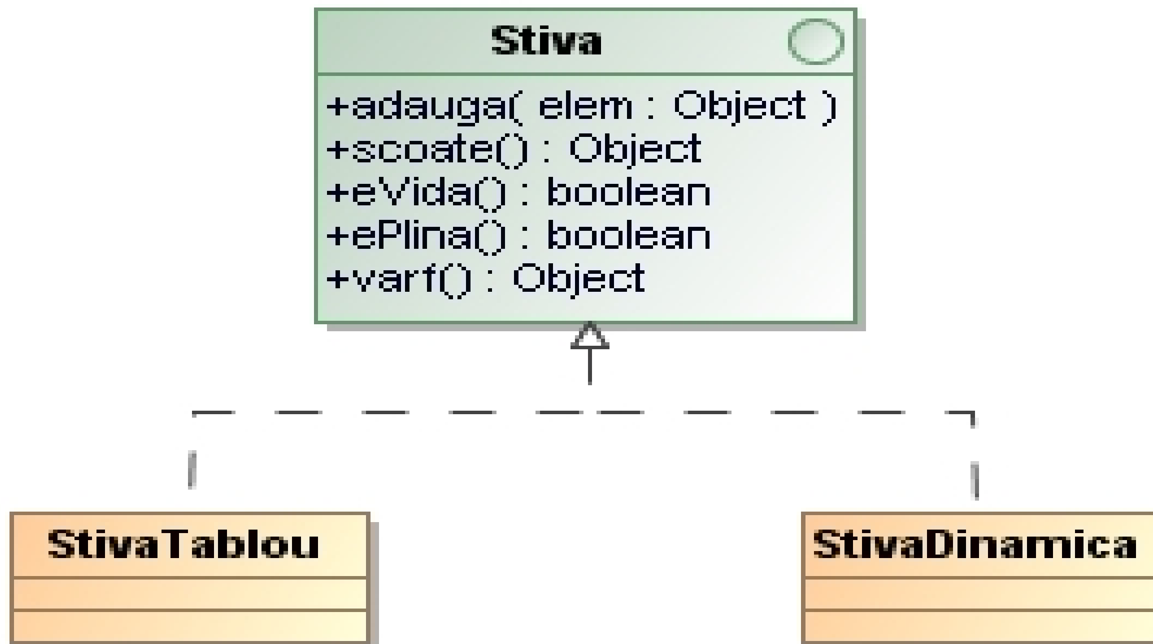
Abstract Class vs Interface

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 modifiiers 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();
   }
}
```

Advanced Programming Methods

Lecture 3-4 - Java IO Operations

Overview

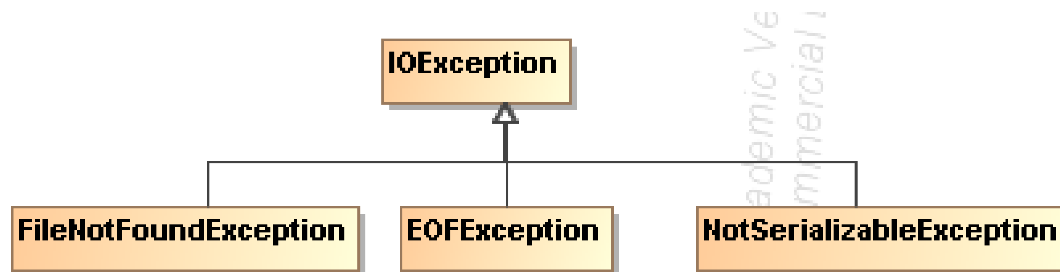
1. Java IO
2. Java NIO
3. Try-with-resources

Java IO

Java.IO

- Package java.io
  - classes working on bytes (InputStream, OutputStream)
  - Classes working on chars (Reader, Writer)
  - Byte-char conversion (InputStreamReader, OutputStreamWriter)
  - Random access (RandomAccessFile)
  - Scanner

- Exceptions:

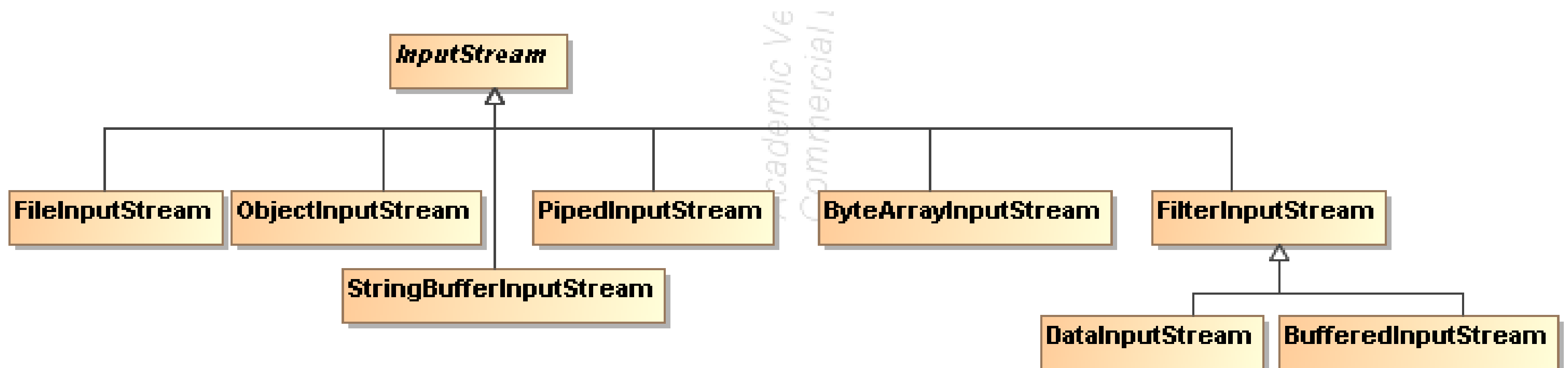


IO Stream

- represents an input source or an output destination
- is a sequence of data
- supports many different kinds of data, including simple bytes, primitive data types, localized characters, and objects.
- simply passes on data; others manipulate and transform the data in useful ways.

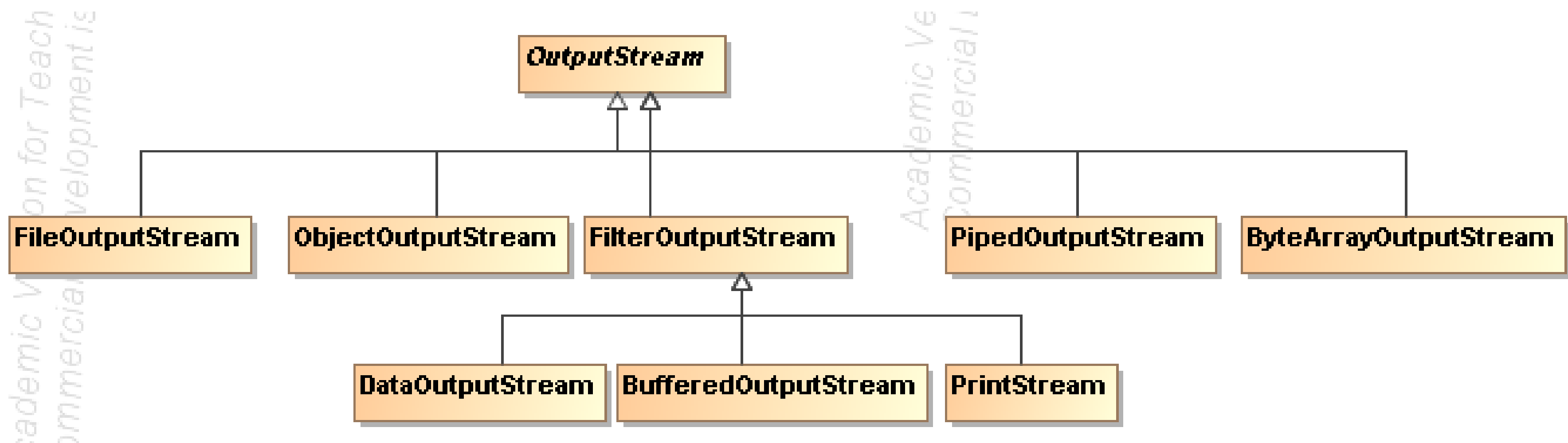
InputStream

- Abstract class that contains methods for reading bytes from a stream (file, memory, pipe, etc.)
  - `read():int` //read a byte, return –1 if no more bytes
  - `read(cbuff:byte[]): int` //read max `cbuff.length bytes`, return the nr of bytes that has been read, or -1
  - `read(buff:byte[], offset:int, length:int):int` //read max `length` bytes and write to `buff` starting with position `offset`, return the number of bytes that has been read, or -1
  - `available(): int` //number of bytes available for reading
  - `close()` //close the stream



OutputStream

- Abstract class that contains methods for writing bytes into a stream (file, memory, pipe, etc.)
  - `write(int)` //write a byte
  - `write(b:byte[])` //write `b.length` bytes from array `b` into the stream
  - `write(b:byte[], offset:int, len:int):int` //write `len` bytes from array `b` starting with the position `offset`
  - `flush()` // force the effective writing into the stream
  - `close()` //close the stream

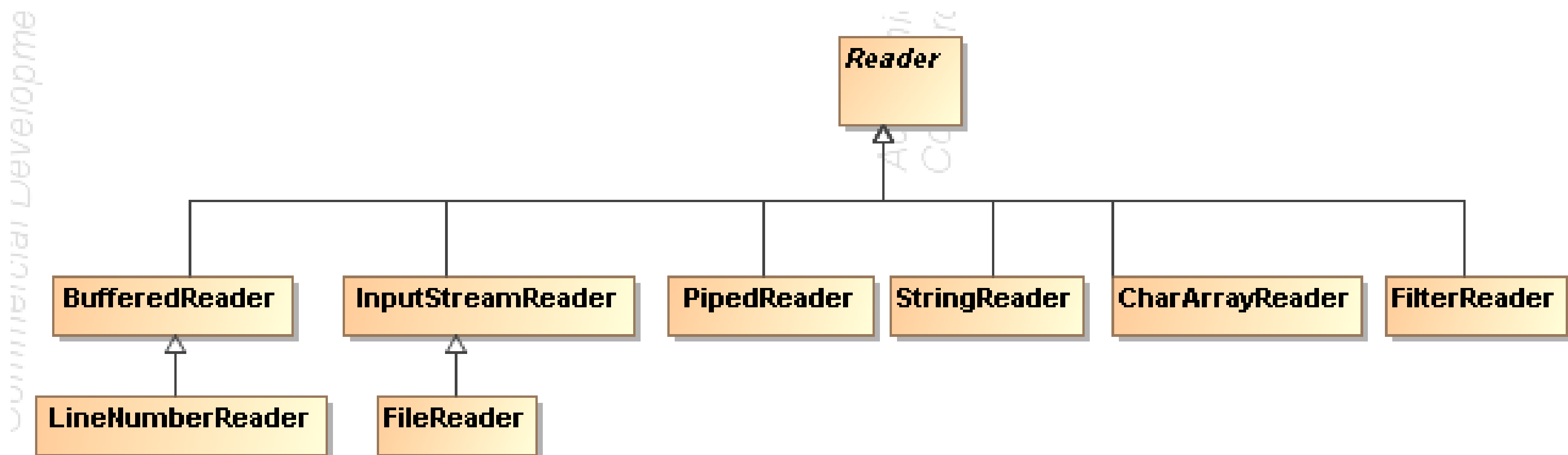


Example

```
FileInputStream in = null;
FileOutputStream out = null;
try {
   in = new FileInputStream("fisier.txt");
   out = new FileOutputStream("fisier2.txt");
   int c;
   while ((c = in.read()) != -1) {
          out.write(c);
   }
 } catch(IOException e){
    System.err.println("Eroare "+e);
 }finally {
   if (in != null)
      try {
          in.close();
      } catch (IOException e){ System.err.println("eroare "+e);}
   if (out != null)
       try {
           out.close();
       } catch (IOException e) { System.err.println("eroare "+e);}
}
```

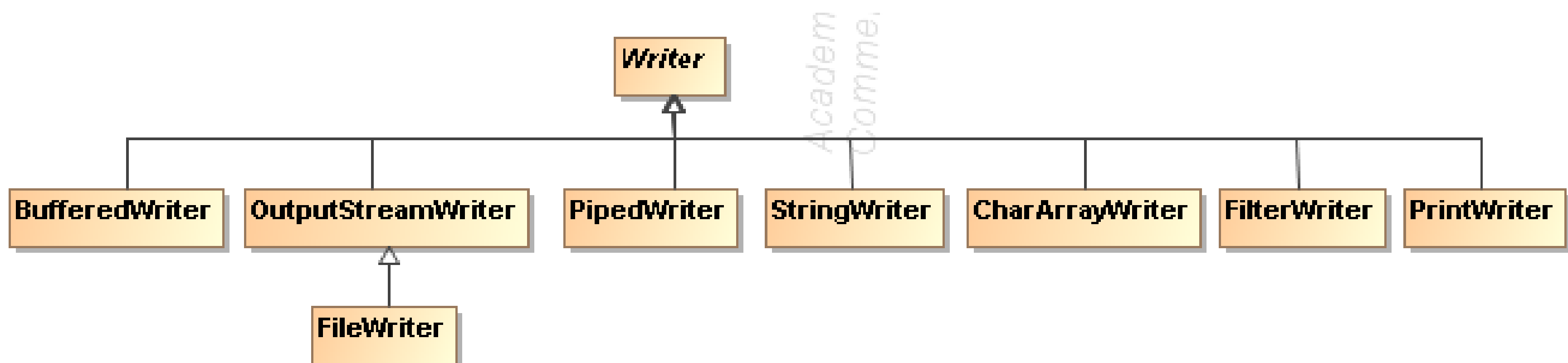
Reader

- Abstract class that contains methods for chars reading (1 char = 2 bytes) from a stream (file, memory, pipe, etc.)
  - `read():int` //read a char, return –1 for the end of the stream
  - `read(cbuff:char[]): int` //read max `cbuff.length` chars, return nr of read chars or -1
  - `read(buff:char[], offset:int, length:int):int` //read max `length` chars into array `buff` starting with offset `offset`, return the number of read chars or -1
  - `close()` //close the stream



Writer

- Abstract class that contains the methods for writing chars into a stream
  - `write(int)` //write a char
  - `write(b:char[])` //write `b.length` chars from array `b` into the stream
  - `write(b:char[], offset:int, len:int):int` //write `len` chars from array `b` starting with offset
  - `write(s:String)` //write a `String`
  - `write(s:String, off:int, len:int)` //write a part of a `String`
  - `flush()` // force the effective writing
  - `close()` //close the stream



Example

```
FileReader input = null;
FileWriter output = null;
try {
   input = new FileReader("Fisier.txt");
   output = new FileWriter("Fisier2out.txt");
   int c;
   while ((c = input.read()) != -1) output.write(c);
} catch (IOException e) {
   System.err.println("Eroare la citire/scriere"+e);
} finally {
    if (input != null)
        try {
           input.close();
        } catch (IOException e) {System.err.println("eroare "+e);}
    if (output != null)
         try {
             output.close();
         } catch (IOException e) {System.err.println("Eroare "+e);}
}
```

Classes

Operations	Byte	Char
Files	FileInputStream, FileOutputStream	FileReader, FileWriter
Memory	ByteArrayInputStream, ByteArrayOutputStream	CharArrayReader CharArrayWriter
Buffered Operations	BufferedInputStream BufferedOutputStream	BufferedReader BufferedWriter
Format	PrintStream	PrintWriter
Conversion Byte ↔ Char	InputStreamReader (byte -> char) OutputStreamWriter (char -> byte)	

Example

- Read a list of students (from a file, from keyboard)
- Saving the list of students in ascending order based on their average (into a file)

//Studenti.txt

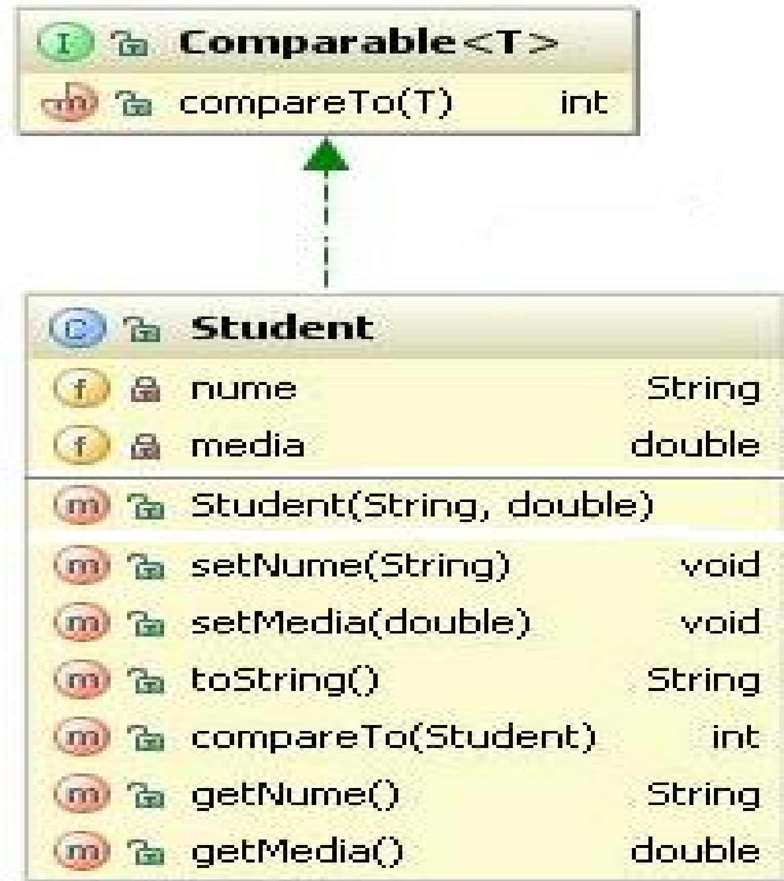
Vasilescu Maria|8.9

Popescu Ion|6.7

Marinescu Ana|9.6

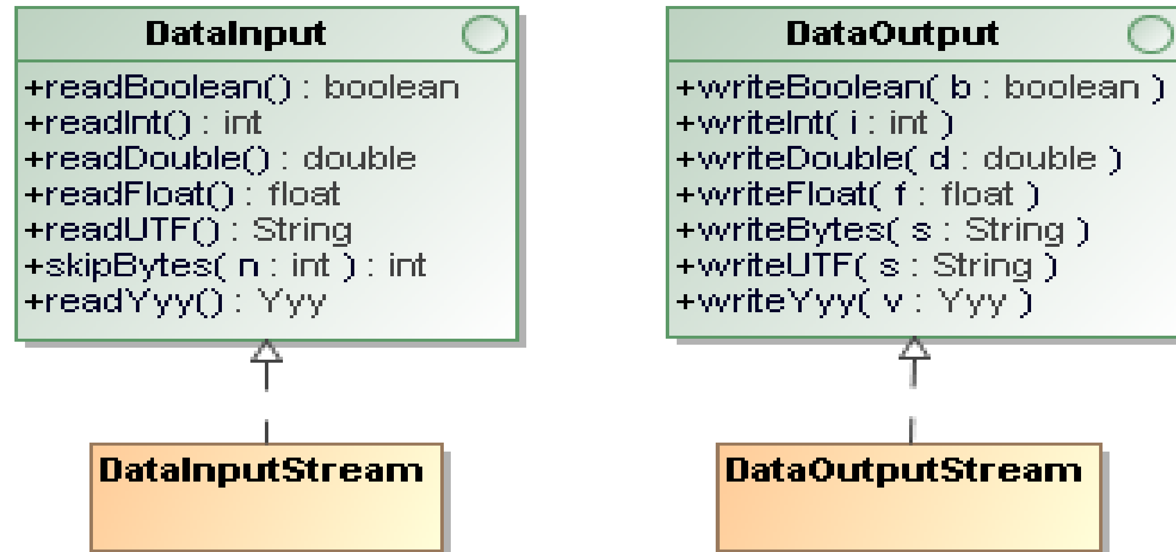
Ionescu George|7.53

Pop Vasile|9.3



Writing and reading data of primitive types

- Interfaces `DataInput` and `DataOutput`



- `Yyy` can be primitive types (`byte, short, char,` ...): `readByte(), readShort(), readChar(), writeByte(byte), writeShort(short), ...`

Obs:

1. In order to read data of primitive types using methods `readYyy,` the data must be saved before using the methods `writeYyy.`
2. When there are no more data it throws the exception `EOFException.`

Example DataOutput

```
void printStudentiDataOutput(List<Student> studs, String numefis){
       DataOutputStream output=null;
       try{
           output=new DataOutputStream(new FileOutputStream(numefis));
           for(Student stud: studs){
               output.writeUTF(stud.getNume());
               output.writeDouble(stud.getMedia());
           }
       } catch (FileNotFoundException e) {
           System.err.println("Eroare scriere DO "+e);
       } catch (IOException e) {
           System.err.println("Eroare scriere DO "+e);
       }finally {
           if (output!=null)
               try {
                   output.close();
               } catch (IOException e) {
                   System.err.println("Eroare scriere DO "+e);
               }
       }
}
```

Example DataInput

```
List<Student> citesteStudentiDataInput(String numefis){
    List<Student> studs=new ArrayList<Student>();
    DataInputStream input=null;
    try{
       input=new DataInputStream(new FileInputStream(numefis));
       while(true){
           String nume=input.readUTF();
           double media=input.readDouble();
           studs.add(new Student(nume,media));
       }
    }catch(EOFException e){ }
    catch (FileNotFoundException e) { System.err.println("Eroare citire“+e);}
    catch (IOException e) { System.err.println("Eroare citire DI "+e);}
    finally {
        if (input!=null)
          try { input.close();}
          catch (IOException e) {
                    System.err.println("Eroare inchidere fisier "+e);
           }}
    return studs;
}
```

Standard streams

- `System.in` of type `InputStream`
- `System.out` of type `PrintStream`
- `System.err` of type `PrintStream`

The associated streams can be modified using the methods:

`System.setIn(), System.setOut(), System.setErr(),`

```
Example:
System.setOut(new PrintStream(new File("Output.txt")));
System.setErr(new PrintStream(new File("Erori.txt")));
```

Continuation in Lecture 4

BufferedReader/BufferedWriter

- Use a buffer to keep the data which are going to be read/write from/to a stream.
- Read/Write operations are more efficient since the reading/writing is effectively done only when the buffer is empty/full.

BufferedReader
+BufferedReader(reader : Reader) +close() +read() : int +readLine() : String +ready() : boolean

BufferedWriter
+BufferedWriter(writer : Writer) +newLine() +flush() +close() +write(...)

```
BufferedReader br=new BufferedReader(new FileReader(numefisier));
BufferedWriter bw=new BufferedWriter(new FileWriter(numefisier));
// rewrite the existing data in the file

//add at the end of the file
BufferedWriter bw=new BufferedWriter(new FileWriter(numefisier, true));
```

Example BufferedReader

```
List<Student> citesteStudenti(String numefis){
   List<Student> ls=new ArrayList<Student>();
   BufferedReader br=null;
   try{
       br=new BufferedReader(new FileReader(numefis));
       String linie;
       while((linie=br.readLine())!=null){
           String[] elems=linie.split("[|]");
           if (elems.length<2){
               System.err.println("Linie invalida "+linie);
               continue;}
         Student stud=new Student(elems[0], Double.parseDouble(elems[1]));
         ls.add(stud);
         }
    }catch (FileNotFoundException e) {System.err.println("Eroare citire "+e);}
     catch (IOException e) { System.err.println("Eroare citire "+e);}
     finally{
        if (br!=null)
            try { br.close();}
            catch (IOException e) { System.err.println("Eroare inchidere fisier: "+e); }
    }
   return ls;
}
```

Example BufferedWriter

```
void printStudentiBW(List<Student> studs, String numefis){
        BufferedWriter bw=null;
        try{
            bw=new BufferedWriter(new FileWriter(numefis));
            //bw=new BufferedWriter(new FileWriter(numefis,true));
            for(Student stud: studs){
                bw.write(stud.getNume()+'|'+stud.getMedia());
                bw.newLine();    //scrie sfarsitul de linie
            }
        } catch (IOException e) {
            System.err.println("Eroare scriere BW "+e);
        } finally {
            if (bw!=null)
                try {
                    bw.close();
                } catch (IOException e) {
                    System.err.println("Eroare inchidere fisier "+e);
                }
        }
    }
```

PrintWriter

- Contains methods to save any type of data in text format.
- Contains methods to format the data .

PrintWriter
+PrintWriter(numefis : String)
+PrintWriter(numefisier : String, autoFlush : boolean)
+PrintWriter(writer : Writer)
+PrintWriter(...)
+print(e : Yyy)
+println(e : Yyy)
+printf()
+format()
+flush()
+close()

- `Yyy` is any primitive or reference type. If `Yyy` is a reference type it is called the method `toString` corresponding to `e`.

Example 1 PrintWriter

```
void printStudentiPrintWriter(List<Student> studs, String numefis){
        PrintWriter pw=null;
        try{
            pw=new PrintWriter(numefis);
            for(Student stud: studs){
                pw.println(stud.getNume()+'|'+stud.getMedia());
            }

        } catch (FileNotFoundException e) {
            System.err.println("Eroare scriere PW "+e);
        }finally {
            if (pw!=null)
                pw.close();
        }
}
```

Example 2 PrintWriter

```
void printStudentiPWTabel(List<Student> studs, String numefis){
   PrintWriter pw=null;
   try{
      pw=new PrintWriter(numefis);
      String linie=getLinie('-',48);
      int crt=0;
      for(Student stud:studs){
         pw.println(linie);
//pw.printf("| %3d | %-30s | %5.2f |%n",(++crt),stud.getNume(),stud.getMedia());
  pw.format("| %3d | %-30s | %5.2f |%n",(++crt),stud.getNume(),stud.getMedia());
       }
       if (crt>0)
          pw.println(linie);
    } catch (FileNotFoundException e) {
          System.err.println("Eroare scriere PWTabel "+e);
    } finally {
          if (pw!=null)
              pw.close();
    }
 }
```

Example 2 PrintWriter

```
String getLinie(char c, int length){
        char[] tmp=new char[length];
        Arrays.fill(tmp,c);
        return String.valueOf(tmp);
}
//file result
------------------------------------------------
|   1 | Popescu Ion                      |  6.70 |
------------------------------------------------
|   2 | Ionescu George                   |  7.53 |
------------------------------------------------
|   3 | Vasilescu Maria                  |  8.90 |
------------------------------------------------
|   4 | Pop Vasile                       |  9.30 |
------------------------------------------------
|   5 | Marinescu Ana                    |  9.60 |
------------------------------------------------
```

Reading from the keyboard

- Class `BufferedReader`

```
BufferedReader br=new BufferedReader(new InputStreamReader(System.in));
```

- Class `Scanner (package java.util)`

```
Scanner input=new Scanner(System.in);
```

- Class `Scanner` contains methods to read data of primitive types from the keyboard (or other stream):
  - `nextInt():int`
  - `nextDouble():double`
  - `nextFloat():Float`
  - `nextLine():String`
  - `...`
  - `hasNextInt():boolean`
  - `hasNextDouble():boolean`
  - `hasNextFloat():boolean`
  - `...`

Example BufferedReader (keyboard)

```
List<Student> citesteStudenti(){   //from the keyboard
  List<Student> ls=new ArrayList<Student>();
  BufferedReader br=null;
  try{
    br=new BufferedReader(new InputStreamReader(System.in));
    System.out.println("La terminare introduceti cuvantul \"gata\"");
    boolean gata=false;
    while(!gata){
            System.out.println("Introduceti numele: ");
            String snume=br.readLine();
            if ("gata".equalsIgnoreCase(snume)){gata=true; continue;}
            System.out.println("Introduceti media: ");
            String smedia=br.readLine();
            if ("gata".equalsIgnoreCase(smedia)){gata=true; continue;}
            try{
               double media=Double.parseDouble(smedia);
               lista.add(new Student(snume,media));
            }catch(NumberFormatException nfe){
               System.err.println("Eroare: "+nfe);
            }
     } }/*catch, finally, ...*/ }//citesteStudenti
```

Example Scanner (keyboard)

```
List<Student> citesteStudentiScanner(){
  List<Student> lista=new ArrayList<Student>();
  Scanner scanner=null;
  try{
    scanner=new Scanner(System.in);
   System.out.println("La terminare introduceti cuvantul \"gata\"");
    boolean gata=false;
    while(!gata){
       System.out.println("Introduceti numele: ");
       String snume=scanner.nextLine();
       if ("gata".equalsIgnoreCase(snume)){gata=true; continue;  }
       System.out.println("Introduceti media: ");
       if (scanner.hasNextDouble()) {
           double media=scanner.nextDouble();
           lista.add(new Student(snume,media));
            scanner.nextLine();  //to read <Enter>
            continue;
        }else{
        //next slide
```

Example Scanner (keyboard) cont.

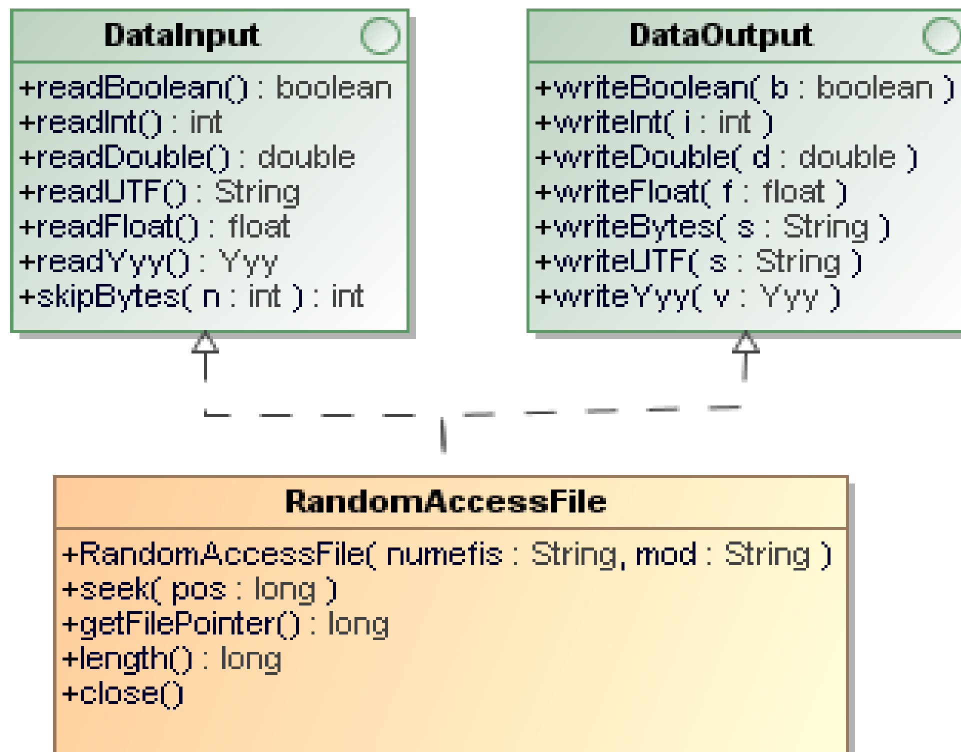
```
List<Student> citesteStudentiScanner(){
  //...
  if (scanner.hasNextDouble()){
    //...
  } else{
        String msj=scanner.nextLine();
        if ("gata".equalsIgnoreCase(msj)){
                        gata=true;
                        continue;
         }else
            System.out.println("Trebuie sa introduceti media studentului");
    }//else
   }//while
 } finally {
    if (scanner!=null)
         scanner.close();
 }
 return lista;
}
```

Example Scanner file

```
Scanner inscan=null;
try{
  inscan=new Scanner(new BufferedReader(new FileReader("intregi.txt")));
  //inscan.useDelimiter(“,");
  while(inscan.hasNextInt()){
     int nr=inscan.nextInt();
     System.out.println("nr = " + nr);
  }
} catch (FileNotFoundException e) {
    System.err.println("Eroare "+e);
}finally {
   if (inscan!=null)
    inscan.close();
}
```

RandomAccessFile

- Allow random access to a file.
- Can be used for either reading or writing.
- Class uses the notion of cursor to denote the current position in the file. Initially the cursor is on the position 0 at the beginning of the file.
- Operations of reading/writing move the cursor according the number of bytes read/written.



Example writing RandomAccessFile

```
void printStudentiRAF(List<Student> studs, String numefis){
  RandomAccessFile out=null;
  try{
    out=new RandomAccessFile(numefis,"rw");
    for(Student stud: studs){
      out.writeUTF(stud.getNume());
      out.writeDouble(stud.getMedia());
    }
  }catch (FileNotFoundException e){System.err.println("Eroare RAF "+e);}
  catch (IOException e) { System.err.println("Eroare scriere RAF "+e);}
  finally{
      if (out!=null)
          try {
              out.close();
          } catch (IOException e) {
               System.err.println("Eroare inchidere fisier "+e);
          }
    }
 }
```

Example reading RandomAccessFile

```
List<Student> citesteStudentiRAF(String numefis){
  List<Student> studs=new ArrayList<Student>();
  RandomAccessFile in=null;
  try{
          in=new RandomAccessFile(numefis, "r");
          while(true){
              String nume=in.readUTF();
              double media=in.readDouble();
              studs.add(new Student(nume,media));
          }
  }catch(EOFException e){ }
  catch (FileNotFoundException e){System.err.println("Eroare la citire: "+e);}
  catch (IOException e) { System.err.println("Eroare la citire "+e);}
  finally {
      if (in!=null)
         try {
             in.close();
         } catch (IOException e) {System.err.println("Eroare RAF "+e);}
}
 return studs;     }
```

Example appending RandomAccessFile

```
void adaugaStudent(Student stud, String numefis){
        RandomAccessFile out=null;
        try{
            out=new RandomAccessFile(numefis, "rw");
            out.seek(out.length());
            out.writeUTF(stud.getNume());
            out.writeDouble(stud.getMedia());
        } catch (FileNotFoundException e) {
            System.err.println("Eroare RAF "+e);
        } catch (IOException e) {
            System.err.println("Eroare RAF "+e);
        }finally {
            if (out!=null)
                try {
                    out.close();
                } catch (IOException e) {
                    System.err.println("Eroare RAF "+e);
                }
        }
    }
```

Class File

- Represent the name of a file (not its content).
- Allow platform-independent operations on the files (create, delete, rename, etc.) .
  - `File(name:String) //name  is the path to a file or a directory`
  - `getName():String`
  - `getAbsolutePath():String`
  - `isFile():boolean`
  - `isDirectory():boolean`
  - `exists():boolean`
  - `delete():boolean`
  - `deleteOnExit()    //Directory/File is removed at the exit of JVM`
  - `mkdir()`
  - `list():String[]`
  - `list(filtru:FilenameFilter):String[]`
  - ...

Class File: examples

- Printing the current directory

```
File dirCurent=new File(".");
System.out.println("Directory:" + dirCurent.getAbsolutePath());
```

- Creating an OS-independent path

```
String namefis=".."+File.separator+"data"+File.separator+"intregi.txt";
File f1=new File(namefis);
System.out.println("F1 "+f1.getName());
System.out.println("Exists f1? "+f1.exists());
```

- Selecting the .txt files from a directory

```
File dir=new File(".");
String[] files=dir.list(new FilenameFilter(){
   public boolean accept(File dir, String name) {
      return name.toLowerCase().endsWith(".txt");
}  });
System.out.println("Files "+ Arrays.toString(files));
```

- Removing a file

```
File namef=new File("erori.txt");
if (namef.exists())
   boolean ok=namef.delete();
```

Java NIO

Java NIO (New IO)

- From Java 1.4
- is an alternative IO API for Java (to the standard Java IO and Java Networking API's)
- consist of the following core components:
  - Channels
  - Buffers
  - Selectors

Channels and Buffers

- In the standard IO API you work with byte streams and character streams.
- In NIO you work with channels and buffers. Data is always read from a channel into a buffer, or written from a buffer to a channel.
- all IO in NIO starts with a Channel.

Channels and Buffers

- Channels are similar to streams with a few differences:

  - You can both read and write to a Channels. Streams are typically one-way (read or write).
  - Channels can be read and written asynchronously.
  - Channels always read to, or write from, a Buffer.

Channels and Buffers

the most important Channel implementations in Java NIO:

- FileChannel: reads data from and to files.
- DatagramChannel: can read and write data over the network via UDP.
- SocketChannel: can read and write data over the network via TCP.
- ServerSocketChannel: allows you to listen for incoming TCP connections, like a web server does.

Channels and Buffers

- A buffer is essentially a block of memory into which you can write data, which you can then later read again.
- Buffer types let you work with the bytes in the buffer as char, short, int, long, float or double:
  - ByteBuffer
  - MappedByteBuffer
  - CharBuffer
  - DoubleBuffer
  - FloatBuffer
  - IntBuffer
  - LongBuffer
  - ShortBuffer

Channels and Buffers

- Using a Buffer to read and write data typically follows this little 4-step process:
  - Write data into the Buffer: The buffer keeps track of how much data you have written.
  - Call buffer.flip(): in order to switch the buffer from writing mode into reading mode
  - Read data out of the Buffer: In reading mode the buffer lets you read all the data written into the buffer.
  - Call buffer.clear() or buffer.compact(): to make buffer ready for writing again

Channels and Buffers

- The clear() method clears the whole buffer.
- The compact() method only clears the data which you have already read. Any unread data is moved to the beginning of the buffer, and data will now be written into the buffer after the unread data.

Channels and Buffers

```
RandomAccessFile aFile = new RandomAccessFile("data/nio-data.txt", "rw");
FileChannel inChannel = aFile.getChannel();


//create buffer with capacity of 48 bytes
ByteBuffer buf = ByteBuffer.allocate(48);


int bytesRead = inChannel.read(buf); //read into buffer.
while (bytesRead != -1) {
  buf.flip();  //make buffer ready for read
  while(buf.hasRemaining()){
      System.out.print((char) buf.get()); // read 1 byte at a time
  }
  buf.clear(); //make buffer ready for writing
  bytesRead = inChannel.read(buf);
}
aFile.close();
```

Channels and Buffers

- A Buffer has three properties:

  1. Capacity: a certain fixed size. Once the Buffer is full, you need to empty it (read the data, or clear it) before you can write more data into it.

  2. Position:

     - Write mode:Initially the position is 0. When a byte, long etc. has been written into the Buffer the position is advanced to point to the next cell in the buffer to insert data into. Position can maximally become capacity – 1
     - Read mode:When you flip a Buffer from writing mode to reading mode, the position is reset back to 0. As you read data from the Buffer you do so from position, and position is advanced to next position to read.

Channels and Buffers

3. Limit:

- Write mode: is the limit of how much data you can write into the buffer and it is equal to the capacity of the Buffer
- Read mode: is the limit of how much data you can read from the data. Therefore, when flipping a Buffer into read mode, limit is set to write position of the write mode. In other words, you can read as many bytes as were written (limit is set to the number of bytes written, which is marked by position).

Scattering Reads

- reads data from a single channel into multiple buffers

```
ByteBuffer buf1 = ByteBuffer.allocate(128);
ByteBuffer buf2   = ByteBuffer.allocate(1024);
ByteBuffer[] bufferArray = { buf1,buf2  };
channel.read(bufferArray);
```

Gathering Writes

- writes data from multiple buffers into a single channel

```
ByteBuffer buf1 = ByteBuffer.allocate(128);
ByteBuffer buf2   = ByteBuffer.allocate(1024);
ByteBuffer[] bufferArray = { buf1,buf2  };
channel.write(bufferArray);
```

Java NIO FileChannel

- writes data from multiple buffers into a single channel
- is a channel that is connected to a file.
- you can read data from a file, and write data to a file.
- is an alternative to reading files with the standard Java IO API.

Channel to Channel Transfer

- you can transfer data directly from one channel to another

```
RandomAccessFile fromFile = new RandomAccessFile("fromFile.txt", "rw");
FileChannel      fromChannel = fromFile.getChannel();

RandomAccessFile toFile = new RandomAccessFile("toFile.txt", "rw");
FileChannel      toChannel = toFile.getChannel();

long position = 0;
long count    = fromChannel.size();

toChannel.transferFrom(fromChannel, position, count);
```

Java NIO Path

- an interface that is similar to the java.io.File class
- An instance represents a path in the file system. A path can point to either a file or a directory. A path can be absolute or relative.

Java NIO Files

- provides several methods for manipulating files in the file system

Java NIO AsynchronousFileChannel

- makes it possible to read data from, and write data to files asynchronously
- Read and write operations can be done either via a Future or via a CompletionHandler

Reading via a Future

```
AsynchronousFileChannel fileChannel =
                    AsynchronousFileChannel.open(path, StandardOpenOption.READ);

ByteBuffer buffer = ByteBuffer.allocate(1024);
long position = 0;

Future<Integer> operation = fileChannel.read(buffer, position);

while(!operation.isDone());

buffer.flip();
byte[] data = new byte[buffer.limit()];
buffer.get(data);
System.out.println(new String(data));
buffer.clear();
```

Writing via a CompletionHandler

```
Path path = Paths.get("data/test-write.txt");
if(!Files.exists(path)){
    Files.createFile(path);}
AsynchronousFileChannel fileChannel = AsynchronousFileChannel.open(path, StandardOpenOption.WRITE);
ByteBuffer buffer = ByteBuffer.allocate(1024);
long position = 0;
buffer.put("test data".getBytes());
buffer.flip();
fileChannel.write(buffer, position, buffer, new CompletionHandler<Integer, ByteBuffer>() {
    @Override
    public void completed(Integer result, ByteBuffer attachment) {
        System.out.println("bytes written: " + result);}
    @Override
    public void failed(Throwable exc, ByteBuffer attachment) {
        System.out.println("Write failed");
        exc.printStackTrace();}
});
```

Selectors

- A Selector allows a single thread to handle multiple Channel's.
- is handy if your application has many Channels open
- To use a Selector you register the Channel's with it. Then you call it's select() method. This method will block until there is an event ready for one of the registered channels. Once the method returns, the thread can then process these events. Examples of events are incoming connection, data received etc.

Try-with-resources

Old Style

```
private static void printFile() throws IOException {
    InputStream input = null;
    try {
        input = new FileInputStream("file.txt");
        int data = input.read();
        while(data != -1){
            System.out.print((char) data);
            data = input.read();
        }
    } finally {
        if(input != null){
            input.close();
        }
    }
}
```

- The red marked code may throw exceptions

Try-with-resources

- From Java 7 the previous code can be rewritten as follows:

```
private static void printFileJava7() throws IOException {

    try(FileInputStream input = new FileInputStream("file.txt")) {

        int data = input.read();
        while(data != -1){
            System.out.print((char) data);
            data = input.read();
        }
    }
}
```

Try-with-resources

- When the try block finishes the FileInputStream will be closed automatically. This is possible because FileInputStream implements the Java interface java.lang.AutoCloseable.

```
public interface AutoClosable {

    public void close() throws Exception;
}
```

- All classes implementing this interface can be used inside the try-with-resources construct.

Advanced Programming Methods

Lecture 5 - Functional Programming in Java

Overview

1. Anonymous inner classes in Java
2. Lambda expressions in Java 8
3. Processing Data with Java 8 Streams

Note: Lecture notes are based on Oracle tutorials.

Anonymous Inner classes

- provide a way to implement classes that may occur only once in an application.

```
JButton testButton = new JButton("Test Button");
    testButton.addActionListener(new ActionListener(){
        @Override public void actionPerformed(ActionEvent ae){
            System.out.println("Click Detected by Anon Class");
        }
    });
```

Functional Interfaces

- are interfaces with only one method
- Using functional interfaces with anonymous inner classes are a common pattern in Java

```
public interface ActionListener extends EventListener {
    public void actionPerformed(ActionEvent e);
}
```

Lambda Expressions

- are Java's first step into functional programming
- can be created without belonging to any class
- can be passed around as if they were objects and executed on demand.

```
(int x, int y) -> x + y

() -> 42

(String s) -> { System.out.println(s); }

testButton.addActionListener(e -> System.out.println("Click Detected by
    Lambda Listner"));
```

Lambda Expressions

- Lambda function body

```
(oldState, newState) -> System.out.println("State changed")


(oldState, newState) -> {
    System.out.println("Old state: " + oldState);
    System.out.println("New state: " + newState);
  }
```

- Returning a value

```
(param) -> {System.out.println("param: " + param; return "return value";}


 (a1, a2) -> { return a1 > a2; }


 (a1, a2) -> a1 > a2;
```

Lambdas as Objects

- A Java lambda expression is essentially an object.
- You can assign a lambda expression to a variable and pass it around, like you do with any other object.

```
public interface MyComparator {

    public boolean compare(int a1, int a2);

}


MyComparator myComparator = (a1, a2) -> return a1 > a2;

boolean result = myComparator.compare(2, 5);
```

Runnable Lambda

```
// Anonymous Runnable
Runnable r1 = new Runnable(){
@Override
public void run(){ System.out.println("Hello world one!"); } };


// Lambda Runnable
 Runnable r2 = () -> System.out.println("Hello world two!");


// Run em!
 r1.run();
 r2.run();
```

Comparator Lambda

```
List<Person> personList = Person.createShortList();

    // Sort with Inner Class

    Collections.sort(personList, new Comparator<Person>(){

      public int compare(Person p1, Person p2){

        return p1.getSurName().compareTo(p2.getSurName());

      }});


    // Use Lambda instead

  Collections.sort(personList, (Person p1, Person p2) →
    p1.getSurName().compareTo(p2.getSurName()));

  Collections.sort(personList, (p1,  p2) ->
    p2.getSurName().compareTo(p1.getSurName()));
```

Lambda Expressions

- can improve your code
- provide a means to better support the Don't Repeat Yourself (DRY) principle
- make your code simpler and more readable.
- Motivational example: Given a list of people, various criteria are used to send messages to matching persons:
  - Drivers(persons over the age of 16) get phone calls
  - Draftees(male persons between the ages of 18 and 25) get emails
  - Pilots(persons between the ages of 23 and 65) get mails

First Attempt

```
public class RoboContactMethods {
  public void callDrivers(List<Person> pl){
     for(Person p:pl){
        if (p.getAge() >= 16){ roboCall(p);}
      } }
 public void emailDraftees(List<Person> pl){
     for(Person p:pl){
       if (p.getAge() >= 18 && p.getAge() <= 25 && p.getGender() == Gender.MALE){
         roboEmail(p);
       } }}
 public void mailPilots(List<Person> pl){
      for(Person p:pl){
       if (p.getAge() >= 23 && p.getAge() <= 65){        roboMail(p);  }
     } }
…...}
```

First Attempt

- The DRY principle is not followed.
  - Each method repeats a looping mechanism.
  - The selection criteria must be rewritten for each method
- A large number of methods are required to implement each use case.
- The code is inflexible. If the search criteria changed, it would require a number of code changes for an update. Thus, the code is not very maintainable.

Second Attempt

```
public class RoboContactMethods2 {

   public void callDrivers(List<Person> pl){

      for(Person p:pl){

         if (isDriver(p)){  roboCall(p);}}}

  public void emailDraftees(List<Person> pl){

       for(Person p:pl){

        if (isDraftee(p)){       roboEmail(p);}}}

 public void mailPilots(List<Person> pl){

     for(Person p:pl){

       if (isPilot(p)){ roboMail(p);}} }

  public boolean isDriver(Person p){ return p.getAge() >= 16; }

   public boolean isDraftee(Person p){

       return p.getAge() >= 18 && p.getAge() <= 25 && p.getGender() == Gender.MALE; }

   public boolean isPilot(Person p){  return p.getAge() >= 23 && p.getAge() <= 65; }
```

Third Attempt

- Using a functional interface and anonymous inner classes

```
public interface Predicate<T> {
   public boolean test(T t);
}


public void phoneContacts(List<Person> pl, Predicate<Person> aTest){
    for(Person p:pl){
       if (aTest.test(p)){    roboCall(p); }
} }


robo.phoneContacts(pl,  new Predicate<Person>(){
           @Override
            public boolean test(Person p){
               return p.getAge() >=16;  } }  );
```

Fourth Attempt

- Using lambda expressions

```
public void phoneContacts(List<Person> pl, Predicate<Person> pred){
    for(Person p:pl){
       if (pred.test(p)){    roboCall(p); }
} }


Predicate<Person> allDrivers = p -> p.getAge() >= 16;
 Predicate<Person> allDraftees = p -> p.getAge() >= 18 && p.getAge() <= 25 &&
     p.getGender() == Gender.MALE;
 Predicate<Person> allPilots = p -> p.getAge() >= 23 && p.getAge() <= 65;


robo.phoneContacts(pl, allDrivers);
```

java.util.function

- standard interfaces are designed as a starter set for developers:
  - Predicate: A property of the object passed as argument
  - Consumer: An action to be performed with the object passed as argument
  - Function: Transform a T to a U
  - Supplier: Provide an instance of a T (such as a factory)
  - UnaryOperator: A unary operator from T -> T
  - BinaryOperator: A binary operator from (T, T) -> T

Function Interface

- It has only one method apply with the following signature:

  public R apply(T t)

- Example for class Person:

```
public String printCustom(Function <Person, String> f){

    return f.apply(this);}
```

```
Function<Person, String> westernStyle = p -> {return "\nName: " + p.getGivenName() + "
    " + p.getSurName() + "\n"};

Function<Person, String> easternStyle =  p -> "\nName: " + p.getSurName() + " " +
    p.getGivenName() + "\n"};

person.printCustom(westernStyle);

person.printCustom(easternStyle);

person.printCustom(p -> "Name: " + p.getGivenName() + " EMail: " + p.getEmail());
```

Java 8 Streams

- is a new addition to the Java Collections API, which brings a new way to process collections of objects.
- declarative way
- Stream: a sequence of elements from a source that supports aggregate operations.

```
List<String> myList = Arrays.asList("a1", "a2", "b1", "c2", "c1");

myList.stream()

 .filter(s -> s.startsWith("c"))

 .map(String::toUpperCase)

 .sorted()

 .forEach(System.out::println);
```

- Output:

C1

C2

Java 8 Streams

- Sequence of elements: A stream provides an interface to a sequenced set of values of a specific element type. However, streams don’t actually store elements; they are computed on demand.
- Source: Streams consume from a data-providing source such as collections, arrays, or I/O resources.
- Aggregate operations: Streams support SQL-like operations and common operations from functional programing languages, such as filter, map, reduce, find, match, sorted, and so on.

Streams vs Collections

Two fundamental characteristics that make stream operations very different from collection operations:

- Pipelining: Many stream operations return a stream themselves. This allows operations to be chained to form a larger pipeline. This enables certain optimizations, such as laziness and short-circuiting
- Internal iteration: In contrast to collections, which are iterated explicitly (external iteration), stream operations do the iteration behind the scenes for you.

Streams vs Collections

- collections are about data
- streams are about computations.
- A collection is an in-memory data structure, which holds all the values that the data structure currently has—every element in the collection has to be computed before it can be added to the collection.
- In contrast, a stream is a conceptually fixed data structure in which elements are computed on demand.

Obtaining a Stream From a Collection

```
List<String> items = new ArrayList<String>();

items.add("one");
items.add("two");
items.add("three");

Stream<String> stream = items.stream();
```

- is similar to how you obtain an Iterator by calling the items.iterator() method, but a Stream is a different than an Iterator.

Stream Processing Phases

1. Configuration-- intermediate operations:
   - filters, mappings
   - can be connected together to form a pipeline
   - return a stream
   - Are lazy-do not perform any processing
2. Processing—terminal operations:
   - operations that close a stream pipeline
   - produce a result from a pipeline such as a List, an Integer, or even void (any non-Stream type).

Filtering

- stream.filter(item -> item.startsWith("o"));

- filter(Predicate): Takes a predicate (java.util.function.Predicate) as an argument and returns a stream including all elements that match the given predicate
- distinct: Returns a stream with unique elements (according to the implementation of equals for a stream element)
- limit(n): Returns a stream that is no longer than the given size n
- skip(n): Returns a stream with the first n number of elements discarded

Filtering

```
List<Integer> numbers = Arrays.asList(1, 2, 3, 4, 5, 6, 7, 8);

List<Integer> twoEvenSquares =

    numbers.stream()

           .filter(n -> {System.out.println("filtering " + n); return n % 2 == 0;})

           .map(n -> { System.out.println("mapping " + n); return n * n;})

           .limit(2)

           .collect(toList());
```

```
filtering 1

filtering 2

mapping 2

filtering 3

filtering 4

mapping 4
```

- limit(2) uses short-circuiting; we need to process only part of the stream, not all of it, to return a result.

Mapping

- Streams support the method map, which takes a function (java.util.function.Function) as an argument to project the elements of a stream into another form. The function is applied to each element, “mapping” it into a new element.

```
items.stream()
    .map( item -> item.toUpperCase() )
```

- maps all strings in the items collection to their uppercase equivalents.
- doesn't actually perform the mapping. It only configures the stream for mapping. Once one of the stream processing methods are invoked, the mapping (and filtering) will be performed.

Mapping

```
List<String> words = Arrays.asList("Oracle", "Java", "Magazine");
 List<Integer> wordLengths =
    words.stream()
         .map(String::length)
         .collect(toList());
```

Stream.collect()

- is an extremely useful terminal operation to transform the elements of the stream into a different kind of result, e.g. a List, Set or Map .
- Collect accepts a Collector which consists of four different operations: a *supplier*, an *accumulator*, a *combiner* and a *finisher*.
- Java 8 supports various builtin collectors via the Collectors class. So for the most common operations you don't have to implement a collector yourself.

Stream.collect()

```
List<Person> filtered =
persons
.stream()
.filter(p -> p.name.startsWith("P"))
.collect(Collectors.toList());


Double averageAge = persons
.stream()
.collect(Collectors.averagingInt(p -> p.age));
```

Stream.collect()

```
String phrase = persons
.stream()
.filter(p -> p.age >= 18)
.map(p -> p.name)
.collect(Collectors.joining(" and ", "In Germany ", " are of legal age."));
```

- The join collector accepts a delimiter as well as an optional prefix and suffix.

Stream.collect()

- In order to transform the stream elements into a map, we have to specify how both the keys and the values should be mapped.
- the mapped keys must be unique, otherwise an IllegalStateException is thrown.
- You can optionally pass a merge function as an additional parameter to bypass the exception:

```
Map<Integer, String> map = persons
.stream()
.collect(Collectors.toMap(
p -> p.age,
p -> p.name,
(name1, name2) -> name1 + ";" + name2));
```

Stream.min() and Stream.max()

- Are terminal operations
- return an Optional instance which has a get() method on, which you use to obtain the value. In case the stream has no elements the get() method will return null
- take a Comparator as parameter. The Comparator.comparing() method creates a Comparator based on the lambda expression passed to it. In fact, the comparing() method takes a Function which is a functional interface suited for lambda expressions

```
String shortest = items.stream()
        .min(Comparator.comparing(item -> item.length()))
        .get();
```

Stream.min() and Stream.max()

- The Optional<T> class (java.util .Optional) is a container class to represent the existence or absence of a value
- we can choose to apply an operation on the optional object by using the ifPresent method

```
Stream.of("a1", "a2", "a3")

.map(s -> s.substring(1))

.mapToInt(Integer::parseInt)

.max()

.ifPresent(System.out::println);
```

- Stream.of() creates a stream from a bunch of object references

Stream.count()

- Returns the number of elements in the stream

```
long count = items.stream()
    .filter( item -> item.startsWith("t"))
    .count();
```

Stream.reduce()

- can reduce the elements of a stream to a single value
- takes a BinaryOperator as parameter, which can easily be implemented using a lambda expression.
- Returns an Optional
- The BinaryOperator.apply() method:
    - takes two parameters. The acc which is the accumulated value, and item which is an element from the stream.

```
String reduced2 = items.stream()
        .reduce((acc, item) -> acc + " " + item)
        .get();
```

Stream.reduce()

- There is another reduce() method which takes two parameters: an initial value for the accumulated value, and then a BinaryOperator.

```
String reduced = items.stream()
    .filter( item -> item.startsWith("o"))
    .reduce("", (acc, item) -> acc + " " + item);
```

Stream.reduce()

```
int sum = 0;
for (int x : numbers) {
    sum += x;
}
int sum = numbers.stream().reduce(0, (a, b) -> a + b);


int product = numbers.stream().reduce(1, (a, b) -> a * b);
int max = numbers.stream().reduce(1, Integer::max);
```

Numerical Streams

- IntStream, DoubleStream, and LongStream—that respectively specialize the elements of a stream to be int, double, and long.
- to convert a stream to a specialized version: mapToInt, mapToDouble, and mapToLong.
- to help generate ranges: range and rangeClosed.

```
IntStream oddNumbers =
    IntStream.rangeClosed(10, 30)
            .filter(n -> n % 2 == 1);
```

Building Streams

- InStream<Integer> numbersFromValues = Stream.of(1, 2, 3, 4);

- int[] numbers = {1, 2, 3, 4};

  IntStream numbersFromArray = Arrays.stream(numbers);

- Converting a file into a stream of lines:

  long numberOfLines =

  Files.lines(Paths.get("yourFile.txt"),Charset.defaultCharset())

  .count();

Infinite Streams

- There are two static methods—Stream.iterate and Stream .generate—that let you create a stream from a function.
- because elements are calculated on demand, these two operations can produce elements “forever.”

```
Stream<Integer> numbers = Stream.iterate(0, n -> n + 10);
```

- The iterate method takes an initial value (here, 0) and a lambda (of type UnaryOperator<T>) to apply successively on each new value produced.

Infinite Streams

- We can turn an infinite stream into a fixed-size stream using the limit operation:

```
numbers.limit(5).forEach(System.out::println);
// 0, 10, 20, 30, 40.
```

Finding and Matching

- A common data processing pattern is determining whether some elements match a given property. You can use the anyMatch, allMatch, and noneMatch operations to help you do this. They all take a predicate as an argument and return a boolean as the result (they are, therefore, terminal operations
- Stream interface provides the operations findFirst and findAny for retrieving arbitrary elements from a stream. Both findFirst and findAny return an Optional object

Processing Order

```
Stream.of("d2", "a2", "b1", "b3", "c")
.map(s -> {System.out.println("map: " + s);return s.toUpperCase();})
.filter(s -> {System.out.println("filter: " + s);return s.startsWith("A");})
.forEach(s -> System.out.println("forEach: " + s));


// map: d2
// filter: D2
// map: a2
// filter: A2
// forEach: A2
// map: b1
// filter: B1
// map: b3
// filter: B3
// map: c
// filter: C
```

Processing Order

```
Stream.of("d2", "a2", "b1", "b3", "c")
.filter(s -> {System.out.println("filter: " + s);return s.startsWith("a");})
.map(s -> {System.out.println("map: " + s);return s.toUpperCase();})
.forEach(s -> System.out.println("forEach: " + s));
// filter: d2
// filter: a2
// map: a2
// forEach: A2
// filter: b1
// filter: b3
// filter: c
```

Reusing Streams

- Java 8 streams cannot be reused. As soon as you call any terminal operation the stream is closed

```
Stream<String> stream =
Stream.of("d2", "a2", "b1", "b3", "c")
.filter(s -> s.startsWith("a"));

stream.anyMatch(s -> true); // ok
stream.noneMatch(s -> true); // exception
```

Reusing Streams

```
Supplier<Stream<String>> streamSupplier =
() -> Stream.of("d2", "a2", "b1", "b3", "c")
.filter(s -> s.startsWith("a"));



streamSupplier.get().anyMatch(s -> true); // ok
streamSupplier.get().noneMatch(s -> true); // ok
```

- *Each call to get() constructs a new stream on which we can call the desired terminal operation.*

Advanced Programming Methods

Lecture 6-7 - Meta Programming and Reflection in Java

Overview

1. instanceof operator
2. Java Serialization
3. Java Annotations
4. Java Reflection

Note: Lecture notes are based on Oracle tutorials.

Instanceof operator

- compares an object to a specified type.
- to test if an object is an instance of a class, an instance of a subclass, or an instance of a class that implements a particular interface.
- null is not an instance of anything.

Instanceof operator

```
class Parent {}
class Child extends Parent implements MyInterface {}
interface MyInterface {}

Parent obj1 = new Parent();
Parent obj2 = new Child();

obj1 instanceof Parent: true
obj1 instanceof Child: false
obj1 instanceof MyInterface: false
obj2 instanceof Parent: true
obj2 instanceof Child: true
obj2 instanceof MyInterface: true
```

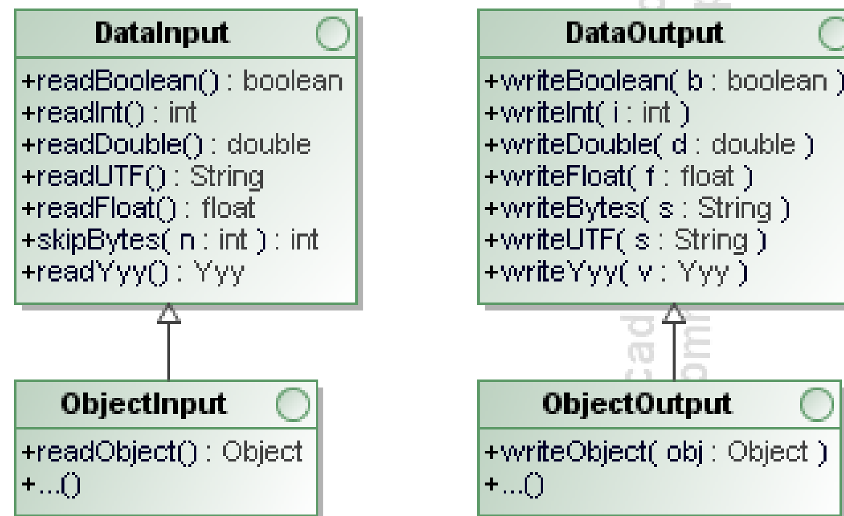
Real use of Instanceof operator

```
interface Printable{}
class A implements Printable{
public void a(){System.out.println("a method");}
}
class B implements Printable{
public void b(){System.out.println("b method");}
}
class Call{
void invoke(Printable p){
if(p instanceof A){
A a=(A)p;//Downcasting
a.a();
}
if(p instanceof B){
B b=(B)p;//Downcasting
b.b();
} } }
```

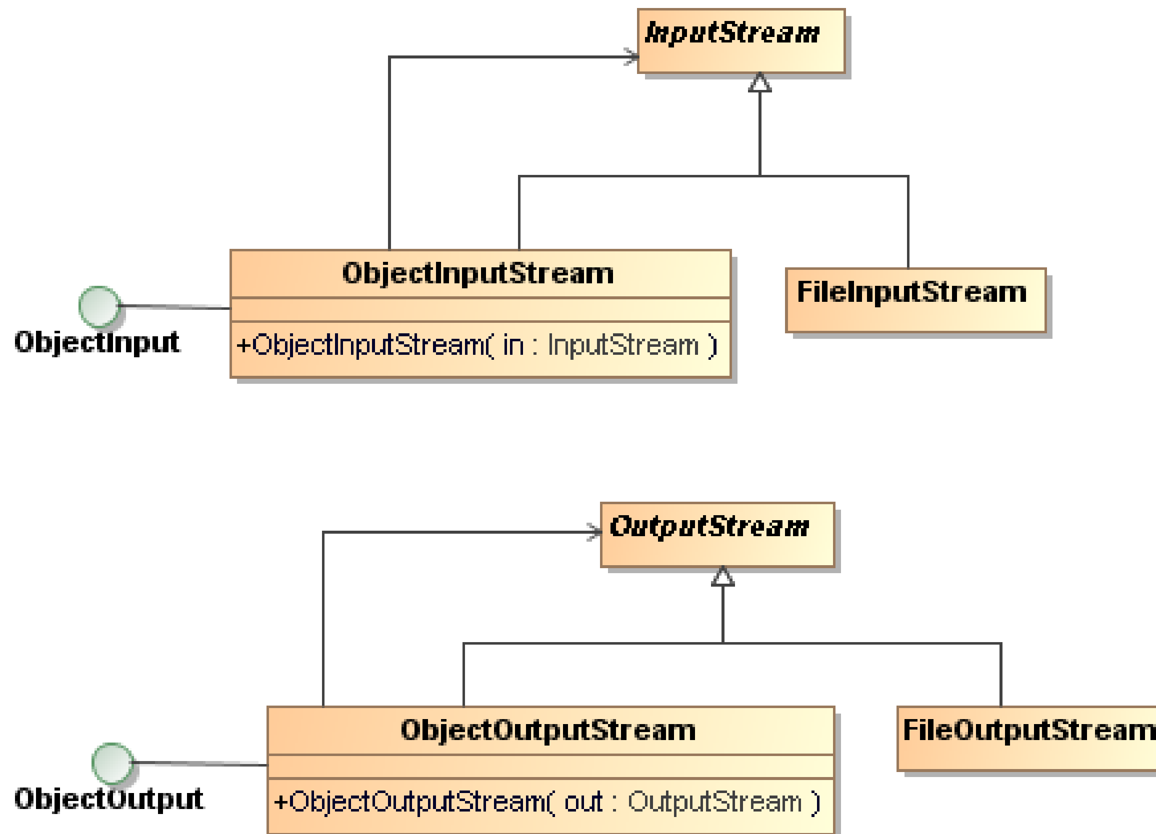
Java Serialization

Java Objects Serialization

- The process of writing/reading objects from/to a file/external support.
- An object is persistent (serializable) if it can be written into a file/external support and can be read from a file/external support



Objects Serialization



Objects Serialization

```
void serializareObj(String numefis){
        ObjectOutputStream out=null;
        try{
            out=new ObjectOutputStream(new FileOutputStream(numefis));
            out.writeObject(23);
            out.writeObject("Vasilescu Ana");
            out.writeObject(23.45f);
        } catch (IOException e) {
            System.err.println("Eroare "+e);
        } finally {
            if (out!=null)
                try {
                    out.close();
                } catch (IOException e) {
                    System.err.println("Eroare "+e);
                }
        }
    }
```

Objects Serialization

```
void deserializareObj(String numefis){
  ObjectInputStream in=null;
  try{
     in=new ObjectInputStream(new FileInputStream(numefis));
     Integer intreg=(Integer)in.readObject();
     String text=(String)in.readObject();
     Float nr=(Float)in.readObject();
     System.out.println("Intreg: "+intreg+" String: "+text+" Float: "+nr);
  } catch (IOException e) {System.err.println("Eroare "+e);}
   catch (ClassNotFoundException e) {
     System.err.println("Eroare deserializare "+e);
   }finally {
       if (in!=null){
          try {
              in.close();
          } catch (IOException e) {System.err.println("Eroare "+e);}

        }
    }
}
```

Serializable Objects

- The classes whose objects are serializable must be declared to implement the interface `Serializable` (package `java.io`).
- Interface Serializable does not contain any method.

```
class Student implements Comparable<Student>, Serializable{
 //...
}
class Test{
  public static void main(String[] args){
     ObjectOutputStream out=
      //... initialization
      Student stud=new Student("Popescu Ioan", 7.9);
      out.writeObject(stud);
      //...
  }
}
```

- The state of `stud` (the values of its fields) is saved into the file.

Serializable objects

- All the reachable objects (the objects that can be reach using the references) are saved into the file only once.

```
class CircularList implements Serializable{
  private class Node implements Serializable{
      Node urm;
      //...
  }
   private Node head; //last node of the list refers to the head of the list
   //...
}
```

- The objects which are referred by a serializable object must be also serializable.

Obs:

Static attributes of a serializable class are not saved into the file/external support.

Example serializable objects

```
void printSerializabil(List<Student> studs, String numefis){
        ObjectOutputStream out=null;
        try{
          out=new ObjectOutputStream(new FileOutputStream(numefis));
            out.writeObject(studs);
        } catch (IOException e) {
            System.err.println("Eroare serializare "+e );
        } finally {
            if (out!=null)
                try {
                    out.close();
                } catch (IOException e) {
                    System.err.println("Eroare "+e);
                }
        }
    }
```

Example serializable objects

```
@SuppressWarnings("unchecked")
List<Student> citesteSerializabil(String numefis){
        List<Student> rez=null;
        ObjectInputStream in=null;
        try{
            in=new ObjectInputStream(new FileInputStream(numefis));
            rez=(List<Student>)in.readObject();
        } catch (IOException e) {
            System.err.println("Eroare deserializare"+e);
        } catch (ClassNotFoundException e) {
            System.err.println("Eroare deserializare "+e);
        }finally{
          if (in!=null)
                try {
             in.close();
                }catch (IOException e) {System.err.println("Eroare "+e); }
        }
        return rez;
}
```

Objects Serialization

- Method `in.readObject():Object`
  1. Read the object from the stream
  2. Identify the object type
  3. Initialize the non-static members of the object byte by byte (without a constructor call) and then return the new created object
- Method `out.writeObject(Object)`
  - Save the non-static members and the information required by JVM to rebuild the object
  - an object (from a given reference) is saved only once on a stream:

```
ObjectOutputStream out=...
out.writeObject(new Produs("A"));
Produs produs2=new Produs("B");
out.writeObject(produs2);
produs2.setNume("BB");
out.writeObject(produs2);
//...
out.close();
```

```
ObjectInputStream in=...
Produs p1=(Produs)in.readObject();
Produs p2=(Produs)in.readObject();
Produs p3=(Produs)in.readObject();
//...
```

Objects Serialization - serialVersionUID

```
public class Student implements Serializable{
  private String nume;
  private double media;
  //...
}
```

Scenario:

1. The objects of class Student are serialized.
2. The class Student is changed (add/remove fields/methods).
3. We want to de-serialize the saved objects.

```
public class Student implements Serializable{
  [any modif access] static final long serialVersionUID = 1L;
   private String nume;
  private double media;
   private int grupa;
  //...
}
```

New added fields are initialized with the default values corresponding to their types.

Objects Serialization - transient

- There are situation when we do not want to save the values of some fields (e.g. passwords, file descriptors, etc.)
- Those fields are declared using the keyword `transient:`

```
public class Student implements Serializable{
  private String nume;
  private double media;
  private transient String parola;
  //...
}
```

At reading, the transient fields are initialized with the default values corresponding to their types.

Serializable data structures

```
public class Stack implements Serializable{
   private class Node implements Serializable{
   //...
   }
    private Node top;
   //...
 }
//...
Stack s=new Stack();
 s.push("ana");
 s.push(new Produs("Paine", 2.3));
                  //class Produs must be serializable
//...
 ObjectOuputStream out=...
  out.writeObject(s);
```

Java Annotations

Annotations

- a form of metadata
- provide data about a program that is not part of the program itself.
- have no direct effect on the operation of the code they annotate.

Annotations

- Information for the compiler — Annotations can be used by the compiler to detect errors or suppress warnings.
- Compile-time and deployment-time processing — Software tools can process annotation information to generate code, XML files, and so forth.
- Runtime processing — Some annotations are available to be examined at runtime.

Annotation Basics

- The @ character signals to the compiler that this is an annotation. The name following the @ character is the name of the annotation:

```
@Entity
```

- annotation can have elements for which you can set values

```
@Entity(tableName = "vehicles", primaryKey = "id")
```

Annotation placement

```
@Entity
public class Vehicle {
    @Persistent
    protected String vehicleName = null;
    @Getter
    public String getVehicleName() {
        return this.vehicleName;}
    public void setVehicleName(@Optional vehicleName) {
        this.vehicleName = vehicleName;}
    public List addVehicleNameToList(List names) {
        @Optional
        List localNames = names;
        if(localNames == null) { localNames = new ArrayList();}
        localNames.add(getVehicleName());
        return localNames;
    }
}
```

Type Annotations

As of the Java SE 8 release, annotations can also be applied to the use of types:

- Class instance creation expression:

```
new @Interned MyObject();
```

- Type cast:

```
myString = (@NonNull String) str;
```

- implements clause:

```
class UnmodifiableList<T> implements  @Readonly List<@Readonly T> { ... }
```

- Thrown exception declaration:

```
void monitorTemperature() throws @Critical TemperatureException { ... }
```

Type annotations have been created to support stronger type checking.

Predefined Annotations

- @Deprecated annotation indicates that the marked element is deprecated and should no longer be used. The compiler generates a warning whenever a program uses a method, class, or field with the @Deprecated annotation.

```
// Javadoc comment follows
   /**
    * @deprecated
    * explanation of why it was deprecated
    */
   @Deprecated
   static void deprecatedMethod() { }
}
```

Predefined Annotations

- @Override annotation informs the compiler that the element is meant to override an element declared in a superclass.

```
// mark method as a superclass method
// that has been overridden
@Override
int overriddenMethod() { }
```

Predefined Annotations

- @SuppressWarnings annotation tells the compiler to suppress specific warnings that it would otherwise generate.

```
// use a deprecated method and tell
// compiler not to generate a warning
@SuppressWarnings("deprecation")
 void useDeprecatedMethod() {
     // deprecation warning
     // - suppressed
     objectOne.deprecatedMethod();
 }
```

Predefined Annotations

- @SafeVarargs annotation, when applied to a method or constructor, asserts that the code does not perform potentially unsafe operations on its varargs parameter. When this annotation type is used, unchecked warnings relating to varargs usage are suppressed.

- @FunctionalInterface annotation indicates that the type declaration is intended to be a functional interface, as defined by the Java Language Specification.

Creating your own annotations

- It is possible to create your own Java annotation.
- Annotations are defined in their own file, just like a Java class or interface.

```
@interface MyAnnotation {
    String   value();
    String   name();
    int      age();
    String[] newNames();
}
```

Creating your own annotations

- Use of the custom annotation

```
@MyAnnotation(
    value="123",
    name="ABC",
    age=0,
    newNames={"AAA", "BBB"}
)
public class MyClass {



}
```

Java Reflection

Java looking at Java

- One of the unusual capabilities of Java is that a program can examine itself
  - You can determine the class of an object
  - You can find out all about a class: its access modifiers, superclass, fields, constructors, and methods
  - You can find out what what is in an interface
  - Even if you don’t know the names of things when you write the program, you can:
    - Create an instance of a class
    - Get and set instance variables
    - Invoke a method on an object
    - Create and manipulate arrays

What exactly is a class?

- It’s a collection of different things, such as:
  - Fields
  - Methods
  - Constructors

- We define these different things with names, types, parameters, values, expressions, etc while programming, but in reflection all of this already exists.

Programming vs Reflecting

- We use reflection to manipulate things that already exist and, normally, are set.
- But unlike programming, we are not tied to specific names, types or views.
- We have the ability to dynamically change what things are, regardless of how they were written!
- More specifically, we are modifying objects at runtime.

What do you mean Runtime?

- Normally you program something like this:
  - Write/Modify the class, methods, etc
  - Compile it
  - Run it

- If you want to make any changes you have to recompile and rerun that class.

What do you mean Runtime?

- With reflection, we can manipulate a class without ever recompiling it:
  - Write/Modify the class, methods, etc
  - Compile it
  - Run it
  - **Modify the class here! By reflection**

- It is important to note that ***another*** class is the one doing the modification.

Uses of Reflection

- You *do* need reflection if you are working with programs that process programs
- Some common uses of reflection:
  - To load and use classes unknown at compile time
  - Test programs by forcing specific states
  - By debuggers to inspect running programs
  - Malicious things
    - Hacking

Programming Reflection

- To program with reflection, we must put on our meta-thinking caps.
- We are going to modify classes from classes with classes!
- To do this we have a great set of classes in the following package:
  - `java.lang.reflect.*;`

Java.lang.reflect.*

Some classes we will go over, (there are more):

Method

Describes a method for a class and gives access to it.

Field

Describes a field for a class, its type, name, etc.

Constructor<T>

Provides information about constructors and the ability to execute a constructor and get a new class instance

Java.lang.reflect.*

- AccessibleObject
  - Describes the accessibility of an object, i.e. its view public, private, protected, default.
- Array
  - A special class created just for reflecting with Arrays, since Arrays are such odd objects in Java we must use this class to manipulate them.

So where do we start?

- To start manipulating a class we must first get a hold of that class's "blueprint".
  - Using the `java.lang.Class` class
- There are two ways to do this, if the class is already loaded:

  ```
  Class<? extends Object> theClass = ClassName.class;
  ```

- Or if we need to cause it to load:

  ```
  Class theClass = Class.forName("package.class");
  ```

- We won't use this second one, its rather complex at times.
  - Example Package: "`java.lang.String`"

So where do we start?

- So now we have the definition of a class.
- This is like the blueprint to the entire thing, it lists where everything is and how to get to it.
- It is important to point out that this class has information that pertains to the structure of the class, not specific instance information, but hold that thought for a little later.
- For now lets look at how to get some information from the class

The Parts of the Class

- Fields
- Methods
- Constructors
- Miscellaneous

Getting those sweet fields

- There are two ways to get class fields:
  - `getFields();`
    - Returns an array of Field objects, specifically all the fields that are public for this class and its super classes.
  - `getDeclaredFields();`
    - Returns an array of Field objects, regardless of view.
- Optionally if you know the field name:
  - `getField(String name);`
    - Returns a Field with the given name

The Parts of the Class

- Fields
- Methods
- Constructors
- Miscellaneous

Calling all methods, report for duty

- Like Fields there are two ways to get Methods
  - `getMethods();`
    - Returns all the public methods for this class and any it inherits from super classes.
  - `getDeclaredMethods();`
    - Returns all the methods for this class only regardless of view.
- Like Fields you can also get a specific method, but it takes more information.

Calling all methods, report for duty

- To get a specific method you call
  - `getMethod(String name, Class<?>… parameterTypes);`
- The name parameter is pretty straight forward, but does `Class<?>`… mean?
- This means you can pass any number of `Class<?>` parameters after the name.
- The `Class<?>` parameters you pass reference the types of parameters the method takes.

Calling all methods, report for duty

- For example, say we have this method:
  - `public int doSomething(String stuff, int times, int max){}`
- If we were trying to get this specific method we would have to call getMethod like this:
  - `getMethod("doSomething", String.class, int.class, int.class);`
- We are directly passing the types, and this is because the reflection will use the method "fingerprints" to track it down and return it to us.

The Parts of the Class

- Fields
- Methods
- Constructors
- Miscellaneous

Building blocks

- To get the constructos we have the methods:
  - `getConstructors()`
    - Returns all public constructors for the class
  - `getDeclaredConstructors()`
    - Returns all constructors for the class, regardless of view
- We can again get specific constructors with:
  - `getConstructor(Class<?>… parameterTypes);`
    - Returns the constructor that takes the given parameters

The Parts of the Class

- Fields
- Methods
- Constructors
- Miscellaneous

The others

- we will only focus on variables and methods, but there are a number of other useful methods:
  - `getEnclosingMethod()`
    - Gets the method that declared an anonymous class
  - `getName()`
    - Returns the class name
  - `newInstance()`
    - Creates a new instance of the class

The Classes of Reflection

- Field
- Method
- Constructor

The Field Class

- Some useful methods:
  - `get(Object obj)`
    - Gets the value of this field in the given object
  - `get`*`PrimitiveType`*`(Object obj)`
  - `set(Object obj, Object value)`
    - Sets the value of this field in the given object, if possible
  - `set`*`PrimitiveType`*`(Object obj, `*`PrimitiveType`*` value)`
  - `getType()`
    - Returns the type of this field
  - `getName()`
    - Returns the name of this field

The Field Class

- You may have noticed the two methods `get`*`PrimitiveType(..)`* *and* *`setPrimitiveType(..)`*
- Here *`PrimitiveType`* is replaced with a real primitive type, so if a field represents an `int` you would say, `getInt()` or `setInt()`.
- This is done because primitive types are not classes and so we need a special way to get and set them

The Field Class

- The first parameter to all of those methods was `Object obj`
- This parameter is a specific instance of the class.
  - a constructed version of the class
- Like I mentioned before the Field object represents a generic version of a field for a class, it holds no value, its just a blueprint as to where it would be in the class.
- To get a value we must provide a class that has been constructed already.

The Field Class

- Don’t forget we can have two types of fields, static/non-static
- If we want to get the value of a static field, we can pass null as the Object obj parameter.

The Classes of Reflection

- Field
- Method
- Constructor

The Method Class

- Some useful methods
  - `getName()`
    - Gets the methods name
  - `getReturnType()`
    - Gets the type of variable returned by this method
  - `getParameterTypes()`
    - Returns an array of parameters in the order the method takes them
  - `invoke(Object obj, Object… args)`
    - Runs this method on the given object, with parameters.

The Method Class

- The main method of this class that we will use is `invoke(Object obj, Object... params)`
- The first parameter is exactly like the Field class methods, it is an instantiated class with this method that we can invoke.
- The second parameter means we can pass as many parameters as necessary to call this method, usually we will have to use the result of `getParameterTypes()` in order to fill those in.

The Classes of Reflection

- Field
- Method
- Constructor

The Constructor Class

- Some useful methods
  - `getParameterTypes()`
    - Returns an array of parameter types that this constructor takes
  - `newInstance(Object… initargs)`
    - Creates a new class that this constructor is from using the given parameters as arguments.

The Constructor Class

The method we are most concerned with is
`newInstance(Object… initArgs)`

- This is similar to `invoke(..)` for methods except we don't pass an already instantiate object because we are making a new one!
- Like methods we will probably call `getParameterTypes()` first.

Overview

- Lets take a step back and look at all this information
- We can get a class blueprint and it’s a class of type Class from java.lang.Class
- For reflection we use classes like Field, Method, and Constructor to reference pieces of the class
  - These are generic versions and we must pass them constructed versions (except for constructors)
  - From each of these reflection classes we have the ability to manipulate instances of classes.

Lets try it out

- So it turned out what we learned works pretty well for everything with a public visibility.
- But what about those private, protected, and default views?
- Java kept throwing an IllegalAccessException, we just don’t have permissions to edit those.
- Well not to worry we can get permission!

The Classes of Reflection

- Field
- Method
- Constructor
- AccessibleObject!

The AccessibleObject

- The accessible object is a superclass that Field, Method, and Constructor extend
  - How convenient!
- But what does it do?
- It controls access to variables by checking the accessibility of a field, method, or constructor anytime you try to get, set, or invoke one.

The AccessibleObject

- Some *very* useful methods:
  - `isAccessible()`
    - Tells whether or not the object can be accessed based on its view type
    - A public field, method, or constructor will return true
    - The other types will return false.
  - `setAccessible(boolean flag)`
    - This will override the accessibility setting to whatever is passed in, true or false

Overriding Accessibility

- So how can we use this?
- Well suppose we have a Field object that references a field in our class that was declared like this:
  - `private String secretMessage;`
- Well as we have seen we get an Exception, but we can avoid it by overriding the accessibility
  - `theField.setAccessible(true);`

Overriding Accessibility

- Now before you start the triangle pyramid of evil, note:
  - It is possible to prevent use of setAccessible()
  - You do this using a SecurityManager to prevent access to variables

Arrays

- If you wish to manipulate arrays with Reflection you must use the java.lang.reflect.Array class, you cannot use the Field class
- This is because Java does not handle Arrays in the same way it handles Objects or Primitives

Arrays

- Useful Methods
  - `get(Object array, int index)`
    - Gets the value from the array at the given index
  - `get`*`PrimitiveType`*`(Object array, int index)`
  - `set(Object array, int index, Object value)`
    - Sets the value in the array at the index to the given value
  - `set`*`PrimitiveType`*`(Object array, int index,` *`PrimitiveType`* `value)`

Arrays

- Just like the Field class, the *PrimitiveType* is replaced by an actual primitive type and you must use this type of placement when accessing a primitive array
- But there are a couple more methods that are unique to this class

Arrays

- Unique Methods
  - `getLength(Object array)`
    - Returns the length of the given array
  - `newInstance(Class<?> componentType, int… dimensions)`
    - Creates a new array of the given type and with the given dimensions
  - `newInstance(Class<?> componentType, int length)`
    - Creates a new array of the given type and with the given length

Advanced Programming Methods

Lecture 7-8 - Concurrency in Java

Overview

- Introduction
- Java threads
- Java.util.concurrent

References

NOTE: The slides are based on the following free tutorials. You may want to consult them too.

1. http://winterbe.com/posts/2015/04/07/java8-concurrency-tutorial-thread-executor-examples/
2. http://tutorials.jenkov.com/java-util-concurrent/index.html
3. http://www.javacodegeeks.com/2015/09/java-concurrency-essentials.html
4. Oracle tutorials

Concurrent Programming

- there are two basic units of execution: processes and threads
- a computer system normally has many active processes and threads –even for only one execution core
- processing time for a single core is shared among processes and threads through an OS feature called time slicing.
- more and more common for computer systems to have multiple processors or processors with multiple execution cores

Processes

- a process has a self-contained execution environment.
- in general it has a complete, private set of basic run-time resources; for example, each process has its own memory space.
- most implementations of the Java virtual machine run as a single process

Processes

- processes are fully isolated from each other

-to facilitate communication between processes, most operating systems support Inter Process Communication (IPC) resources, such as pipes and sockets. (for communication between processes either on the same system or on different systems)

Threads

- are called lightweight processes
- creating a new thread requires fewer resources than creating a new process.
- threads exist within a process — every process has at least one.
- threads share the process's resources, including memory and open files. This makes for efficient, but potentially problematic, communication.

Threads

- Threads are the units that are scheduled by the system for executing on the processor not processes

- On a single processor, each thread has its turn by multiplexing based on time

- On a multiple processor, each thread is running at the same time with each processor/core running a particular thread.

Threads

- a thread is a particular execution path of a process.
- one allows multiple threads to read and write the same memory (no process can directly access the memory of another process).

- when one thread modifies a process resource, the change is immediately visible to sibling threads.

Advantages of Multi-threading

- faster on a multi-CPU system

- even in a single CPU system, application can remain responsive by using worker thread runs concurrently with the main thread

Cost of Multi-threading

- program overhead and additional complexity

- there are time and resource costs in both creating and destroying threads

- the time required for scheduling threads, loading them onto the process, and storing their states after each time slice is pure overhead.

Cost of Multi-threading

- biggest cost: Since the threads in a process all share the same resources and heap, it adds additional programming complexity to ensure that they are not ruining each other's work.

- debugging multithreaded programs can be quite difficult: the timing on each run of the program can be different; reproducing the same scheduling results is difficult

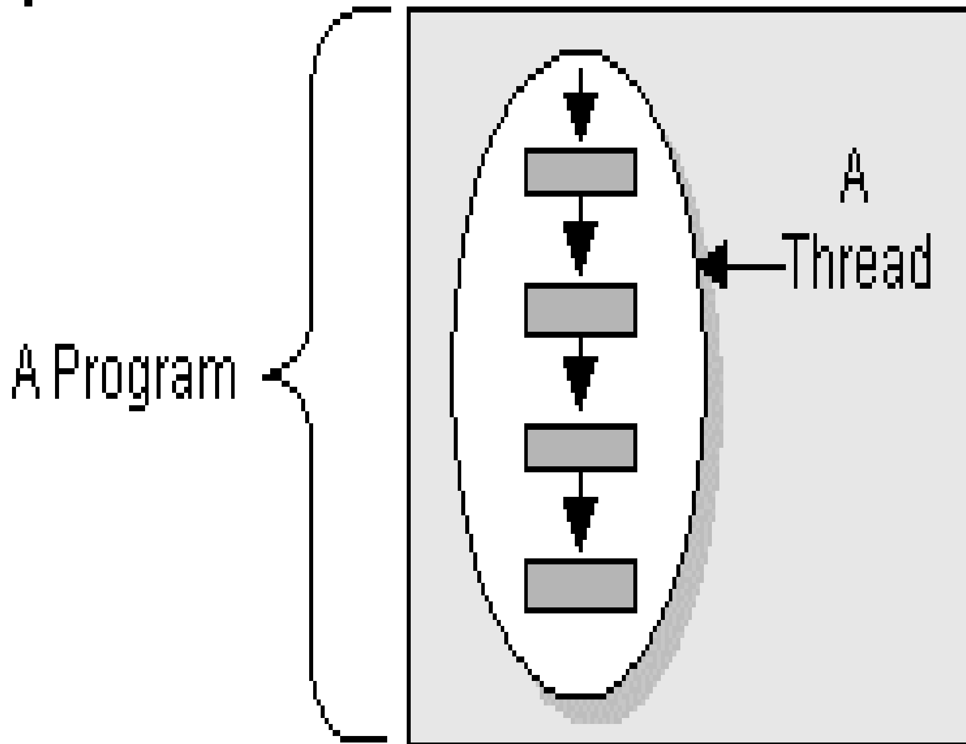
Contents

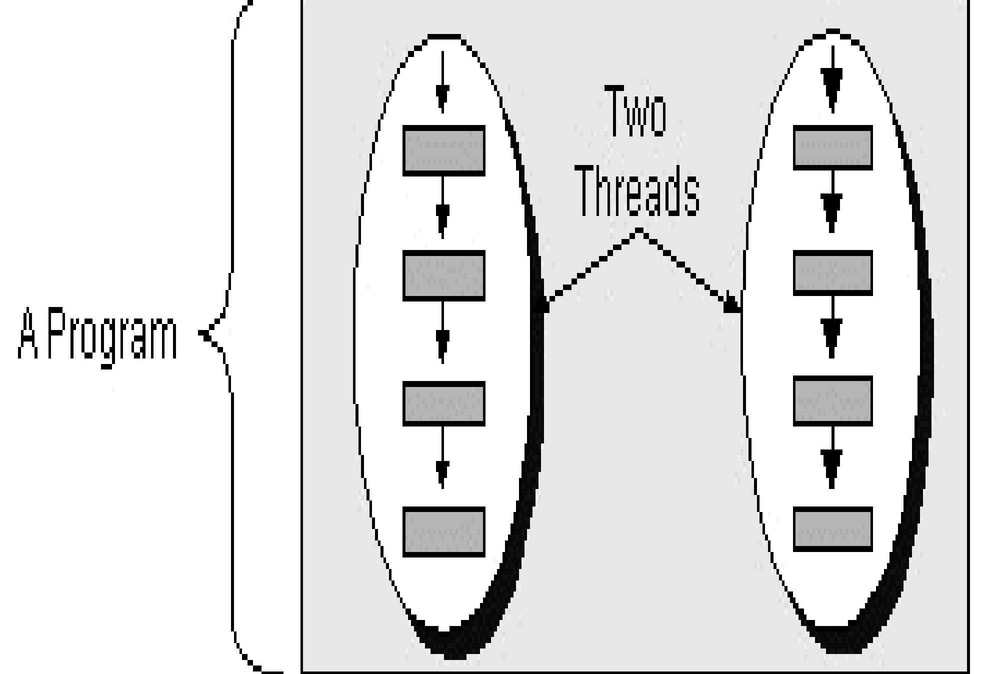
1. What is a thread ?
2. Define and launch a thread
3. The life-cycle of a thread
4. interrupt a thread
5. thread synchronization
6. other issues

What is a thread ?

- A sequential (or single-threaded) program is one that, when executed, has only one single flow of control.
  - i.e., at any time instant, there is at most only one instruction (or statement or execution point) that is being executed in the program.
- A multi-threaded program is one that can have multiple flows of control when executed.
  - At some time instance, there may exist multiple instructions (or execution points) that are being executed in the program
  - Ex: in a Web browser we may do the following tasks at the same time:
  - 1. scroll a page,
  - 2. download an applet or image,
  - 3. play sound,
  - 4 print a page.
- A thread is a single sequential flow of control within a program.

single-threaded vs multithreaded programs

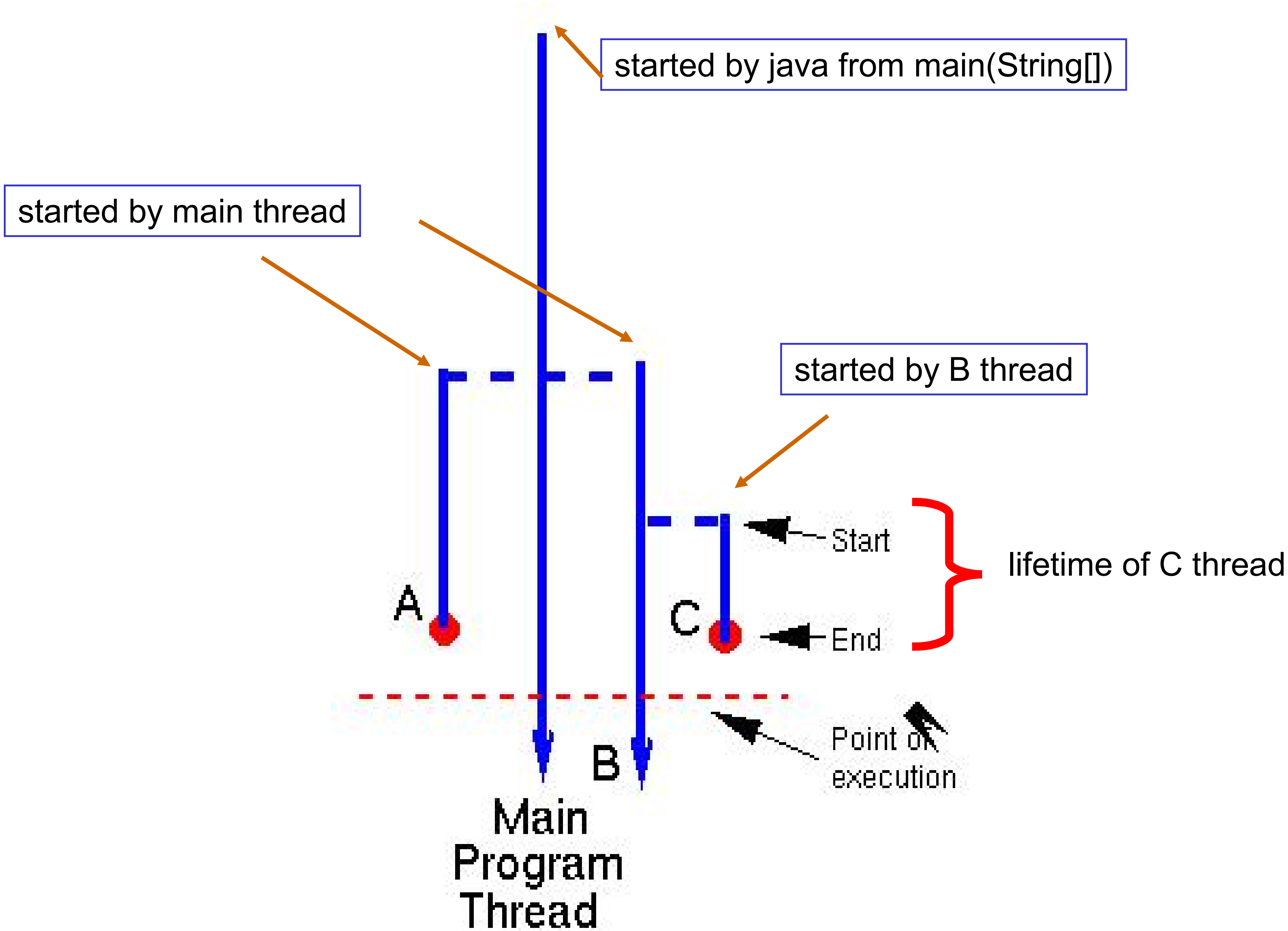





```
{ A(); A1();  A2();   A3();
  B1();  B2();  }
```

```
{  A();
   newThreads {
      { A1(); A2(); A3() };
      {B1(); B2() }
   }
}
```

Thread ecology in a java program



2. Define and launch a java thread

- **Each Java Run time thread is encapsulated in a java.lang.Thread instance.**
- **Two ways to define a thread:**

  1. **Extend the Thread class**
  2. **Implement the Runnable interface :**

```
package java.lang;
public interface Runnable {  public void run() ; }
```

- **Steps for extending the Thread class:**
  - **Subclass the Thread class;**
  - **Override the default Thread method run(), which is the entry point of the thread, like the main(String[]) method in a java program.**

Define a thread

// Example:

```
public class Print2Console extends Thread {
        public void run() {  // run() is to a thread what main() is to a java program
            for (int b = -128; b < 128; b++)  out.println(b);  }
        … // additional methods, fields …
         }
```

Implement the Runnable interface if you need a parent class:

```
// by extending JTextArea we can reuse all existing code of JTextArea
public class Print2GUI extend JTextArea implement Runnable {
        public void run() {
            for (int b = -128; b < 128; b++)  append( Integer.toString(b) + "\n" );  }
         }
```

How to launch a thread

1. create an instance of [a subclass of] of Thread, say thread.
   - Thread thread = new Print2Console();
   - Thread thread = new Thread(new Print2GUI(..));

2. call its start() method, thread.start();. // note: not call run() !!

Ex:

- Printer2Console t1 = new Print2Console(); // t1 is a thread instance !
- t1.start() ; // this will start a new thread, which begins its execution by calling t1.run()
- … // parent thread continue immediately here without waiting for the child thread to complete its execution. cf: t1.run();
- Print2GUI jtext = new Print2GUI();
- Thread t2 = new Thread(jtext);
- t2.start();
- …

The java.lang.Thread constructors

```
// Public Constructors
Thread([ ThreadGroup group,] [ Runnable target, ]
            [ String name ] );
    Instances :
    Thread();
    Thread(Runnable target);
    Thread(Runnable target, String name);
    Thread(String name);
    Thread(ThreadGroup group, Runnable target);
    Thread(ThreadGroup group, Runnable target, String name);
    Thread(ThreadGroup group, String name);
//  name is a string used to identify the thread instance
//  group is the thread group to which this thread belongs.
```

Some thread property access methods

- int getID() // every thread has a unique ID, since jdk1.5
- String getName(); setName(String)
  - // get/set the name of the thread
- ThreadGroup getThreadGroup();
- int getPriority() ; setPriority(int) // thread has priority in [0, 31]
- Thread.State getState() // return current state of this thread

- boolean isAlive()
  - Tests if this thread has been started and has not yet died. .
- boolean isDaemon()
  - Tests if this thread is a daemon thread.
- boolean isInterrupted()
  - Tests whether this thread has been interrupted.

State methods for current thread accesses

- static Thread currentThread()
  - Returns a reference to the currently executing thread object.
- static boolean holdsLock(Object obj)
  - Returns true if and only if the current thread holds the monitor lock on the specified object.
- static boolean interrupted()
  - Tests whether the current thread has been interrupted.
- static void sleep([long millis [, int nanos]])
  - Causes the currently executing thread to sleep (cease execution) for the specified time.
- static void yield()
  - Causes the currently executing thread object to temporarily pause and allow other threads to execute.

An example

```
public class SimpleThread extends Thread {
        public SimpleThread(String str) { super(str);  }
        public void run() {
           for (int i = 0; i < 10; i++) {
              System.out.println(i + " " + getName());
              try { // at this point, current thread is ‘this’.
                 Thread.sleep((long)(Math.random() * 1000));
              } catch (InterruptedException e) {}
           }
           System.out.println("DONE! " + getName());
        }       }
```

main program

```
public class TwoThreadsTest {
    public static void main (String[] args) {
        new SimpleThread("Thread1").start();
        new SimpleThread("Thread2").start();        } }
```

possible output:

```
0 Thread1
0 Thread2
1 Thread2
1 Thread1
2 Thread1
2 Thread2
3 Thread2
3 Thread1
4 Thread1
4 Thread2
5 Thread1
5 Thread2
6 Thread2
6 Thread1
7 Thread1
7 Thread2
8 Thread2
9 Thread2
8 Thread1
DONE! Thread2
9 Thread1
DONE! Thread1
```

Lecture 8

3. The Life Cycle of a Java Thread

New → (Runnable → blocked/waiting) * → Runnable → dead(terminated)

sleep(long ms [,int ns])

// sleep (ms + ns x 10^{-3}) milliseconds and then continue

[IO] blocked by synchronized method/block

```
synchronized( obj ) { …  }      // synchronized statement
synchronized m(… ) { …  }    // synchronized method
```

// return to runnable if IO complete

obj.wait()

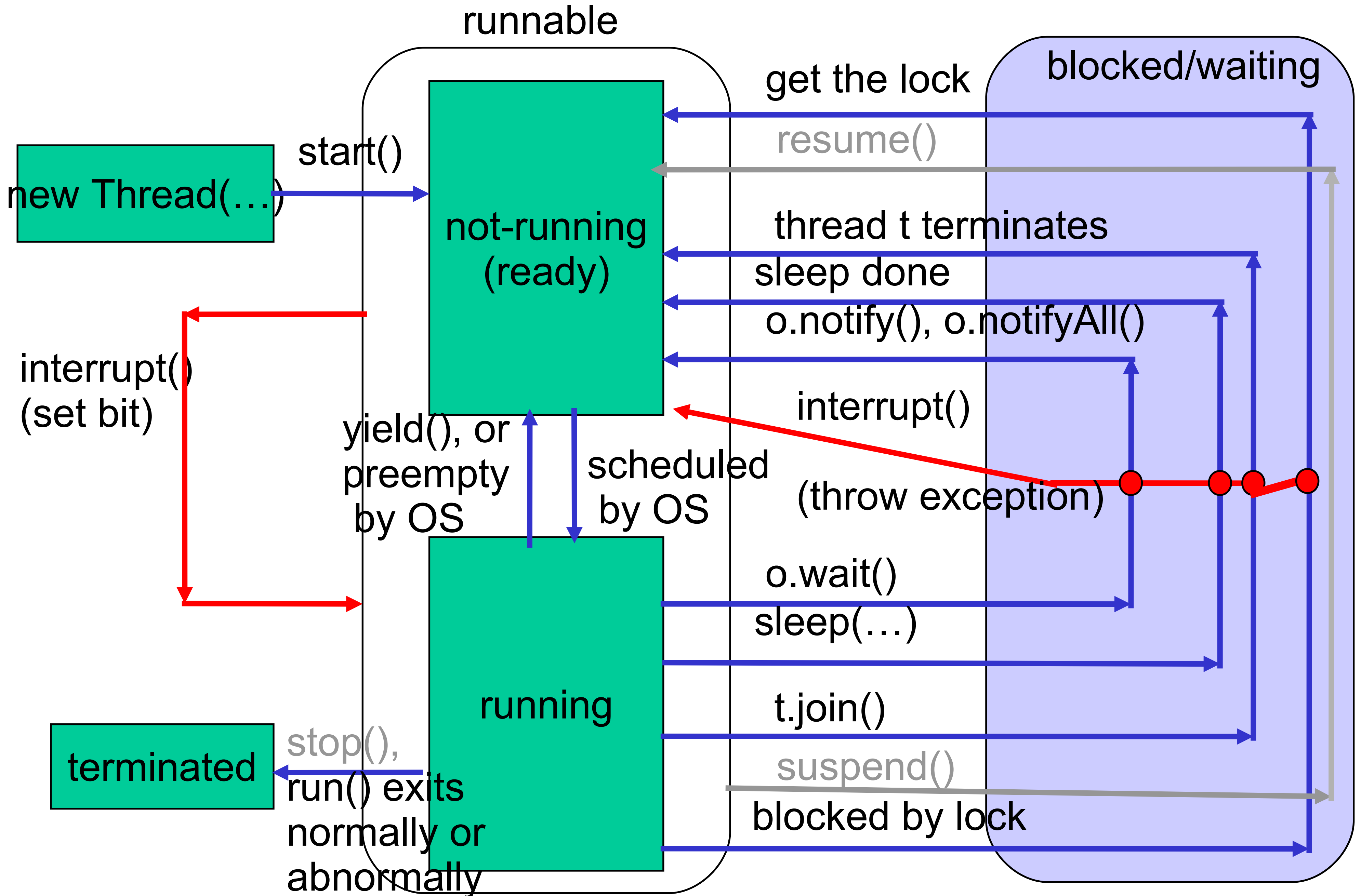
// return to runnable by obj.notify() or obj.notifyAll()

join(long ms [,int ns])

// Waits at most **ms** milliseconds plus **ns** nanoseconds for this thread to die.

3. The states(life cyccle) of a thread (java 1.5)

```
public class Thread { .. // enum in 1.5  is a special class for finite type.
 public static enum State { //use Thread.State for referring to this nested class
  NEW,   //   after new Thread(), but before start().
  RUNNABLE, // after start(), when running or ready
  BLOCKED,   //  blocked by monitor lock
                         // blocked by a synchronized method/block
  WAITING,     // waiting for to be notified; no time out set
     // wait(), join()
 TIMED_WAITING, // waiting for to be notified; time out set
     // sleep(time), wait(time), join(time)
TERMINATED  // complete execution or after stop()
} …
}
```


The life cycle of a Java thread
runnable
blocked/waiting
new Thread(…)
start()
not-running
(ready)
get the lock
resume()
thread t terminates
sleep done
o.notify(), o.notifyAll()
interrupt()
(set bit)
interrupt()
(throw exception)
yield(), or
preempty
by OS
scheduled
by OS
o.wait()
sleep(…)
t.join()
suspend()
blocked by lock
running
terminated
stop(),
run() exits
normally or
abnormally

State transition methods for Thread

- public synchronized native void start() {
  - start a thread by calling its run() method …
  - It is illegal to start a thread more than once }
- public final void join([long ms [, int ns]]);
  - Let current thread wait for receiver thread to die for at most ms+ns time
- static void yield() // callable by current thread only
  - Causes the currently executing thread object to temporarily pause and allow other threads to execute.
- public final void resume(); // deprecated
- public final void suspend();// deprecated→may lead to deadlock
- public final void stop(); // deprecated → lead to inconsistency

// state checking

- public boolean isAlive() ; // true if runnable or blocked

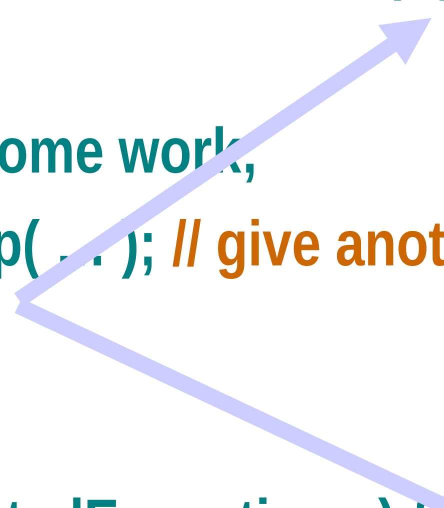
Note: When we call t.join(), we in fact use current thread's time to execute code of t thread

4. interrupting threads

- **A blocking/waiting call (sleep(),wait() or join()) to a thread t can be terminated by an InterruptedException thrown by invoking t.interrupt().**
  - this provides an alternative way to leave the blocked state.
  - however, the control flow is different from the normal case.

Ex:

```
public void run() {
 try { ...  while (more work to do) {      // Normal sleep() exit continue here

              do some work;
              sleep( ... ); // give another thread a chance to work
            }
      }
  catch (InterruptedException e) { // if waked-up by interrupt() then continue here
      ...  // thread interrupted during sleep or wait     }
 }
```



- **Note: the interrupt() method will not throw an InterruptedException if the thread is not blocked/waiting. In such case the thread needs to call the static interrupted() method to find out if it was recently interrupted. So we should rewrite the while loop by**

  while (! interrupted() && moreWorkToDo()) { … }

interrupt-related methods

- void interrupt()
  - send an Interrupt request to a thread.
  - the “interrupted” status of the thread is set to true.
  - if the thread is blocked by sleep(), wait() or join(), the The *interrupted status* of the thread is cleared and an InterruptedException is thrown.
  - conclusion: runnable ==> “interrupted” bit set but no Exception thrown.
  - not runnable ==> Exception thrown but “interrupted” bit not set
- static boolean interrupted() // destructive query
  - Tests whether the current thread (self) has been interrupted.
  - reset the “interrupted” status to false.
- boolean isInterrupted() // non-destructive query
  - Tests whether this thread has been interrupted without changing the “interrupted” status.
  - may be used to query current executing thread or another non-executing thread. e.g. if(t1.isInterrupted() | Thread.currentThread()...)

A complete example

- it consists of two threads.
- the first thread (main):
    - it is the main thread that every Java application has.
    - it creates a new thread from the Runnable object, MessageLoop, and waits for it to finish.
    - if the MessageLoop thread takes too long to finish, the main thread interrupts it.
- the second thread (MessageLoop):
    - it prints out a series of messages.
    - if interrupted before it has printed all its messages, it prints a message and exits.

```
public class SimpleThreads {
public static void main(String args[]) throws InterruptedException {
        // Delay, in milliseconds before  we interrupt MessageLoop thread
        long patience = 1000 * 60 * 60;
        threadMessage("Starting MessageLoop thread");
        long startTime = System.currentTimeMillis();
        Thread t = new Thread(new MessageLoop());
        t.start();
        threadMessage("Waiting for MessageLoop thread to finish");
        // loop until MessageLoop thread exits
        while (t.isAlive()) {
            threadMessage("Still waiting...");
            // Wait maximum of 1 second for MessageLoop thread to finish.
            t.join(1000);
```

```
if (((System.currentTimeMillis() - startTime) > patience) && t.isAlive()) {
            threadMessage("Tired of waiting!");
            t.interrupt();
            // Shouldn't be long now -- wait indefinitely
            t.join();
        }
    }
    threadMessage("Finally!");
  }
// Display a message, preceded by the name of the current thread
  static void threadMessage(String message) {
    String threadName = Thread.currentThread().getName();
    System.out.format("%s: %s%n", threadName, message);
  }
```

```
private static class MessageLoop implements Runnable {
    public void run() {
        String importantInfo[] = { "A","B","C","D"};
        try {
            for (int i = 0; i < importantInfo.length; i++) {
                // Pause for 4 seconds
                Thread.sleep(4000);
                // Print a message
                threadMessage(importantInfo[i]);
            }
        } catch (InterruptedException e) {
            threadMessage("I wasn't done!");
  }}}
```

5. Thread synchronization

- Problem with any multithreaded Java program :
  - Two or more Thread objects access the same pieces of data.
- too little or no synchronization ==> there is inconsistency, loss or corruption of data.
- too much synchronization ==> deadlock or system frozen.
- In between there is unfair processing where several threads can starve another one hogging all resources between themselves.

Multithreading may incur inconsistency : an Example

Two concurrent deposits of 50 into an account with 0 initial balance.:

```
void deposit(int amount) {
   int x = account.getBalance();
   x += amount;
   account.setBalance(x);  }
```

```
deposit(50) :  // deposit 1
  x = account.getBalance()  //1
  x += 50; //2
 account.setBalance(x) //3
```

- deposit(50) : // deposit 2

```
  x = account.getBalance()  //4
  x += 50; //5
 account.setBalance(x) //6
```

The execution sequence:

1,4,2,5,3,6 will result in unwanted result !!

Final balance is 50 instead of 100!!

Synchronized methods and statements

- multithreading can lead to racing hazards where different orders of interleaving produce different results of computation.
  - Order of interleaving is generally unpredictable and is not determined by the programmer.
- Java's synchronized method (as well as synchronized statement) can prevent its body from being interleaved by relevant methods.
  - synchronized(obj) { … } // synchronized statement with obj as lock
  - synchronized … m(…) {… } //synchronized method with this as lock
  - When one thread executes (the body of) a synchronized method/statement, all other threads are excluded from executing any synchronized method with the same object as lock.

Synchronizing threads

- Java use the monitor concept to achieve mutual exclusion and synchronization between threads.
- Synchronized methods /statements guarantee mutual exclusion.
  - Mutual exclusion may cause a thread to be unable to complete its task. So monitor allow a thread to wait until state change and then continue its work.
- wait(), notify() and notifyAll() control the synchronization of threads.
  - Allow one thread to wait for a condition (logical state) and another to set it and then notify waiting threads.
  - condition variables => instance boolean variables
  - wait => wait();
  - notifying => notify(); notifyAll();

Typical usage

```
synchronized void doWhenCondition() {
   while ( !condition )
     wait(); // wait until someone notifies us of changes in condition
   … // do what needs to be done when condition is true
}
synchronized void changeCondition {
   // change some values used in condition test
   notify(); // Let waiting threads know something changed
}
```

Note: A method may serve both roles; it may need some condition to occur to do something and its action my cause condition to change.

Java's Monitor Model

A monitor is a collection of code (called the critical section) associated with an object (called the lock)

At any time instant only one thread at most can has its execution point located in the critical section associated with the lock(mutual exclusion).

Java allows any object to be the lock of a monitor.

Java's Monitor Model(cont.)

The critical section of a monitor controlled by an object e [of class C] comprises the following sections of code:

- The body of all synchronized methods m() callable by e, that is, all synchronized methods m(…) defined in C or super classes of C.
- The body of all synchronized statements with e as target:

  synchronized(e) { …   }. // critical section is determined by the lock object e

Java's Monitor Model(cont.)

A thread enters the critical section of a monitor by invoking e.m() or executing a synchronized statement.

Before it can run the method/statement, it must first own the lock e and will need to wait until the lock is free if it cannot get the lock.

A thread owing a lock will release the lock automatically once it exit the critical section.

Java's Monitor model (continued)

A thread executing in a monitor may encounter condition in which it cannot continue but still does not want to exit.

In such case, it can call the method e.wait() to enter the waiting list of the monitor.

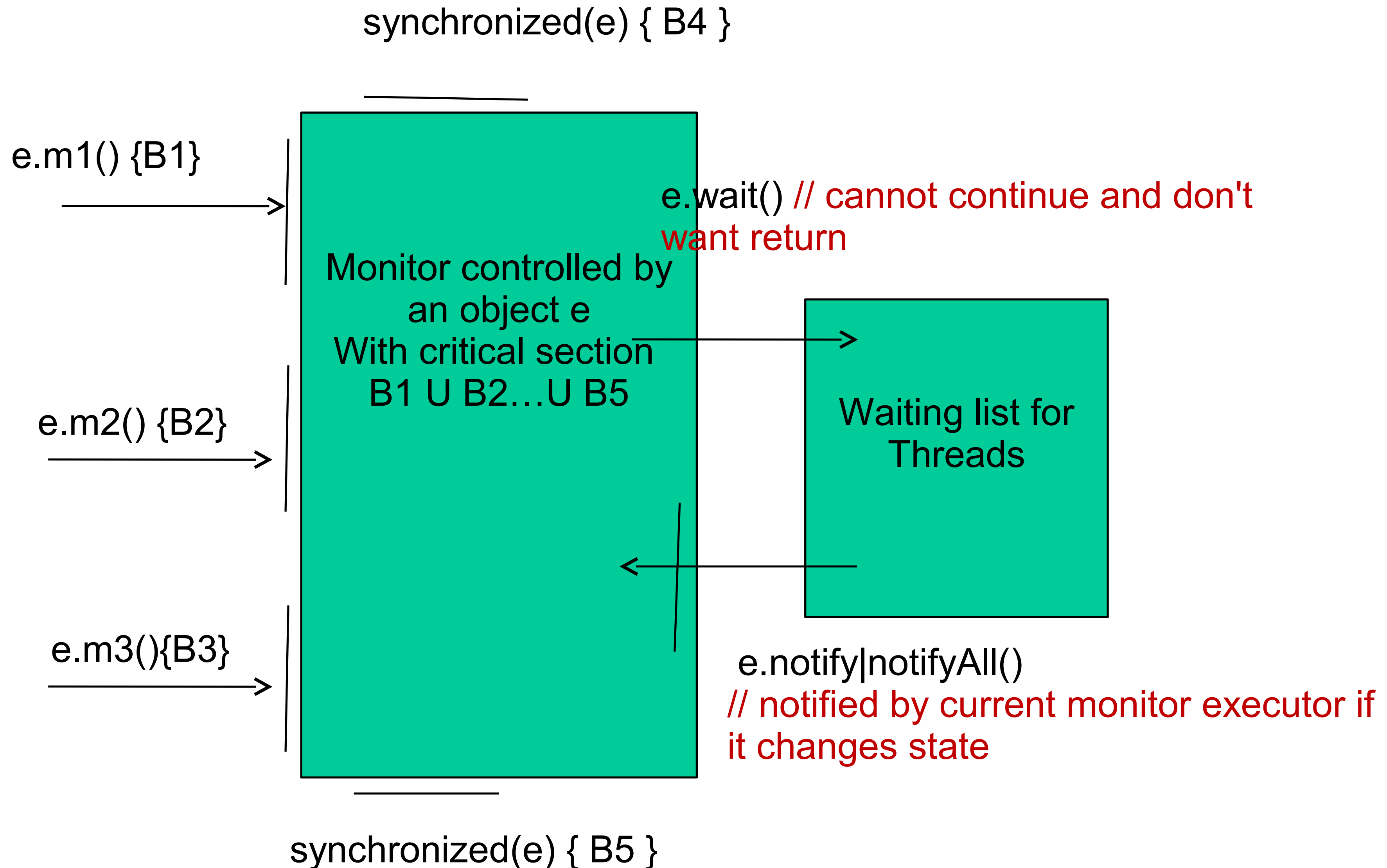
A thread entering waiting list will release the lock so that other outside threads have chance to get the lock.

Java's Monitor model (continued)

A thread changing the monitor state should call e.notify() or e.notifyAll() to have one or all threads in the waiting list to compete with other outside threads for getting the lock to continue execution.

Note: A static method m() in class C can also be synchronized. In such case it belongs to the monitor whose lock object is C.class.

Java's monitor model (continued)



- Note since a section of code may belong to multiple monitors, it is possible that two threads reside at the same code region belonging to two different monitors..

Producer/Consumer Problem

- Two threads: producer and consumer
- One monitor: CubbyHole
- The Producer :
  - generates a pair of integers between 0 and 9 (inclusive), stores it in a CubbyHole object, and prints the sum of each generated pair.
  - sleeps for a random amount of time between 0 and 100 milliseconds before repeating the number generating cycle.
- The Consumer:
  - consumes all pairs of integers from the CubbyHole as quickly as they become available.

Producer.java

```
public class Producer extends Thread {
    private CubbyHole cubbyhole;            private int id;
    public Producer(CubbyHole c, int id) {
    cubbyhole = c;            this.id = id;            }
    public void run() {
        for (int i = 0; i < 10; i++)
          for(int j =0; j < 10; j++ ) {
            cubbyhole.put(i, j);
            System.out.println("Producer #" + this.id   + " put: ("+i +","+j + ").");
             try { sleep((int)(Math.random() * 100));  }
             catch (InterruptedException e) { }
           };
     }
   }
```

Consumer.java

```
public class Consumer extends Thread {
    private CubbyHole cubbyhole;
    private int id;

    public Consumer(CubbyHole c, int id) {
        cubbyhole = c;          this.id = id;    }

    public void run() {
        int value = 0;
        for (int i = 0; i < 10; i++) {
            value = cubbyhole.get();
            System.out.println("Consumer #" + this.id + " got: " + value);
        }   } }
```

CubbyHole without mutual exclusion

```
public class CubbyHole {    private int x,y;
    public synchronized int get() {  return x+y;    }
    public synchronized void put(int i, int j) {x= i; y = j }    }
```

Problem : data inconsistency for some possible execution sequence

Suppose after put(1,9) the data is correct , i.e., (x,y) = (1,9)

And then two method calls get() and put(2,0) try to access CubbyHole concurrently => possible inconsistent result:

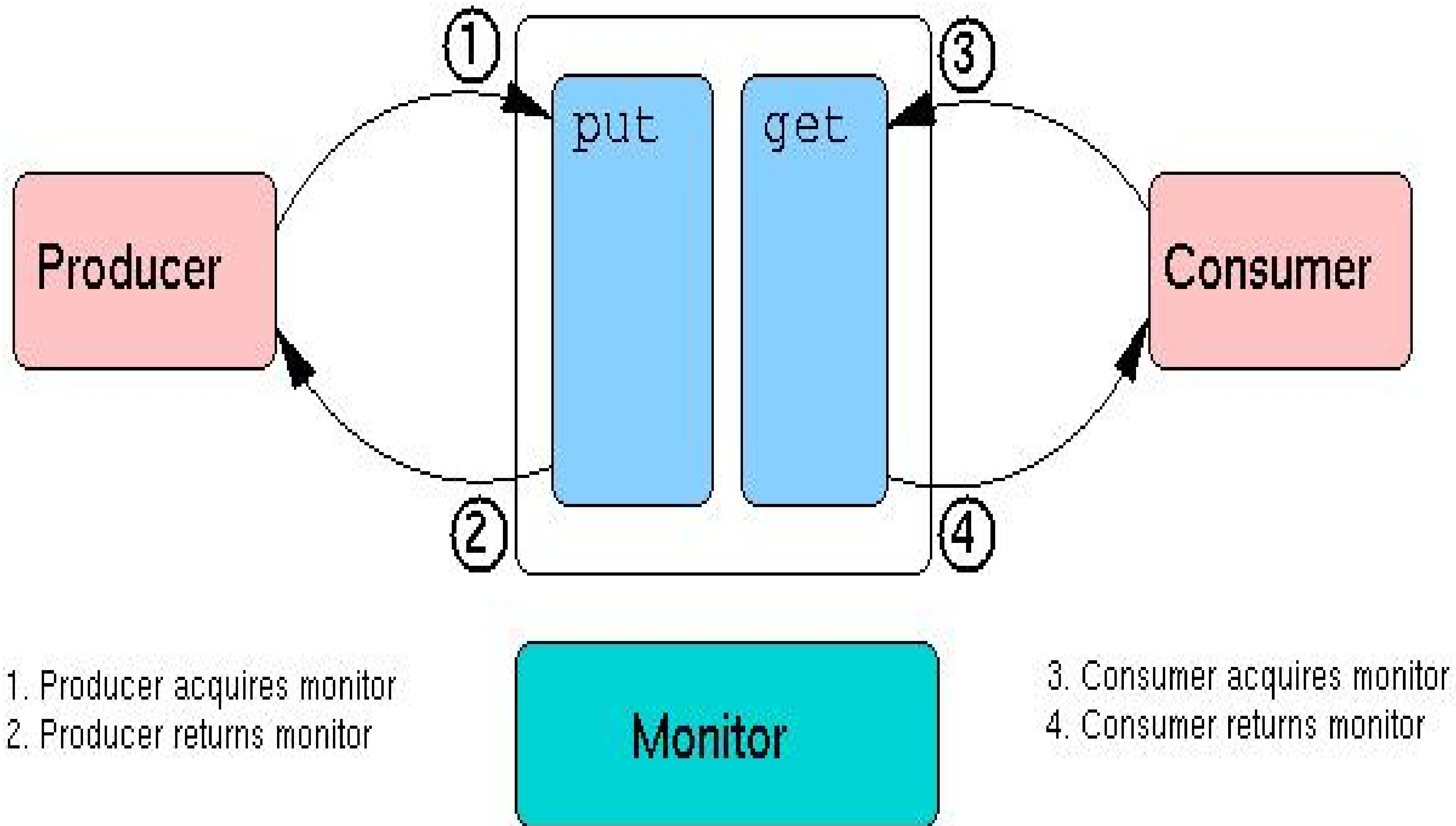
(1,9) → get() { return x + y ; } → { return 1 + y ; }

(1,9) → put(2,0) {x = 2; y = 0;} → (x,y) = (2,0)

(2,0) → get() { return 1 + y ;} → return 1 + 0 = return 1 (instead of 10!)

By marking get() and put() as synchronized method, the inconsistent result cannot occur since, by definition, when either method is in execution by one thread, no other thread can execute any synchronized method with this CubbyHole object as lock.

The CubbyHole



CubbyHole without synchronization

```
public class CubbyHole {
    private int x,y;
    public synchronized int get() {  return x+y;    }
    public synchronized void put(int i, int j) { x= i ; y  = j; }
}
```

Problems:

Consumer quicker than Producer : some data got more than once.

Producer quicker than Consumer: some put data not used by consumer.

ex: Producer #1 put: (0,4)

Consumer #1 got: 4

Consumer #1 got: 4

Producer #1 put: (0,5)

Consumer #1 got: 3
Producer #1 put: (0,4)
Producer #1 put: (0,5)
Consumer #1 got: 5

Another CubbyHole implementation (still incorrect!)

```
pubic class CubbyHole {  int x,y;  boolean available = false;
   public synchronized int get() {    // won't work!
          if (available == true) {
              available = false;   return x+y;
          }  }   // compilation error!! must return a value in any case!!
   public synchronized void put(int a, int b) {    // won't work!
          if (available == false) {
              available = true;     x=a;y=b;
        } }} // but how about the case that available == true ?
put(..); get(); get();  // 2nd get()  must return something!
put(..);put(..); // 2nd put() has no effect!
```

CubbyHole.java

```
public class CubbyHole {
    private int x,y;     private boolean available = false; // condition var
    public synchronized int get() {
        while (available == false) {
            try {    this.wait();      } catch (InterruptedException e) { }       }
        available = false;  // enforce consumers to wait again.
        notifyAll(); // notify all producer/consumer to compete for execution!
                     // use notify() if just wanting to wakeup one waiting thread!
        return x+y;    }
    public synchronized void put(int a, int b) {
        while (available == true) {
            try {  wait();   } catch (InterruptedException e) { }       }
        x= a; y = b;
        available = true;  // wake up waiting consumer/producer to continue
        notifyAll(); // or notify();    }}
```

The main class

```
public class ProducerConsumerTest {
    public static void main(String[] args) {
        CubbyHole c = new CubbyHole();
        Producer p1 = new Producer(c, 1);
        Consumer c1 = new Consumer(c, 1);
        p1.start();
        c1.start();
    }     }
```

Other issues

- Thread priorities
  - public final int getPriority();
  - public final void setPriority();
  - get/set priority between MIN_PRIORITY and MAX_PRIORITY
  - default priority : NORMAL_PRIORITY
- Daemon threads:
  - isDaemon(), setDaemon(boolean)
  - A Daemon thread is one that exists for service of other threads.
  - The JVM exits if all threads in it are Daemon threads.
  - setDaemon(.) must be called before the thread is started.
- **public static boolean holdsLock(Object obj)**
  - check if this thread holds the lock on obj.
  - ex: synchronized(e) { Thread.holdLock(e) ? true:false // is true … }

Thread Groups

- Every Java thread is a member of a thread group.
- Thread groups provide a mechanism for collecting multiple threads into a single object and manipulating those threads all at once, rather than individually.
- When creating a thread,
  - let the runtime system put the new thread in some reasonable default group (the current thread group) or
  - explicitly set the new thread's group.
- you cannot move a thread to a new group after the thread has been created.
  - when launched, main program thread belongs to main thread group.

Creating a Thread Explicitly in a Group

```
public Thread(ThreadGroup group, Runnable runnable)
public Thread(ThreadGroup group, String name)
public Thread(ThreadGroup group, Runnable runnable, String
    name)

ThreadGroup myThreadGroup = new ThreadGroup(
                                    "My Group of Threads");
    Thread myThread = new Thread(myThreadGroup,
                                "a thread for my group");
```

Getting a Thread's Group

```
    theGroup = myThread.getThreadGroup();
```

The ThreadGroup Class

Collection Management Methods:

```
public class EnumerateTest {
        public void listCurrentThreads() {
            ThreadGroup currentGroup =
                    Thread.currentThread().getThreadGroup();
            int numThreads = currentGroup.activeCount();
            Thread[] listOfThreads = new Thread[numThreads];

            currentGroup.enumerate(listOfThreads);
            for (int i = 0; i < numThreads; i++)
                System.out.println("Thread #" + i + " = " +
                                   listOfThreads[i].getName());
        }
    }
```

Methods that Operate on the ThreadGroup

- getMaxPriority(), setMaxPriority(int)
- isDaemon(), setDaemon(boolean)
  - A Daemon thread group is one that destroys itself when its last thread/group is destroyed.
- getName() // name of the thread
- getParent() and parentOf(ThreadGroup) // boolean
- toString()
- activeCount(), activeGroupCount()
- // # of active descendent threads, and groups

- suspend(); //deprecated; suspend all threads in this group.
- resume();
- stop();

Content(java.util.concurrent)

1)ExecutorService

2)ForkJoinPool

3)Blocking Queue

4)Concurrent Collections

5)Semaphore

6)CountDownLatch

7)CyclicBarrier

8)Lock

9)Atomic Variables

Java.util.concurrency

- A a set of ready-to-use data structures and functionality for writing safe multithreaded applications

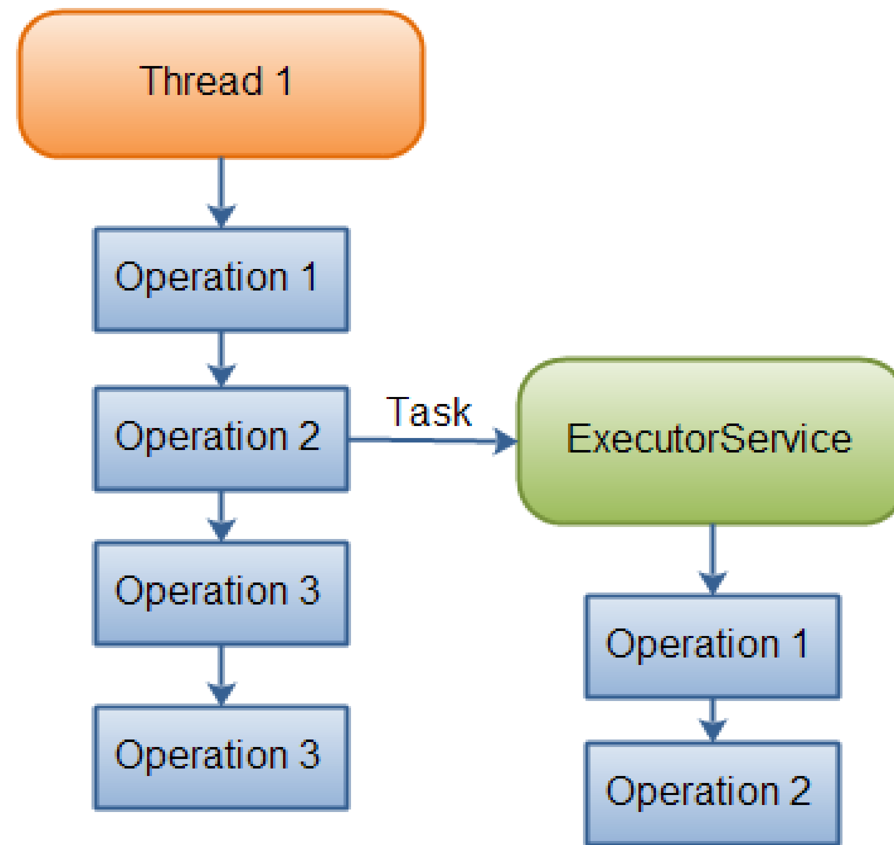
- it is not always trivial to write robust code that executes well in a multi-threaded environment

Executor Service

- The java.util.concurrent.ExecutorService interface represents an asynchronous execution mechanism which is capable of executing tasks in the background.
- It is very similar to a thread pool. In fact, the implementation of ExecutorService present in the java.util.concurrent package is a thread pool implementation.

ExecutorService

```
ExecutorService executorService =Executors.newFixedThreadPool(10);
    //10 threads for executing tasks are created

executorService.execute(new Runnable() {
    public void run() {
        System.out.println("Asynchronous task");
    }
});

executorService.shutdown();
```



Thread 1 delegates a task to an executor service for asynchronous execution

Creating executor service

Using Executors factory class:

```
ExecutorService executorService1 =
    Executors.newSingleThreadExecutor();

ExecutorService executorService2 =
    Executors.newFixedThreadPool(10);

ExecutorService executorService3 =
    Executors.newScheduledThreadPool(10);
```

ExecutorService usage

There are a few different ways to delegate tasks for execution to an ExecutorService:

- execute(Runnable)
- submit(Runnable)
- submit(Callable)
- invokeAny(...)
- invokeAll(...)

execute(Runnable)

```
ExecutorService executorService =
    Executors.newSingleThreadExecutor();
executorService.execute(new Runnable() {
   public void run() {
      System.out.println("Asynchronous task");
   }
});
executorService.shutdown();
```

- There is no way of obtaining the result of the executed Runnable, if necessary. You will have to use a Callable for that

submit(Callable)

```
Future future = executorService.submit(new Callable(){
    public Object call() throws Exception {
        System.out.println("Asynchronous Callable");
        return "Callable Result";
    }
});
System.out.println("future.get() = " + future.get());
```

- The Callable's result can be obtained via the Future object returned

invokeAll()

```
ExecutorService executorService = Executors.newSingleThreadExecutor();
Set<Callable<String>> callables = new HashSet<Callable<String>>();
callables.add(new Callable<String>() {
    public String call() throws Exception {
        return "Task 1";
    }
});
......
List<Future<String>> futures = executorService.invokeAll(callables);
for(Future<String> future : futures){
    System.out.println("future.get = " + future.get());
}
executorService.shutdown();
```

```
ExecutorService executor = Executors.newWorkStealingPool();
List<Callable<String>> callables = Arrays.asList(
        () -> "task1",
        () -> "task2",
        () -> "task3");
executor.invokeAll(callables)
    .stream()
    .map(future -> {
        try {
            return future.get();
        }
        catch (Exception e) {
            throw new IllegalStateException(e);
        }
    })
    .forEach(System.out::println);
```

Callables and Futures

- Callables are functional interfaces just like runnables but instead of being void they return a value.

```
Callable<Integer> task = () -> {
    try {
        TimeUnit.SECONDS.sleep(1);
        return 123;
    }
    catch (InterruptedException e) {
        throw new IllegalStateException("task interrupted", e);
    }
};
```

Callables and Futures

- Callables can be submitted to executor services just like runnables.
- the executor returns a special result of type Future which can be used to retrieve the actual result at a later point in time.
- After submitting the callable to the executor we can check if the future has already been finished execution via isDone()

```
ExecutorService executor = Executors.newFixedThreadPool(1);

Future<Integer> future = executor.submit(task);

System.out.println("future done? " + future.isDone());

Integer result = future.get();

System.out.println("future done? " + future.isDone());

System.out.print("result: " + result);


//future done? false

//future done? true

//result: 123
```

ExecutorService Shutdown

- To terminate the threads inside the ExecutorService you call its shutdown() method. It will not shut down immediately, but it will no longer accept new tasks, and once all threads have finished current tasks, the ExecutorService shuts down

- to shut down the ExecutorService immediately, you can call the shutdownNow() method. This will attempt to stop all executing tasks right away, and skips all submitted but non-processed tasks.

java.util.concurrent.ThreadPoolExecutor

- is an implementation of the ExecutorService interface.
- executes the given task (Callable or Runnable) using one of its internally pooled threads.

- The number of threads in the pool is determined by these variables:
  - corePoolSize
  - maximumPoolSize

ScheduledExecutorService

- can schedule tasks to run after a delay, or to execute repeatedly with a fixed interval of time in between each execution.
- Tasks are executed asynchronously by a worker thread, and not by the thread handing the task to the ScheduledExecutorService.

ScheduledExecutorService

```
ScheduledExecutorService scheduledExecutorService =
        Executors.newScheduledThreadPool(5);


ScheduledFuture scheduledFuture =
    scheduledExecutorService.schedule(new Callable() {
        public Object call() throws Exception {
            System.out.println("Executed!");
            return "Called!";
        }
    }, 5,TimeUnit.SECONDS);
```

- the Callable should be executed after 5 seconds

ScheduledExecutorService Usage

Once you have created a ScheduledExecutorService you use it by calling one of its methods:

- schedule (Callable task, long delay, TimeUnit timeunit)
- schedule (Runnable task, long delay, TimeUnit timeunit)
- scheduleAtFixedRate (Runnable, long initialDelay, long period, TimeUnit timeunit)
- scheduleWithFixedDelay (Runnable, long initialDelay, long period, TimeUnit timeunit)

Advanced Programming Methods

NO Lecture 9

Lecture 10 - Concurrency in Java, GUI in Java

Overview

- Java.util.concurrent (continuation)
- JavaFx – GUI in Java

java.util.concurrent - Continuation

1) ExecutorService
2) ForkJoinPool
3) Blocking Queue
4) Concurrent Collections
5) Semaphore
6) CountDownLatch
7) CyclicBarrier
8) Lock
9) Atomic Variables

ForkJoinPool

- is similar to the ExecutorService but with one difference

- implements the work-stealing strategy, i.e. every time a running thread has to wait for some result; the thread removes the current task from the work queue and executes some other task ready to run. This way the current thread is not blocked and can be used to execute other tasks. Once the result for the originally suspended task has been computed the task gets executed again and the join() method returns the result.

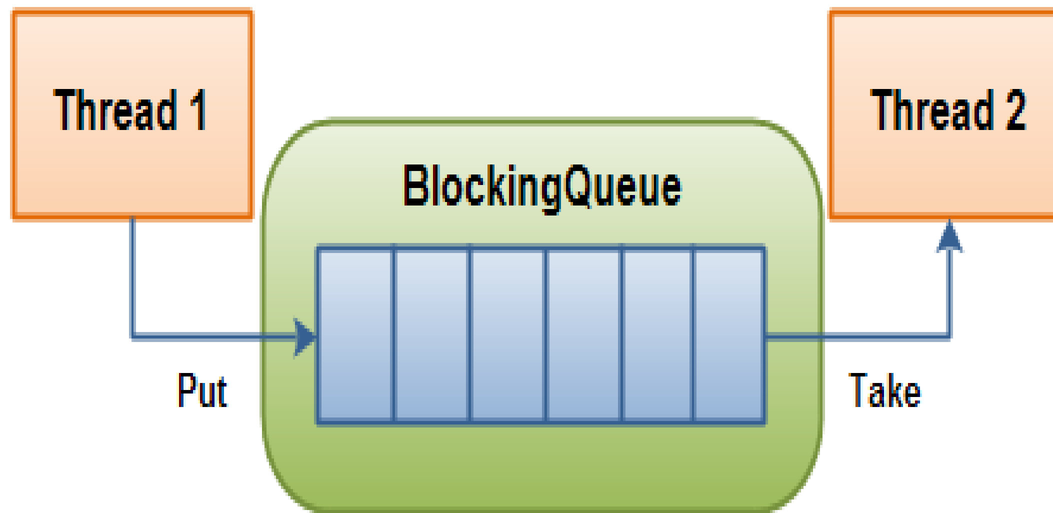
ForkJoinPool

- a call of fork() will start an asynchronous execution of the task,
- a call of join() will wait until the task has finished and retrieve its result.
- makes it easy for tasks to split their work up into smaller tasks(divide and conquer approach) which are then submitted to the ForkJoinPool too.

```
01 public class FindMin extends RecursiveTask<Integer> {

02 private static final long serialVersionUID = 1L;

03 private int[] numbers;

04 private int startIndex;

05 private int endIndex;

06

07 public FindMin(int[] numbers, int startIndex, int endIndex) {

08 this.numbers = numbers;

09 this.startIndex = startIndex;

10 this.endIndex = endIndex;

11 }

12

13 @Override

14 protected Integer compute() {

15 int sliceLength = (endIndex - startIndex) + 1;

16 if (sliceLength > 2) {

17 FindMin lowerFindMin = new FindMin(numbers, startIndex, startIndex + (sliceLength / 2)- 1);

18 lowerFindMin.fork();
```

```
19 FindMin upperFindMin = new FindMin(numbers, startIndex + (sliceLength / 2), endIndex);

20 upperFindMin.fork();

21 return Math.min(lowerFindMin.join(), upperFindMin.join());

22 } else {

23 return Math.min(numbers[startIndex], numbers[endIndex]);

24 }

25 }

26

27 public static void main(String[] args) {

28 int[] numbers = new int[100];

29 Random random = new Random(System.currentTimeMillis());

30 for (int i = 0; i < numbers.length; i++) {

31 numbers[i] = random.nextInt(100);

32 }

33 ForkJoinPool pool = new ForkJoinPool(Runtime.getRuntime().availableProcessors());

34 Integer min = pool.invoke(new FindMin(numbers, 0, numbers.length - 1));

35 System.out.println(min);

36 }

37 }
```

BlockingQueue



```
public class BlockingQueueExample {

    public static void main(String[] args) throws Exception {

        BlockingQueue queue = new ArrayBlockingQueue(1024);

        Producer producer = new Producer(queue);
        Consumer consumer = new Consumer(queue);

        new Thread(producer).start();
        new Thread(consumer).start();

        Thread.sleep(4000);
    }
}
```

```
public class Producer implements Runnable{
    protected BlockingQueue queue = null;
    public Producer(BlockingQueue queue) {
        this.queue = queue;}

    public void run() {
        try {
            queue.put("1");
            Thread.sleep(1000);
            queue.put("2");
            Thread.sleep(1000);
            queue.put("3");
        } catch (InterruptedException e) {
            e.printStackTrace();
        }}}
```

```
public class Consumer implements Runnable{
    protected BlockingQueue queue = null;
    public Consumer(BlockingQueue queue) {
        this.queue = queue; }

    public void run() {
        try {
            System.out.println(queue.take());
            System.out.println(queue.take());
            System.out.println(queue.take());
        } catch (InterruptedException e) {
            e.printStackTrace();
        }}}
```

ConcurrentHashMap

- is very similar to the java.util.HashTable class, except that ConcurrentHashMap offers better concurrency than HashTable does.
- does not lock the Map while you are reading from it.
- does not lock the entire Map when writing to it. It only locks the part of the Map that is being written to, internally.

Semaphore

- the java.util.concurrent.Semaphore class is a counting semaphore.
- The counting semaphore is initialized with a given number of "permits".
- For each call to acquire() a permit is taken by the calling thread.
- For each call to release() a permit is returned to the semaphore.
- Thus, at most N threads can pass the acquire() method without any release() calls, where N is the number of permits the semaphore was initialized with.

Semaphore

As semaphore typically has two uses:

- To guard a critical section against entry by more than N threads at a time.
- To send signals between two threads.

```
ExecutorService executor = Executors.newFixedThreadPool(10);
Semaphore semaphore = new Semaphore(5);
Runnable longRunningTask = () -> {
    boolean permit = false;
    try {
        permit = semaphore.tryAcquire(1, TimeUnit.SECONDS);
        if (permit) {
            System.out.println("Semaphore acquired");
            sleep(5);
        } else {System.out.println("Could not acquire semaphore");}
    } catch (InterruptedException e) {
        throw new IllegalStateException(e);
    } finally {
        if (permit) {semaphore.release();
        }}}

IntStream.range(0, 10).forEach(i -> executor.submit(longRunningTask));
stop(executor);
```

CountDownLatch

- is initialized with a given count.
- This count is decremented by calls to the countDown() method.
- Threads waiting for this count to reach zero can call one of the await() methods. Calling await() blocks the thread until the count reaches zero.

```
CountDownLatch latch = new CountDownLatch(3);

Waiter      waiter      = new Waiter(latch);
Decrementer decrementer = new Decrementer(latch);

new Thread(waiter)     .start();
new Thread(decrementer).start();

Thread.sleep(4000);
```

```
public class Waiter implements Runnable{
     CountDownLatch latch = null;
    public Waiter(CountDownLatch latch) {
        this.latch = latch;}
    public void run() {
        try {
            latch.await();
        } catch (InterruptedException e) {
            e.printStackTrace();
        }
        System.out.println("Waiter Released");
    }
}
```

```
public class Decrementer implements Runnable {
  CountDownLatch latch = null;
   public Decrementer(CountDownLatch latch) {
      this.latch = latch;}
   public void run() {
      try {
         Thread.sleep(1000);
         this.latch.countDown();
         Thread.sleep(1000);
         this.latch.countDown();
         Thread.sleep(1000);
         this.latch.countDown();
      } catch (InterruptedException e) {
         e.printStackTrace();
      }}}
```

Cyclic Barrier

- is a synchronization mechanism that can synchronize threads progressing through some algorithm.
- it is a barrier that all threads must wait at, until all threads reach it, before any of the threads can continue.
- The threads wait for each other by calling the await() method on the CyclicBarrier.
- Once N threads are waiting at the CyclicBarrier, all threads are released and can continue running.

```java
Runnable barrier1Action = new Runnable() {
    public void run() {
        System.out.println("BarrierAction 1 executed ");}};
Runnable barrier2Action = new Runnable() {
    public void run() {
        System.out.println("BarrierAction 2 executed ");}};

CyclicBarrier barrier1 = new CyclicBarrier(2, barrier1Action);
CyclicBarrier barrier2 = new CyclicBarrier(2, barrier2Action);
CyclicBarrierRunnable barrierRunnable1 =
        new CyclicBarrierRunnable(barrier1, barrier2);
CyclicBarrierRunnable barrierRunnable2 =
        new CyclicBarrierRunnable(barrier1, barrier2);
new Thread(barrierRunnable1).start();
new Thread(barrierRunnable2).start();
```

```
public class CyclicBarrierRunnable implements Runnable{

    CyclicBarrier barrier1 = null;
    CyclicBarrier barrier2 = null;

    public CyclicBarrierRunnable(
            CyclicBarrier barrier1,
            CyclicBarrier barrier2) {

        this.barrier1 = barrier1;
        this.barrier2 = barrier2;
    }
```

```
public void run() {
    try {
        Thread.sleep(1000);
        System.out.println(Thread.currentThread().getName() +
                        " waiting at barrier 1");
        this.barrier1.await();
        Thread.sleep(1000);
        System.out.println(Thread.currentThread().getName() +
                        " waiting at barrier 2");
        this.barrier2.await();
        System.out.println(Thread.currentThread().getName() +  " done!");
    } catch (InterruptedException e) {
        e.printStackTrace();
    } catch (BrokenBarrierException e) {
        e.printStackTrace();
    }}}
```

Lock

- is a thread synchronization mechanism just like synchronized blocks. A Lock is, however, more flexible and more sophisticated than a synchronized block.

```
Lock lock = new ReentrantLock();
lock.lock();
//critical section
lock.unlock();
```

ReadWriteLock

- allows multiple threads to read a certain resource, but only one to write it, at a time.

- Read Lock: If no threads have locked the ReadWriteLock for writing, and no thread have requested a write lock. Thus, multiple threads can lock the lock for reading.

- Write Lock: If no threads are reading or writing. Thus, only one thread at a time can lock the lock for writing.

```
ReadWriteLock readWriteLock = new ReentrantReadWriteLock();


readWriteLock.readLock().lock();
    // multiple readers can enter this section
    // if not locked for writing, and not writers waiting
    // to lock for writing.
readWriteLock.readLock().unlock();


readWriteLock.writeLock().lock();
    // only one writer can enter this section,
    // and only if no threads are currently reading.
readWriteLock.writeLock().unlock();
```

Atomic Variables

- the atomic classes make heavy use of compare-and-swap (CAS), an atomic instruction directly supported by most modern CPUs.
- Those instructions usually are much faster than synchronizing via locks.
- My advice is to prefer atomic classes over locks in case you just have to change a single mutable variable concurrently.
- Many atomic classes: AtomicBoolean, AtomicInteger, AtomicReference, AtomicIntegerArray, etc

AtomicBoolean

- provides a boolean variable which can be read and written atomically, and which also contains advanced atomic operations like compareAndSet()
- Example:

```
AtomicBoolean atomicBoolean = new AtomicBoolean(true);

boolean expectedValue = true;

boolean newValue      = false;

boolean wasNewValueSet =
    atomicBoolean.compareAndSet(expectedValue, newValue);
```

AtomicInteger

```
AtomicInteger atomicInt = new AtomicInteger(0);
ExecutorService executor = Executors.newFixedThreadPool(2);
IntStream.range(0, 1000)
    .forEach(i -> {
        Runnable task = () ->
            atomicInt.updateAndGet(n -> n + 2); //thread-safe without synchronization
        executor.submit(task);
    });

stop(executor);
System.out.println(atomicInt.get());    // => 2000
```

JAVA GUI -- JavaFX

Note: Some of the slides and examples are taken from my colleague dr. Camelia Serban.

Content

- What is JavaFX
- Scene graph
- Working with the components
- Layout management
- Events management

References

JavaFX tutorials

http://docs.oracle.com/javafx/index.html

JavaFX API

http://docs.oracle.com/javafx/2.0/api/index.html

What is JavaFX ?

- Classes and interfaces that provide support for creating Java applications that can be designed, implemented, tested on different platforms.
- Provides support for the use of Web components such as HTML5 code or JavaScript scripts
- Contains graphic UI components for creating graphical interfaces and manage their appearance through CSS files
- Provides support for interactive 3D graphics
- Provides support for handling multimedia content
- Supports RIAs (Rich Internet Application)
- Portability: desktop, browser, mobile, TV, game consoles, Blu-ray, etc.
- Ensures interoperability to Swing

What is JavaFX ?

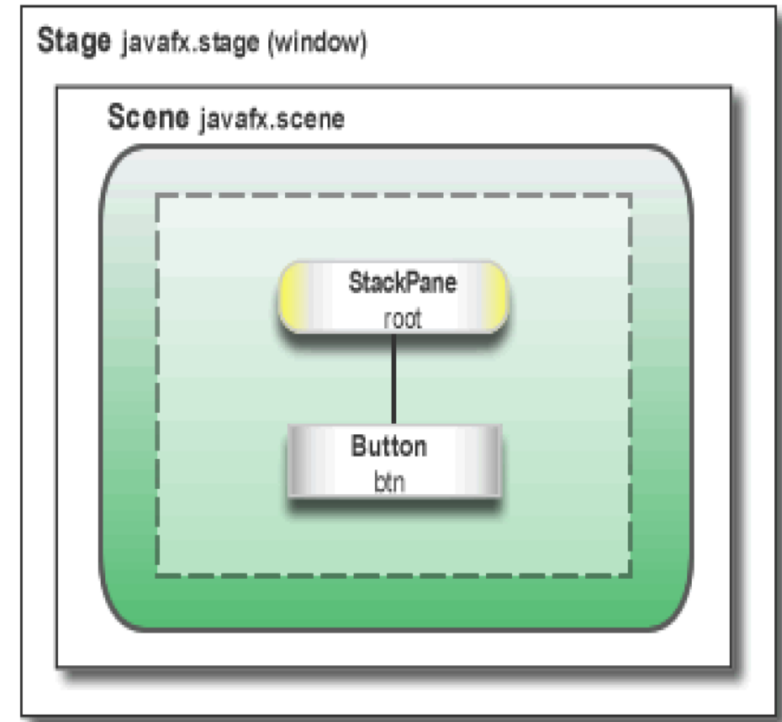
- Java 8 JavaFX is bundled with the Java platform, so JavaFX is available everywhere Java is
- From Java 8 you can also create standalone install packages for Windows, Mac and Linux with Java, which includes the JRE needed to run them. This means that you can distribute JavaFX applications to these platforms even if the platform does not have Java installed already

JavaFX vs. Swing

- JavaFX is intended to replace Swing as the default GUI toolkit in Java.
- JavaFX is more consistent in its design than Swing, and has more features:
  - It is more modern too, enabling you to design GUI using layout files (XML) and style them with CSS, just like we are used to with web applications.
  - JavaFX also integrates 2D + 3D graphics, charts, audio, video, and embedded web applications into one coherent GUI toolkit.

JavaFX APIs -Scene Graph

scene-graph-based programming model

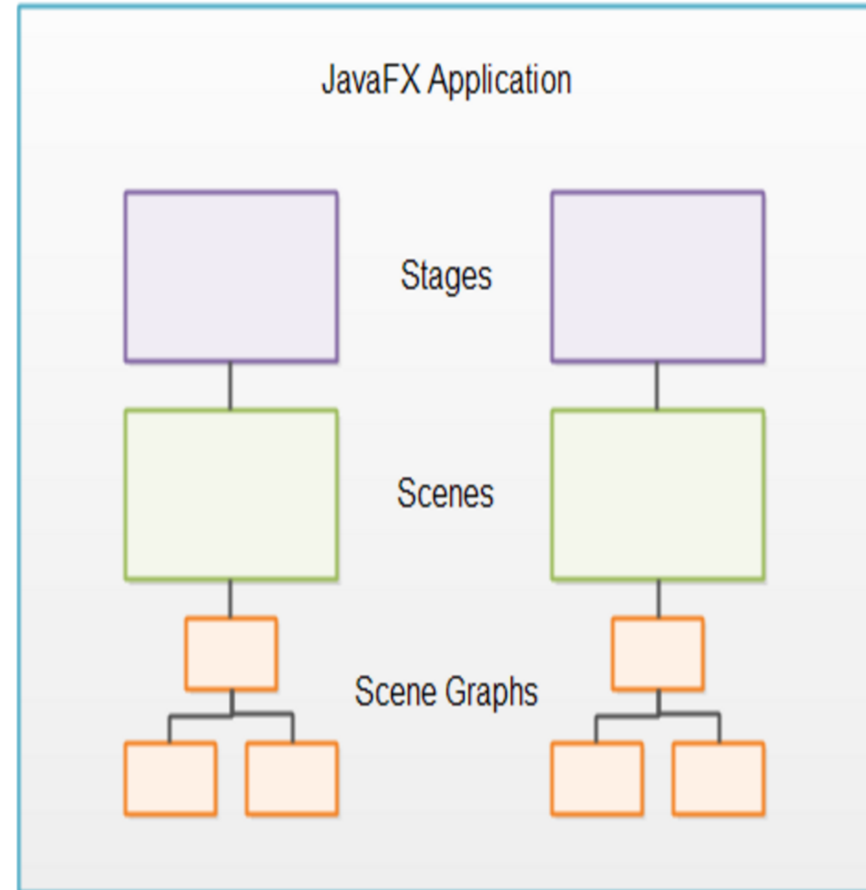


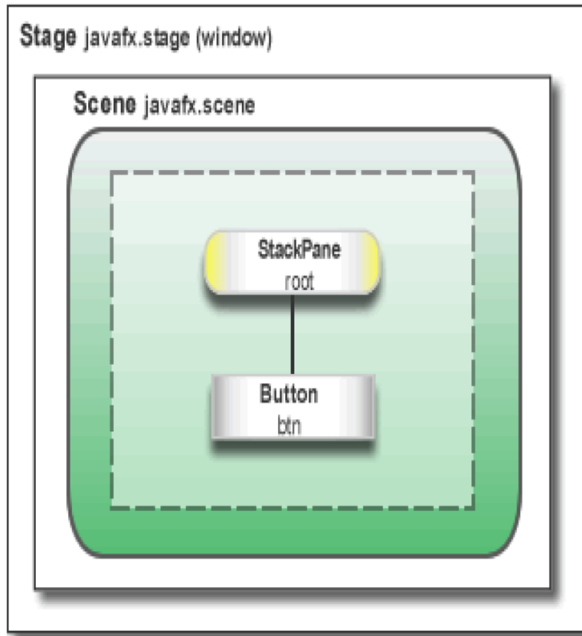
A JavaFX application contains:

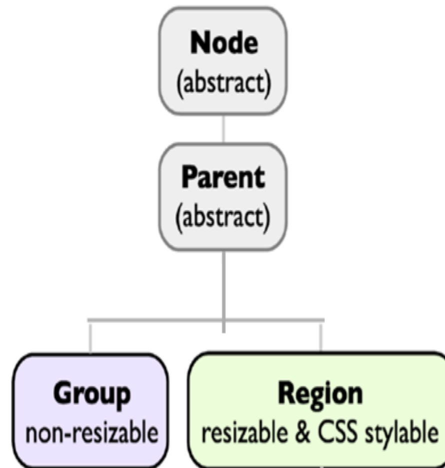
- An object **Stage (window)**
- One or more objects **Scene**

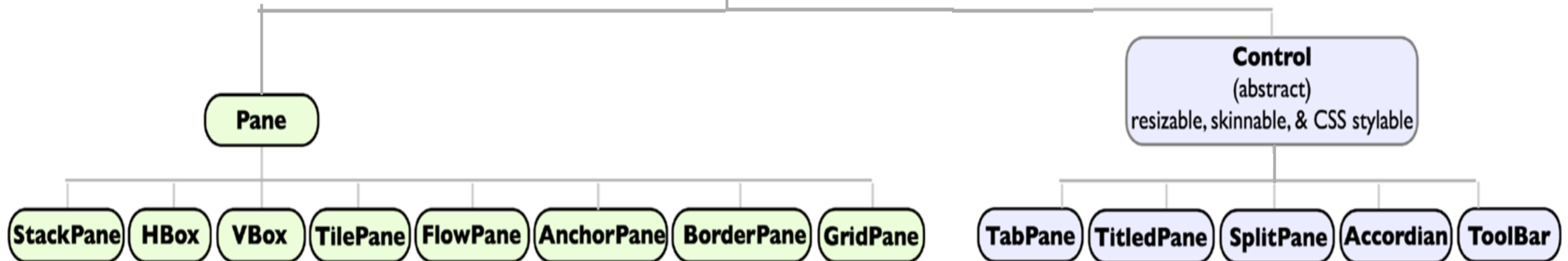
- A Scene Graph is a tree of graphical user interface components.
- A scene graph element is a node.
- Each node has an ID, a class style, a bounding volume, etc.
- Except the root node, each node has a single parent and 0 or more children.
- A node can be associated with various properties (effects (blur, shadow), opacity, transformations) and events (event handlers (Mouse, Keyboard))
- Nodes can be internal (Parent) or leaf

Scene Graph









JavaFX Applications

- A JavaFX application is an instance of class **Application**

```
public abstract class Application extends Object;
```

- Creation of a new object of class Application is done by executing the static method ***launch()*** from the class ***Application***:

```
public static void launch(String... args);
```

  - `args` **aplication parameters**(parameters of the method *main*).

- JavaFX runtime executes the following steps:

  1. Create a new object Application
  2. Call the method init of the new object Application
  3. Call the method start of the new object Application
  4. Wait for the application to terminate

Application parameters can be obtained by calling the method *getParameters*()

Example 1 Group

```
public class Main extends Application {

    @Override
    public void start(Stage stage) {
        Group root = new Group();
        Scene scene = new Scene(root, 500, 500, Color.PINK);
        stage.setTitle("Welcome to JavaFX!");

        stage.setScene(scene);
        stage.show();
    }

    public static void main(String[] args) {
        launch(args); //an object Application is created
    }
}
```

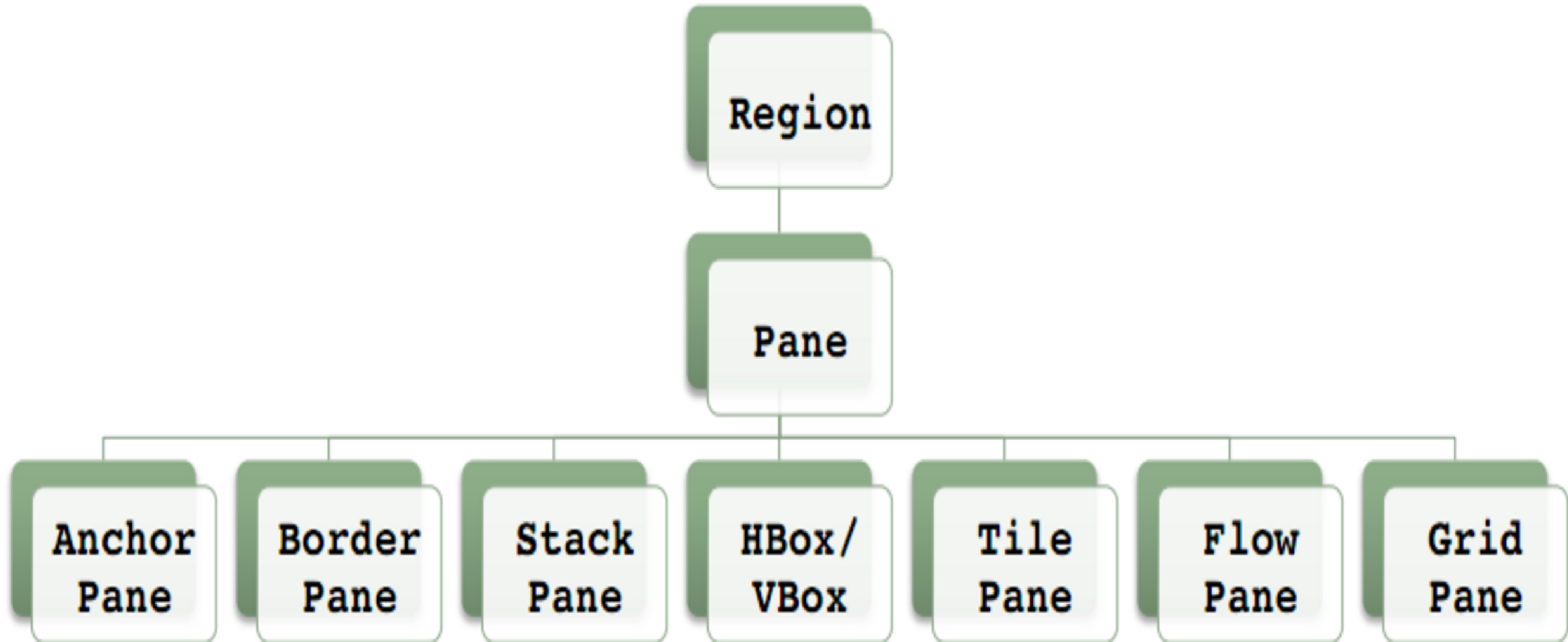
Adding nodes

```
// A node of type Group is created
Group group = new Group();


// A node of type Rectangle is created
Rectangle r = new Rectangle(25,25,50,50);
r.setFill(Color.BLUE);
group.getChildren().add(r);

// A node of type Circle is created
Circle c = new Circle(200,200,50, Color.web("blue", 0.5f));
group.getChildren().add(c);
```

Layout management

- layouts are components which contains other components inside them and manage the nested components

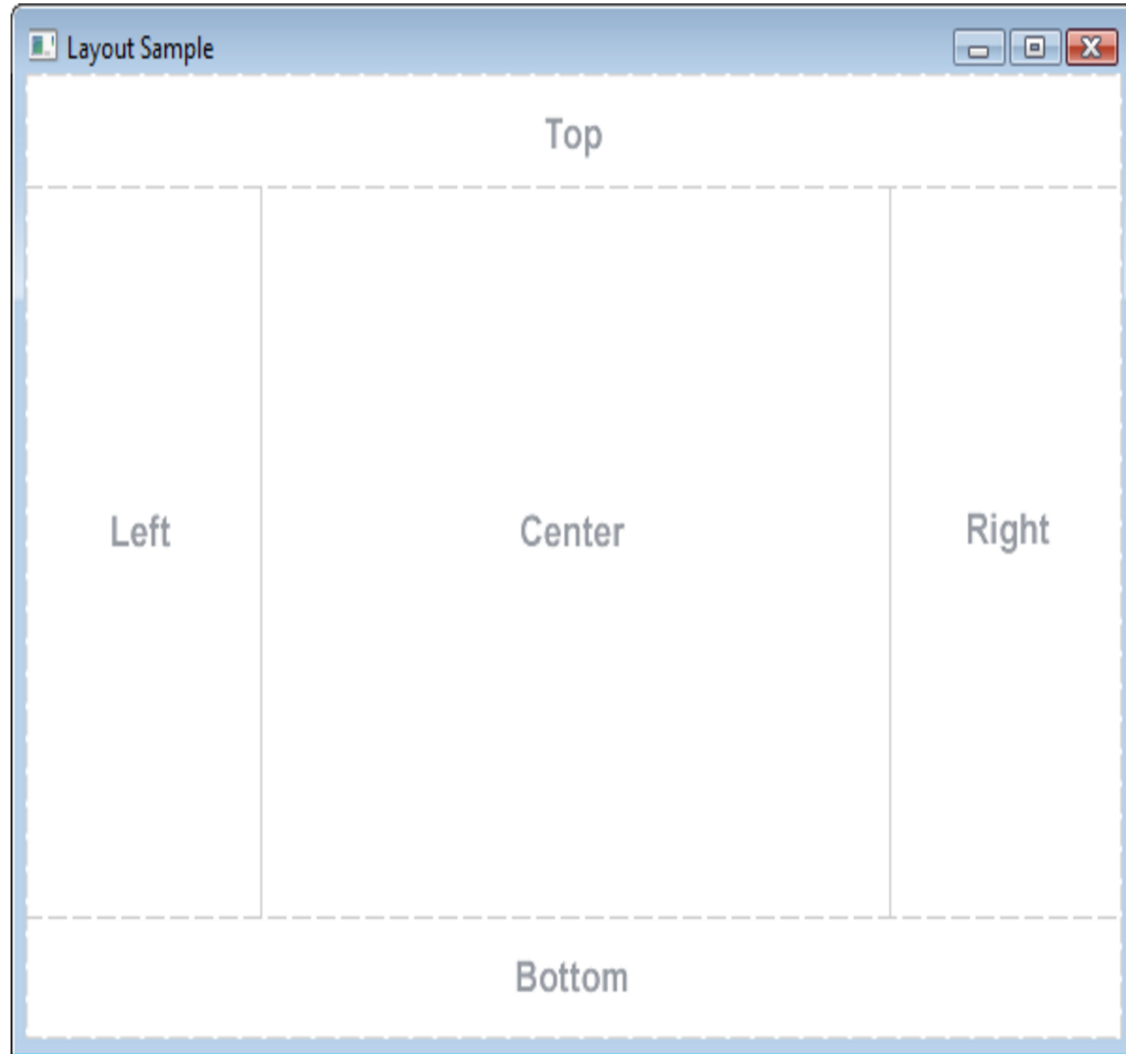
Example: Pane containers



Layout Management

BorderPane

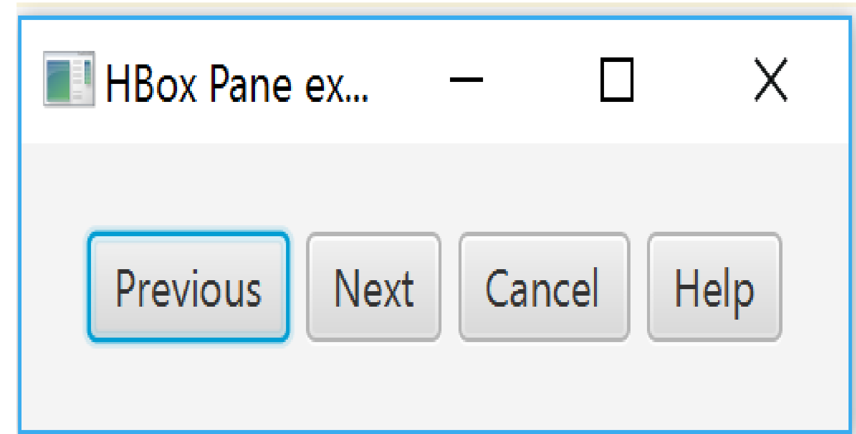
Example
Ex_BorderPane



Layout Management

HBOX (Ex_Hbox example)

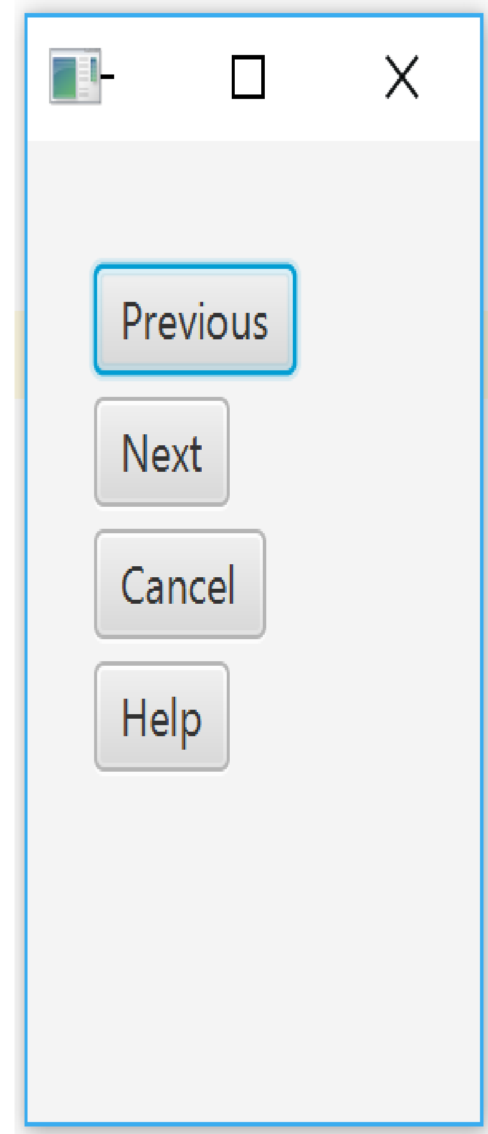
```
HBox root = new HBox(5);
root.setPadding(new Insets(100));
root.setAlignment(Pos.BASELINE_RIGHT);

Button prevBtn = new Button("Previous");
Button nextBtn = new Button("Next");
Button cancBtn = new Button("Cancel");
Button helpBtn = new Button("Help");

root.getChildren().addAll(prevBtn,
nextBtn, cancBtn, helpBtn);
```



Layout Management

VBOX-- Ex_VBox example

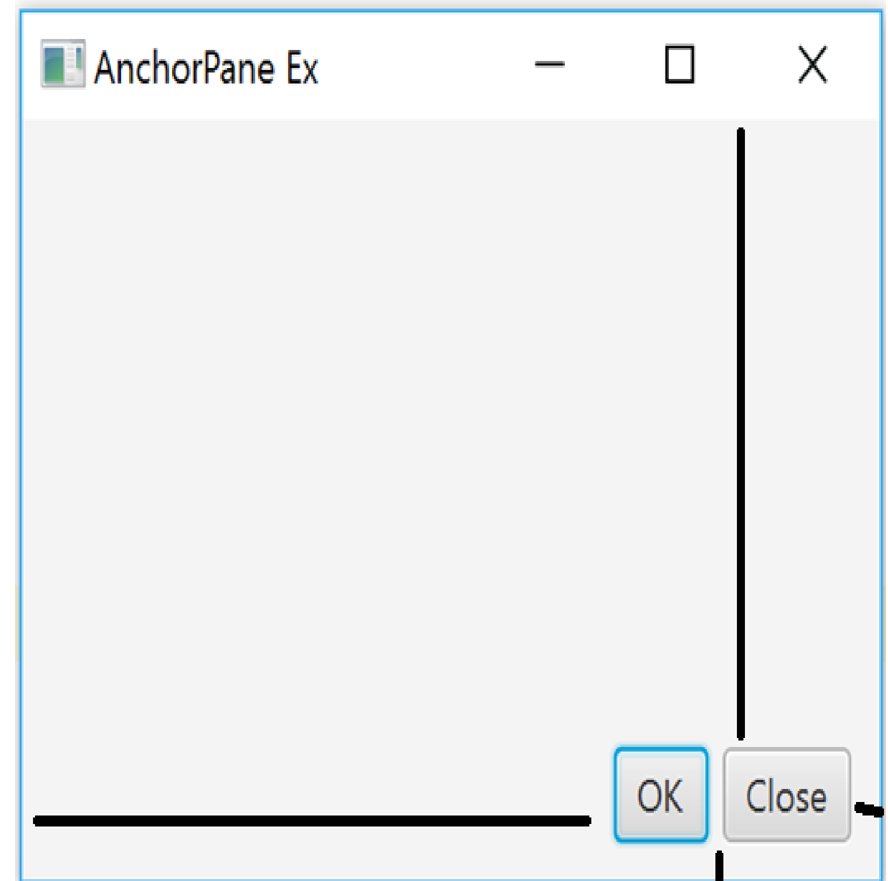
```
VBox root = new VBox(5);
root.setPadding(new Insets(20));
root.setAlignment(Pos.BASELINE_LEFT);

Button prevBtn = new Button("Previous");
Button nextBtn = new Button("Next");
Button cancBtn = new Button("Cancel");
Button helpBtn = new Button("Help");

root.getChildren().addAll(prevBtn,
nextBtn, cancBtn, helpBtn);
Scene scene = new Scene(root, 150, 200);
```



Layout Management

AnchorPane-- Ex_AnchorPane example

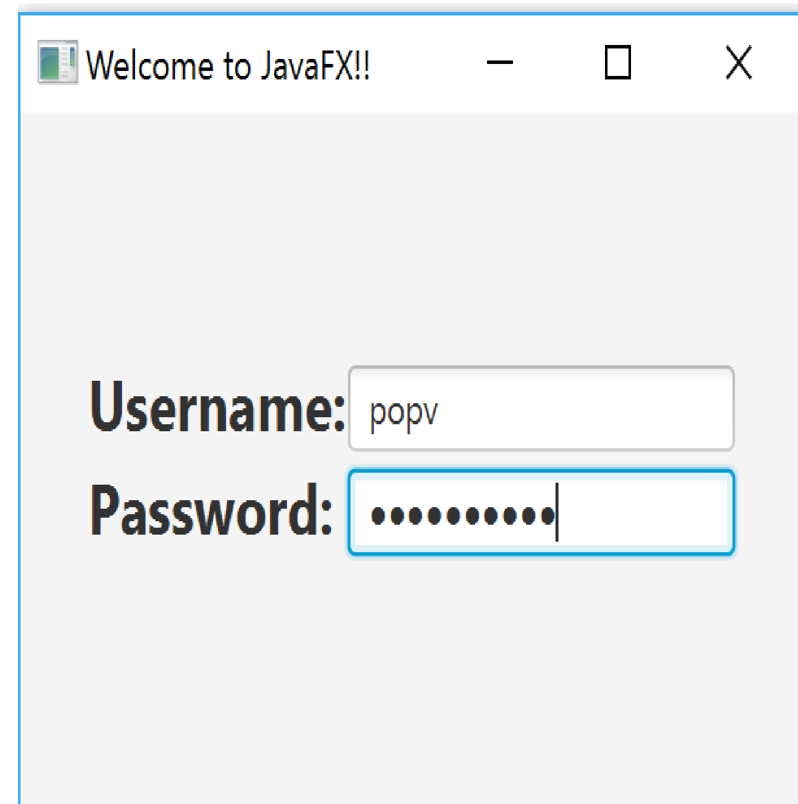
```
AnchorPane root = new AnchorPane();

Button okBtn = new Button("OK");
Button closeBtn = new
Button("Close");
HBox hbox = new HBox(5, okBtn,
closeBtn);

root.getChildren().addAll(hbox);

AnchorPane.setRightAnchor(hbox, 10d);
AnchorPane.setBottomAnchor(hbox,
10d);

Scene scene = new Scene(root, 300,
200);

stage.setTitle("AnchorPane Ex");
stage.setScene(scene);
stage.show();
```



Layout Management

GridPane – Ex_GridPane example

```
GridPane gr=new GridPane();
gr.setPadding(new Insets(20));
gr.setAlignment(Pos.CENTER);

gr.add(createLabel("Username:"),0
,0);
gr.add(createLabel("Password:"),0
,1);

gr.add(new TextField(),1,0);
gr.add(new PasswordField(),1,1);

Scene scene = new Scene(gr, 300,
200);
stage.setTitle("Welcome to
JavaFX!!");
stage.setScene(scene);
stage.show();
```



JavaFx Controls

- Are the main components of the GUI
- A control is a node in the scene graph
- Can be manipulated by the user
- Java FX Controls reference:

https://docs.oracle.com/javase/8/javafx/user-interface-tutorial/ui_controls.htm#JFXUI336

Button
Radio Button
Toggle Button
Checkbox
Choice Box
Text FieldLabel
Password Field
Scroll Bar
Scroll Pane

List View
Table View
Tree View
Combo Box
Separator
Slider
Progress Bar and Progress I
Hyperlink

Tooltip
HTML Editor
Titled Pane and Accordion
Menu
Color Picker
Pagination Control
File Chooser
Customization of UI Controls

Advanced Programming Methods

Lecture 11 - JavaFx(Continuation)

Note: Some of the slides and examples are taken from my colleague dr. Camelia Serban and from http://docs.oracle.com/javase/8/javase-clienttechnologies.htm

JavaFx Controls

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Button
Radio Button
Toggle Button
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Slider
Progress Bar and Progress Indicator
Hyperlink

Tooltip
HTML Editor
Titled Pane and Accordion
Menu
Color Picker
Pagination Control
File Chooser
Customization of UI Controls

Event Driven Programming

Event: Any user action generates an event:

- pressing or releasing the keyboard,
- moving the mouse,
- pressing or releasing a button mouse,
- opening or closing a window,
- performing a mouse click on a component of the interface,
- entering / leaving the mouse cursor in/out of a component area
- ...

- There are also events that are not generated by the application user.
- An event can be treated by executing a program module.

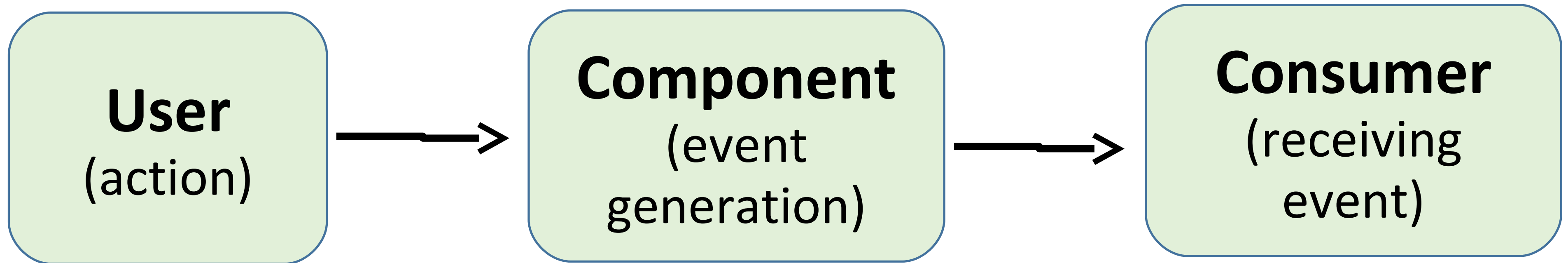
Events Handling

- **Delegation Event Model**

We can distinguish three categories of objects used to handle events:

- **Events Sources** - those objects that generate the events;
- **Events** -which are objects (generated by sources and received by consumers)
- **Events consumers or listeners** - those objects that receive and treat the events.

Events handling

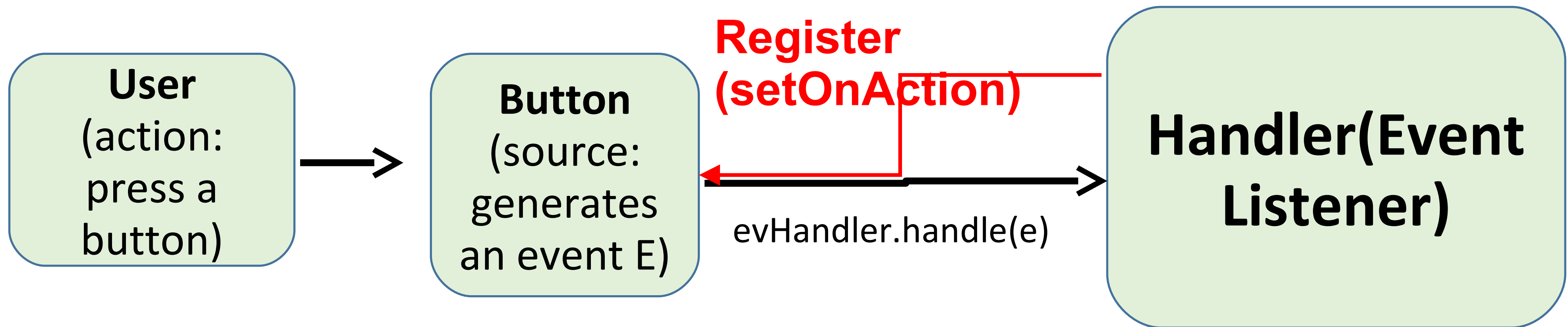


Each consumer must be registered with the event source. This process ensures that the source knows all the consumers to which must submit its generated events.

The "delegation" assumes that an event source (an object) transmits all its generated events to those consumers which were recorded at it.

A consumer receives events only from those sources to which it have been registered !!!

Events Handling



Event handler

```
@FunctionalInterface
Interface EventHandler<T extends Event> extends
EventListener{
        void   handle(T event);
}
```

Button Events (see Ex_Button_Clik_Beeper and Ex_BuutonClik)

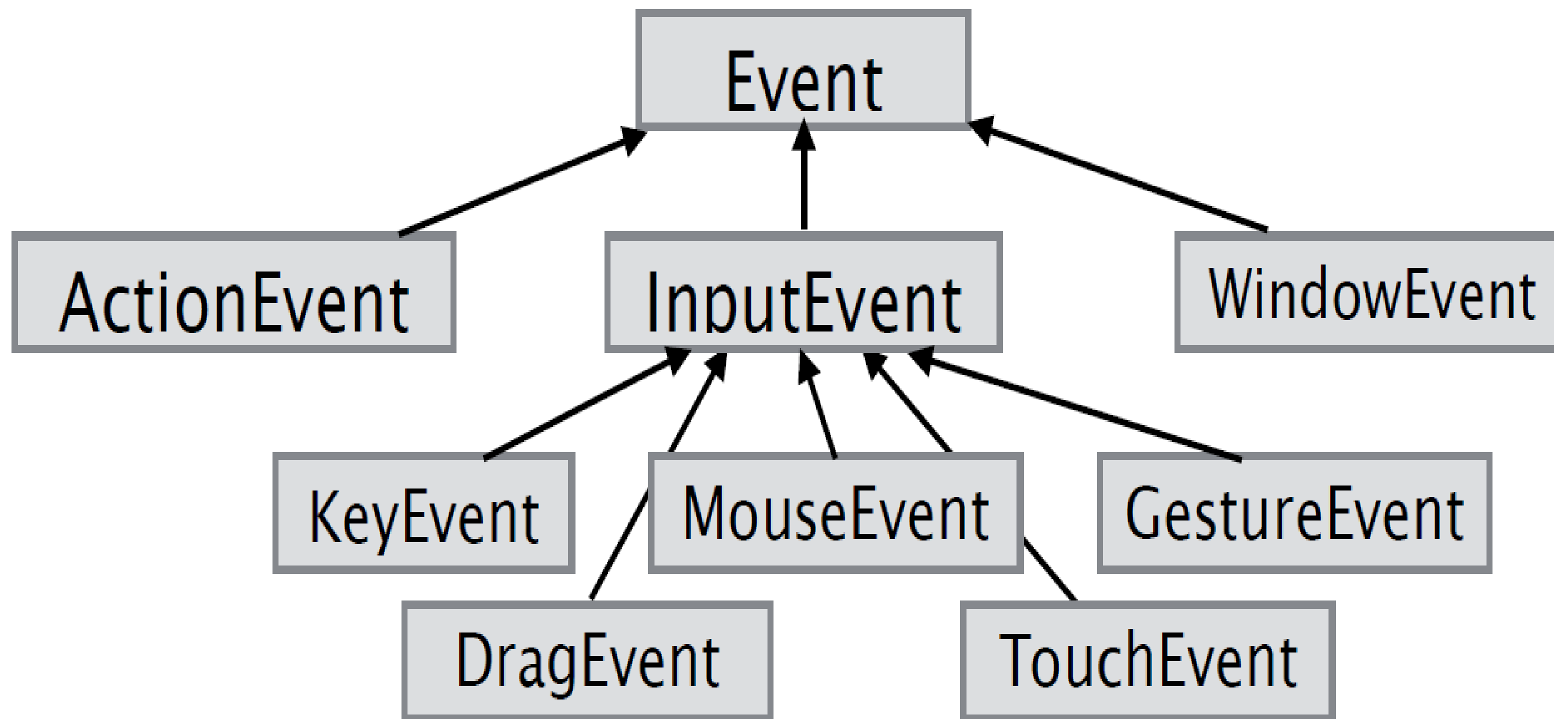
```
Button btn = new Button("Ding!");
btn.setStyle("-fx-font: 42 arial; -fx-base: #f8e7f9;");
// handle the button clicked event
btn.setOnAction(new EventHandler<ActionEvent>() {
    public void handle(ActionEvent e) {
        Toolkit.getDefaultToolkit().beep();
    }
});
```

Only one handler can be associated to the button clicked event!!!

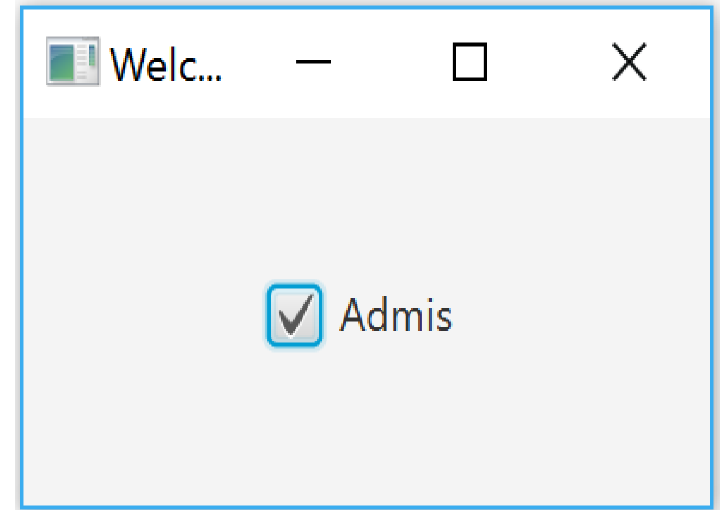
Or using lambda expressions:

```
btn.setOnAction(e->Toolkit.getDefaultToolkit().beep());
```

Types of Events



CheckBox Events – see CheckBoxEv




```
CheckBox myCheckBox=new CheckBox("Admis ");
StackPane st=new StackPane(myCheckBox);

// Handle CheckBox event.
myCheckBox.setOnAction((event) -> {
    boolean selected = myCheckBox.isSelected();
    System.out.println("A fost selectat admis ");
});
```

ObservableValue<T>

- Generic interface **ObservableValue<T>** is used to wrap different values type and to provide a mechanism to observe the values changes through notifications

public interface ObservableValue<T>extends Observable;

- Methods:

```
T getValue(); //get the wrapped value
```

// adding/removing a ChangeListener (which is notified when the value changes)

```
void addListener(ChangeListener<? super T> listener);

void removeListener(ChangeListener<? super T> listener);
```

Property<T>

- A generic interface that defines the methods common to all properties independent of their type.
- It implements ObservableValue<T>
- JavaFX property binding allows you to synchronize the value of two properties so that whenever one of the properties changes, the value of the other property is updated automatically.
  - Unidirectional binding
  - Bidirectional binding
- Examples of implementations:

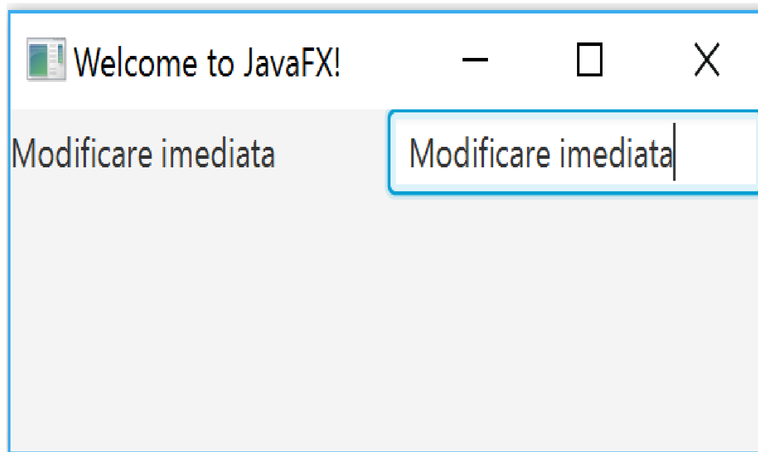
```
public class SimpleStringProperty extends StringPropertyBase;

public class SimpleObjectProperty<T> extends ObjectPropertyBase<T>;

public class SimpleDoubleProperty extends DoublePropertyBase;
```

Property - Observable -listener see Ex_Property

```
BooleanProperty booleanProperty = new SimpleBooleanProperty(true);
// Add change listener
booleanProperty.addListener(new ChangeListener<Boolean>() {
    @Override
    public void changed(ObservableValue<? extends Boolean> observable,
              Boolean oldValue, Boolean newValue) {
        System.out.println("changed " + oldValue + "->" + newValue);
        //myFunc();
    }
});
Button btn = new Button();
btn.setText("Switch boolean flag");
btn.setOnAction(new EventHandler<ActionEvent>() {
    @Override
    public void handle(ActionEvent event) {
        booleanProperty.set(!booleanProperty.get()); //switch
        System.out.println("Switch to " + booleanProperty.get());
    }
});

// Bind to another property variable
btn.underlineProperty().bind(booleanProperty); //button text is underlined
according to the booleanProperty value
```

TextField- ChangeListener see Ex_TextField

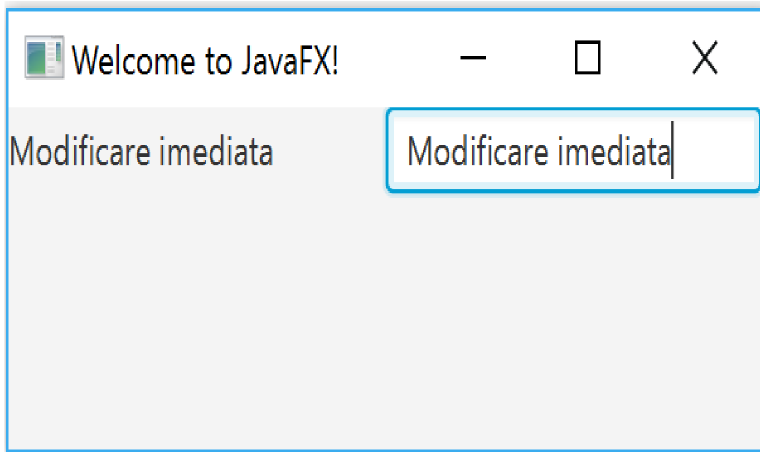
```
Label l=new Label("search item ...");
l.setPrefWidth(150);
TextField txt=new TextField();
gr.add(l,0,0);
gr.add(txt,1,0);

txt.textProperty().addListener(new ChangeListener<String>() {
    @Override
    public void changed(ObservableValue<? extends String> observable,
String oldValue,      String newValue) { l.setText(newValue);
    }
});
```



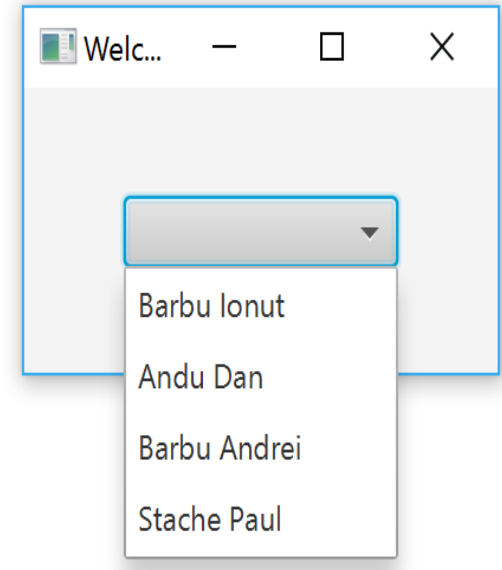
```java
//the same effect using key event handler
txt.setOnKeyPressed(new EventHandler<KeyEvent>() {
    @Override
    public void handle(KeyEvent event) {
        l.setText(txt.getText());
    }
});
```

Or

```java
//the same effect using the properties binding
l.textProperty().bindBidirectional(txt.textProperty());
l.setText("third approach");
```



ComboBox Events



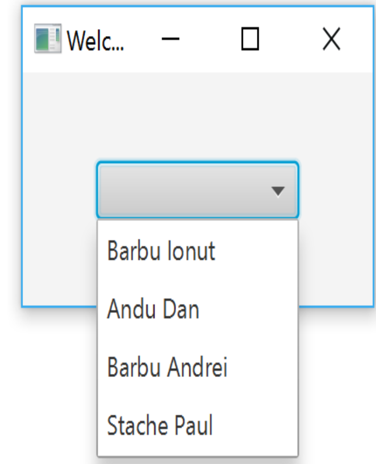
- **Initializing the ComboBox**

```
ComboBox<Student> comboBox=new ComboBox<Student>();
ObservableList<Student> s=getStudList();
comboBox.setItems(s);
```

- **ComboBox Rendering**

```
comboBox.setCellFactory(new Callback<ListView<Student>, ListCell<Student>>() {
    @Override
    public ListCell<Student> call(ListView<Student> param) {
        return new ListCell<Student>(){
            @Override
            protected void updateItem(Student item, boolean empty) {
                super.updateItem(item, empty);

                if (item == null || empty) {
                    setText(null);
                } else {
                    setText(item.getFirstName() + " " + item.getLastName());
                }
            }
        };
    }
});
```

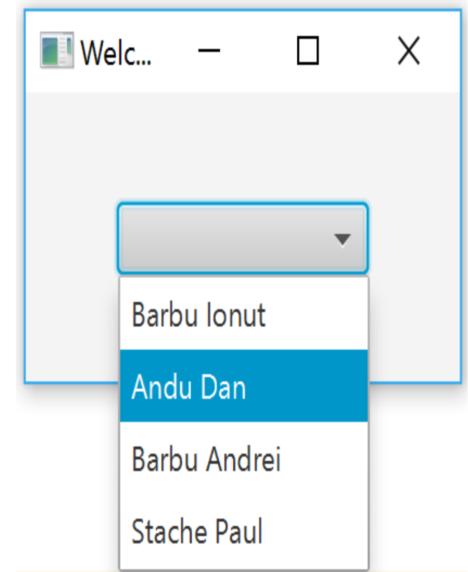
ComboBox Events



- **ComboBox Rendering - lambda**

```
comboBox.setCellFactory(combo-> {
            return new ListCell<Student>() {

                @Override
                protected void updateItem(Student item, boolean empty) {
                    super.updateItem(item, empty);

                    if (item == null || empty) {
                        setText(null);
                    } else {
                        setText(item.getFirstName() + " " + item.getLastName());
                    }
                }
            };
        }
);
```

ComboBox Events



Handling Selection Events

```
//handle selection event
comboBox.setOnAction(ev->{
    Student as=comboBox.getSelectionModel().getSelectedItem();
    System.out.println(as.toString());
});


//listen to selectedItemProperty changes
comboBox.getSelectionModel().selectedItemProperty().addListener(new
ChangeListener<Student>() {
    @Override
    public void changed(ObservableValue<? extends Student>
observable, Student oldValue, Student newValue) {
        System.out.println(newValue.toString());
    }
});
```

ListView events

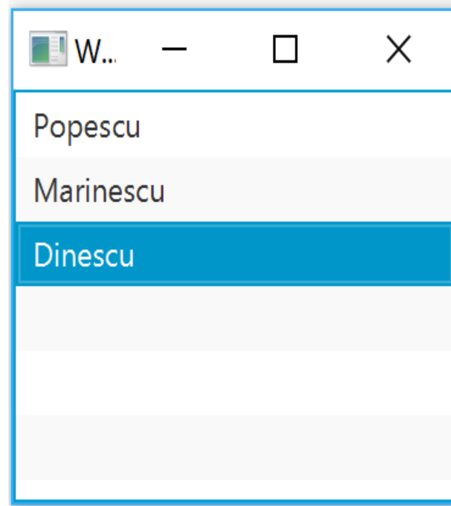
As Combobox, ListView has no ActionEvent, but has selectedItemProperty

```
myListView.getSelectionModel().selectedItemProperty().addList
ener((observable, oldValue, newValue) -> {
       System.out.println("ListView Selection Changed 
(selected: " + newValue.toString() + ")");
});
```

ListView- creation

- An Approach:

```
ListView<String>lview=new ListView<>(FXCollections.observableArrayList());
lview.getItems().addAll("Popescu","Marinescu","Dinescu");
```



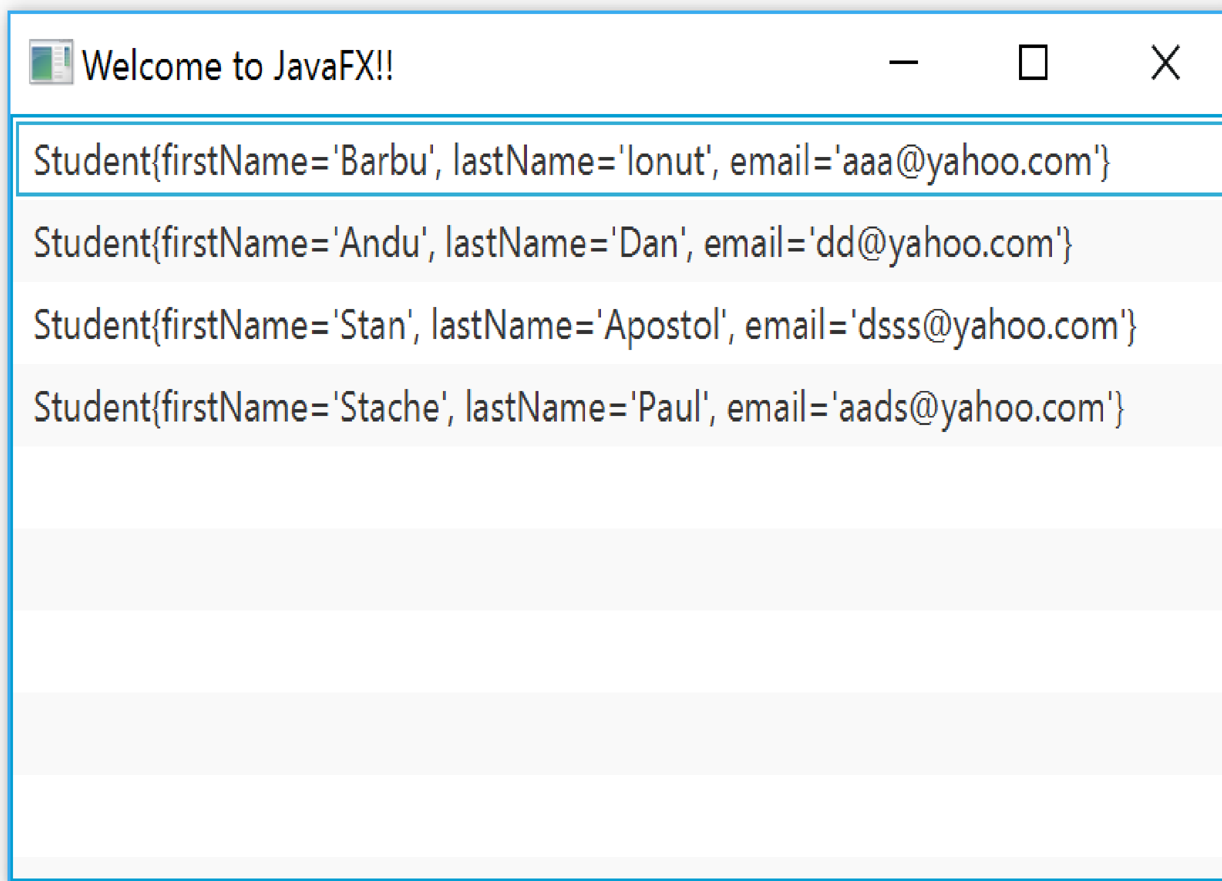
- Another approach:

```
List<String> l=Arrays.asList("Popescu", "Marinescu", "Dinescu"));
ObservableList<String> observableList=FXCollections.observableArrayList(l);
lview.setItems(observableList);
```

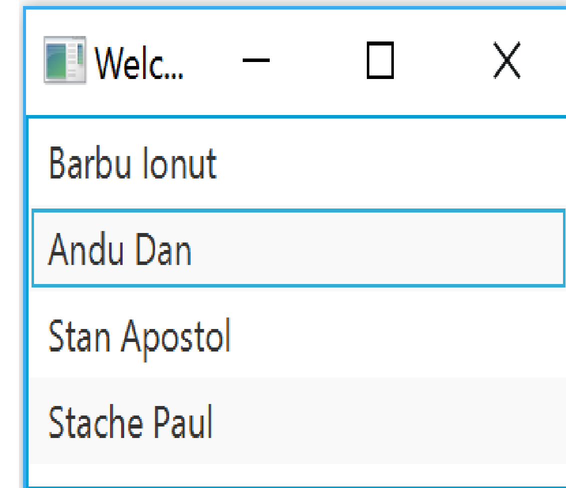
ListView for a custom object

How to display a student?

```
ListView<Student> listView=new ListView<>(students);
```



ListView for a custom object

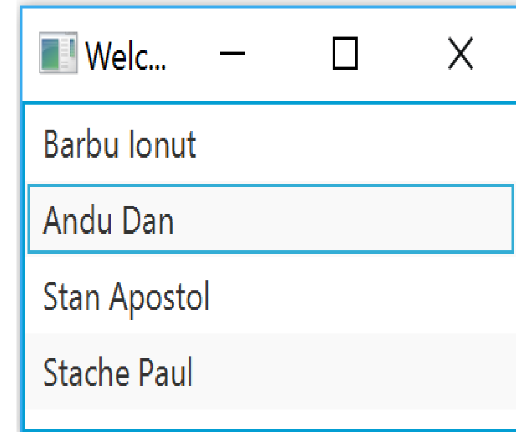


cellFactory method

```
ListView<Student> listView=new ListView<>(students);
```

```
//cellFactory method
listView.setCellFactory(new Callback<ListView<Student>, ListCell<Student>>()
{
    @Override
    public ListCell<Student> call(ListView<Student> param) {
        ListCell<Student> listCell=new ListCell<Student>(){
                // how to update text in this cell?
        };
        return listCell;
    }
});
```

ListView for a custom object



cellFactory method

```
ListView<Student> listView=new ListView<>(students);
```

Override updateItem() method from ListCell

```
listView.setCellFactory(new Callback<ListView<Student>, ListCell<Student>>()
{
    @Override
    public ListCell<Student> call(ListView<Student> param) {
        ListCell<Student> listCell=new ListCell<Student>() {
            // how to update text in this cell
            @Override
            protected void updateItem(Student s, boolean empty) {
                    super.updateItem(s, empty);
                    if (s!=null)
                        setText(s.getFirstName()+" "+s.getLastName());
            }
        };
        return listCell;
    }
});
```

ListView for a custom object

Obs:

1. Each ListCell belongs to one and only one ListView
2. the parameter **param** is not used in the current example, but it can be accessed

```
listView.setCellFactory(new Callback<ListView<Student>, ListCell<Student>>() {
    @Override
    public ListCell<Student> call(ListView<Student> param) {
        ListCell<Student> listCell=new ListCell<Student>() {
            @Override
            protected void updateItem(Student s, boolean empty) {
                {
                    super.updateItem(s, empty);
                    //this is asscoiated to a ListView
                    System.out.println(this.getListView().getItems());
                    if (s!=null)
                        setText(s.getFirstName()+" "+s.getLastName());
                }
            }
        };
        //listCell has not yet an associated listView
        System.out.println(listCell.getListView());  //it displays null
        System.out.println(param.getItems().toString());
        return listCell;
    }
});
```

https://docs.oracle.com/javase/8/javafx/api/javafx/scene/control/ListCell.html

ListView adding new value

```
private ObservableList<Student> studs= FXCollections.observableArrayList();
ListView<Student> list=new ListView<>();
list.setItems(studs);

….

studs.add(new Student("45","andrei","nistor","gdhgh"));
```

ListView selection

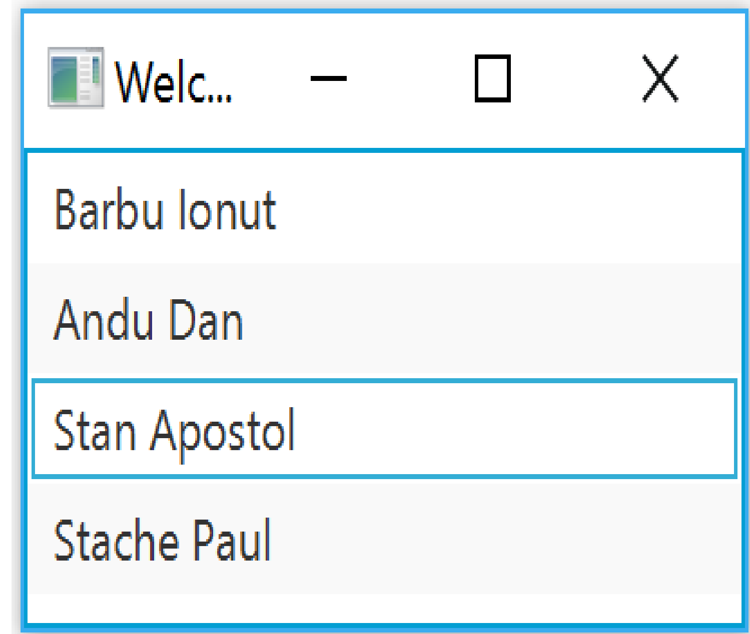
```
//selected item
Student s=listView.getSelectionModel().getSelectedItem();
```

```
listView.getSelectionModel().selectedItemProperty().addListener(
  new ChangeListener<Student>() {
      @Override
      public void changed(ObservableValue<? extends Student> observable, Student
oldValue, Student newValue) {
        System.out.println(newValue.toString());
      }
  }
);
```

ListView set focus

```
ListView<Student> listView=new ListView<>(students);
```

```
listView.getFocusModel().focus(2);
```

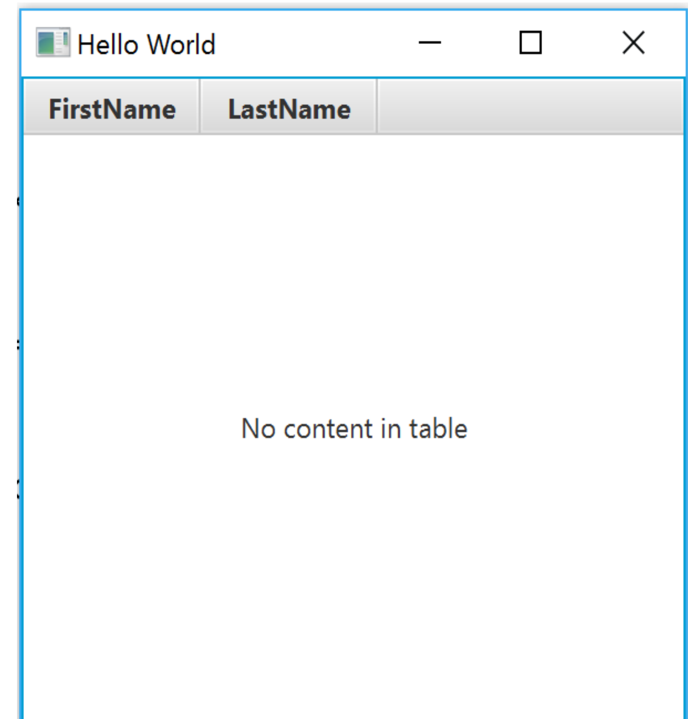


TableView Events

– see GUI.Main from examples_part1

TableView Creation

```
TableView<Student> tableView=new TableView<Student>();

TableColumn<Student,String> columnName=new TableColumn<>("FirstName");
TableColumn<Student,String> columnLastName=new TableColumn<>("LastName");


tableView.getColumns().addAll(columnName,columnLastName);
```



TableView Defining the Data Model

```
List<Student> l=new ArrayList<Student>();
l.add(new Student("Barbu","Ionut","aaa@yahoo.com"));
l.add(new Student("Andu","Dan","dd@yahoo.com"));
l.add(new Student("Stan","Apostol","dsss@yahoo.com"));
l.add(new Student("Stache","Paul","aads@yahoo.com"));

ObservableList<Student> students = FXCollections.observableArrayList(l);

TableView<Student> tableView=new TableView<Student>();

TableColumn<Student,String> columnName=new TableColumn<>("FirstName");
TableColumn<Student,String> columnLastName=new TableColumn<>("LastName");
tableView.getColumns().addAll(columnName,columnLastName);

tableView.setItems(students);
```

Hello World

FirstName	LastName	

TableView setCellValueFactory method

- to specify how to populate all cells within a single TableColumn

```
columnName.setCellValueFactory(new Callback<TableColumn.CellDataFeatures<Student, String>,
ObservableValue<String>>() {
    @Override
    public ObservableValue<String> call(TableColumn.CellDataFeatures<Student, String> param) {
        return new SimpleStringProperty(param.getValue().getFirstName());
    }
});
```

```
columnLastName.setCellValueFactory(new PropertyValueFactory<Student, String>("lastName"));
```

- the "lastName" string is used as a reference to an assumed lastNameProperty() method in the Student class type
- If no method matching above pattern exists, there is fall-through support for attempting to call get<property>() or is<property>() (that is, getLastName() or isLastName() in the example above).

```
public class PropertyValueFactory<S,T> implements Callback<CellDataFeatures<S,T>, ObservableValue<T>>
{..}
```

TableView setCellFactory method

- is responsible for rendering the data contained within each TableCell for a single table column.

```
t1.setCellFactory(column->{
    TableCell cell=new TableCell<Student, String>(){
        public void updateItem(String item, boolean empty) {
            //System.out.println(item);
            super.updateItem(item, empty);
            setText(item);
        }
    };
    cell.setFont(new Font(23));
    cell.setAlignment(Pos.CENTER);
    return cell;
});
```

TableView listening for table selection changes

```
tableView.getSelectionModel().selectedItemProperty().addListener(
 new ChangeListener<Student>() {
    @Override
    public void changed(ObservableValue<? extends Student> observable, Student oldValue,
Student newValue) {
        System.out.println("A fost selectat"+ newValue.toString());
    }
 }
);
```

```
DEMO:
  See GUI.Main from examples_part1
  See example from examples_part2
```

XML

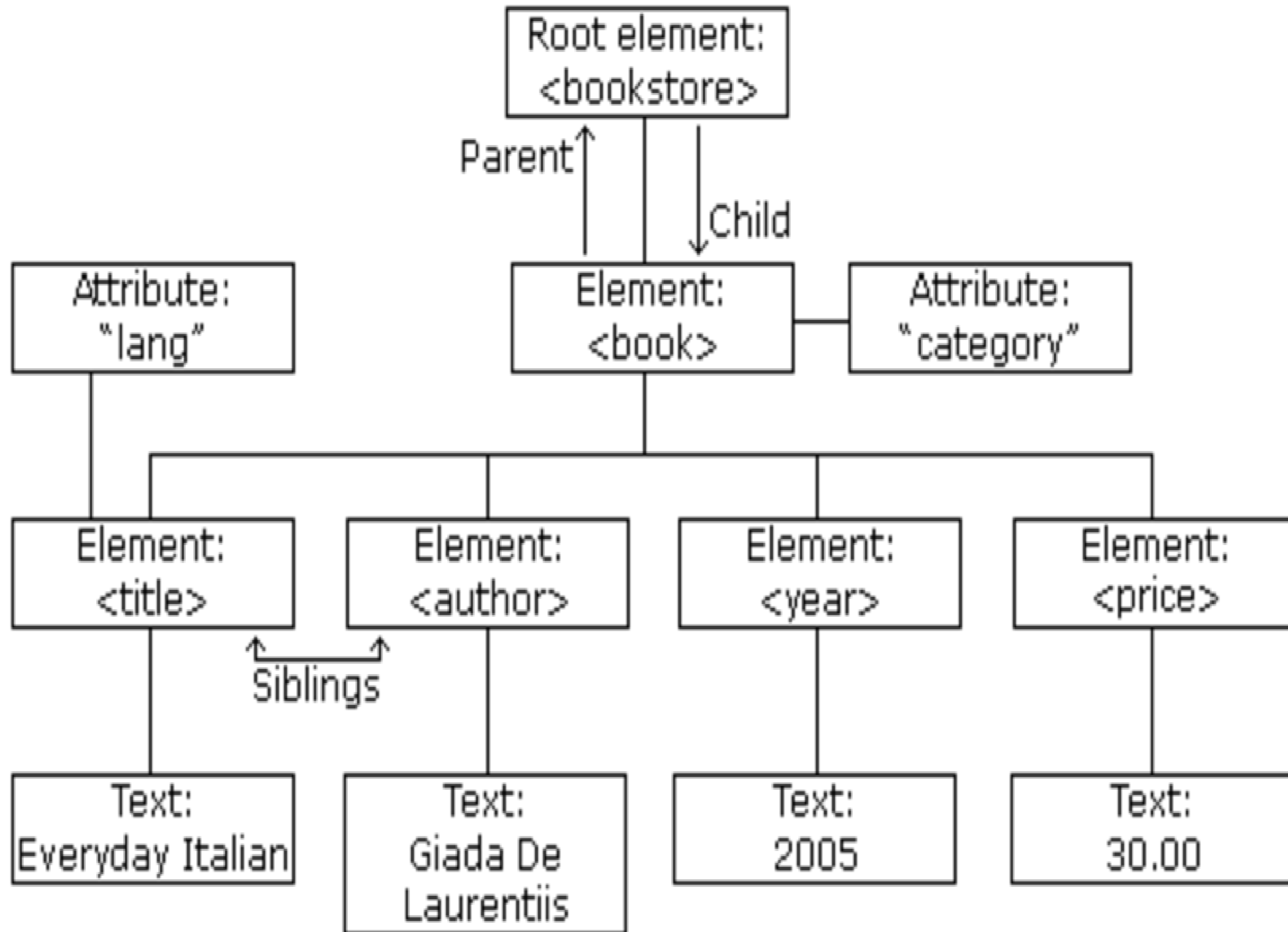
XML stands for EXtensible Markup Language.

XML was designed to store and transport data.

XML was designed to be self-descriptive- human- and machine-readable.

```
<note>
  <to>Tove</to>
  <from>Jani</from>
  <heading>Reminder</heading>
  <body>Don't forget!</body>
</note>
```

XML Tree Structure



Example

```xml
<?xml version="1.0" encoding="UTF-8"?>
<bookstore>
  <book category="cooking">
    <title lang="en">Everyday Italian</title>
    <author>Giada De Laurentiis</author>
    <year>2005</year>
    <price>30.00</price>
  </book>
  <book category="children">
    <title lang="en">Harry Potter</title>
    <author>J K. Rowling</author>
    <year>2005</year>
    <price>29.99</price>
  </book>
  <book category="web">
    <title lang="en">Learning XML</title>
    <author>Erik T. Ray</author>
    <year>2003</year>
    <price>39.95</price>
  </book>
</bookstore>
```

FXML

FXML = is a scriptable, XML-based markup language for constructing Java object graphs

- **declarative approach** (versus programmatic)
- Tree of components
- Role separation
- Language independent (Java, Scala, Clojure, etc.)
- Support for internationalization

FXML

From a Model View Controller (MVC) perspective:

- the FXML file that contains the description of the user interface is the view.
- The controller is a Java class, optionally implementing the Initializable class, which is declared as the controller for the FXML file.
- The model consists of domain objects, defined on the Java side, that you connect to the view through the controller.

FXML

- does not have a schema, but it does have a basic predefined structure.
- maps directly to Java
- most JavaFX classes can be used as elements
- most properties can be used as attributes

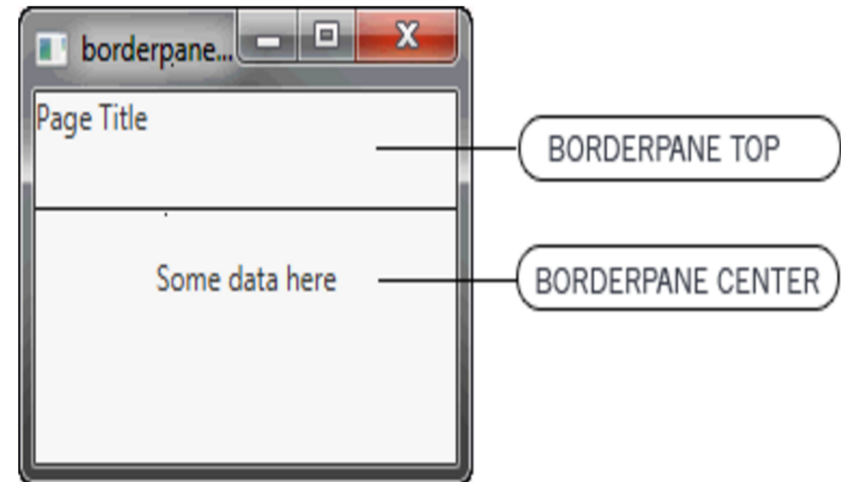
Programmatic vs. Declarative

Programmatic

```
BorderPane border = new BorderPane();
Label top = new Label("Page Title");
border.setTop(top);
Label center = new Label ("Some data here");
border.setCenter(center);
```

Declarative

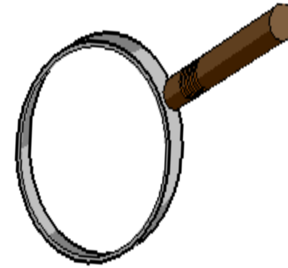
```
<BorderPane>
    <top>
        <Label text="Page Title"/>
    </top>
    <center>
        <Label text="Some data here"/>
    </center>
</BorderPane>
```



FXML structure

```
<?xml version="1.0" encoding="UTF-8"?>
<?import javafx.geometry.Insets?>
<?import javafx.scene.control.Button?>
<?import javafx.scene.control.Label?>
<?import javafx.scene.control.TextField?>
<?import javafx.scene.layout.AnchorPane?>
<?import javafx.scene.layout.ColumnConstraints?>
<?import javafx.scene.layout.GridPane?>
<?import javafx.scene.layout.RowConstraints?>

<AnchorPane xmlns="http://javafx.com/javafx/8.0.60" xmlns:fx="http://javafx.com/fxml/1">
   <children>
      <GridPane hgap="5.0" vgap="5.0">
        <columnConstraints>
          <ColumnConstraints hgrow="SOMETIMES" minWidth="10.0" prefWidth="100.0" />
          <ColumnConstraints hgrow="SOMETIMES" minWidth="10.0" prefWidth="100.0" />
        </columnConstraints>
        <rowConstraints>
          <RowConstraints minHeight="10.0" prefHeight="30.0" vgrow="SOMETIMES" />
          <RowConstraints minHeight="10.0" prefHeight="30.0" vgrow="SOMETIMES" />
          <RowConstraints minHeight="10.0" prefHeight="30.0" vgrow="SOMETIMES" />
        </rowConstraints>
         <children>
            <Button mnemonicParsing="false" prefHeight="25.0" prefWidth="99.0" text="Login"
GridPane.rowIndex="2" />
            <Label prefHeight="30.0" prefWidth="98.0" text="Username" />
            <Label prefHeight="40.0" prefWidth="100.0" text="Password" GridPane.rowIndex="1" />
            <TextField GridPane.columnIndex="1" />
            <TextField prefHeight="31.0" prefWidth="100.0" GridPane.columnIndex="1" GridPane.rowIndex="1" />
         </children>
         <padding>
            <Insets bottom="5.0" left="5.0" right="5.0" top="5.0" />
         </padding>
      </GridPane>
   </children>
</AnchorPane>
```

FXML structure



```
<?xml version="1.0" encoding="UTF-8"?>
<AnchorPane>
   <children>
      <GridPane hgap="5.0" vgap="5.0">
        <columnConstraints> </columnConstraints>
        <rowConstraints></rowConstraints>
         <children>
            <Button text="Login" GridPane.rowIndex="2" GridPane.columnIndex=
"0" />
            <Label text="Username"  GridPane.rowIndex="0"
GridPane.columnIndex= "0" />
            <Label text="Password" GridPane.rowIndex="1"GridPane.columnIndex=
"0" />
            <TextField GridPane.columnIndex="1" GridPane.rowIndex="0" />
            <TextField GridPane.columnIndex="1" GridPane.rowIndex="1" />
         </children>
         <padding>
            <Insets bottom="5.0" left="5.0" right="5.0" top="5.0" />
         </padding>
      </GridPane>
   </children>
</AnchorPane>
```

FXML Loader

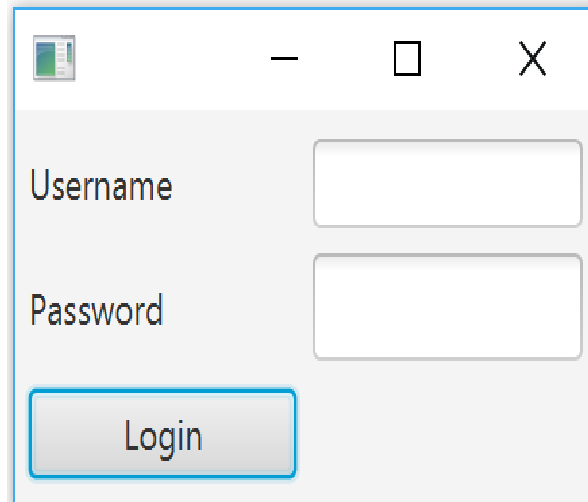
```
public class Main extends Application {
    public static void main(String[] args) {
        launch(args);
    }
    @Override
    public void start(Stage primaryStage) {
        try {
            //Load root layout from fxml file.
            FXMLLoader loader=new FXMLLoader();
            // Loads an object hierarchy from an XML document.
            loader.setLocation(Main.class.getResource("View.fxml"));
            //Finds a resource  with a given name  -> URL.
            AnchorPane rootLayout= (AnchorPane) loader.load();
            // Show the scene containing the root layout.
            Scene scene = new Scene(rootLayout);
            primaryStage.setScene(scene);
            primaryStage.show();
        } catch (IOException e) {
            e.printStackTrace();
        }
    }
}
```

Example

View.fxml

```java
public class Main extends Application {
    public static void main(String[] args) {
        launch(args);
    }
    @Override
    public void start(Stage primaryStage) {
        try {
            //Load root layout from fxml file.
            FXMLLoader loader=new FXMLLoader();

loader.setLocation(Main.class.getResource("View.fxml")
); //URL
            AnchorPane rootLayout= (AnchorPane)
loader.load();

            // Show the scene containing the root
layout.
            Scene scene = new Scene(rootLayout);
            primaryStage.setScene(scene);
            primaryStage.show();

        } catch (IOException e) {
            e.printStackTrace();
        }

    }
}
```

```xml
<?xml version="1.0" encoding="UTF-8"?>
<AnchorPane>
   <children>
      <GridPane hgap="5.0" vgap="5.0">
        <columnConstraints> </columnConstraints>
        <rowConstraints></rowConstraints>
         <children>
            <Button text="Login" GridPane.rowIndex="2"
GridPane.columnIndex= "0" />
            <Label text="Username"  GridPane.rowIndex="0"
GridPane.columnIndex= "0" />
            <Label text="Password"
GridPane.rowIndex="1"GridPane.columnIndex= "0" />
            <TextField GridPane.columnIndex="1"
GridPane.rowIndex="0" />
            <TextField GridPane.columnIndex="1"
GridPane.rowIndex="1" />
         </children>
         <padding>
            <Insets bottom="5.0" left="5.0" right="5.0" top="5.0" />
         </padding>
      </GridPane>
   </children>
</AnchorPane>
```



FXML File templates

In Eclipse there are some predefined templates

In InteliJ we have to define

File and Code Templates

Files | Includes | Code | Other

Schema: Default

- Class
- Interface
- Enum
- AnnotationType
- package-info
- XML Properties File
- Gradle Build Script
- Gradle Build Script with wrapper
- Scala Class
- Scala Trait
- Scala Object
- Scala Script
- Package Object
- Scala Worksheet
- Kotlin File
- Kotlin Class
- Kotlin Enum
- Kotlin Interface
- FXML_AnchoreRoot
- JavaFXApplication
- settings
- Singleton
- XSLT Stylesheet
- FXML_BorderPane

Name: FXML_BorderPane Extension: fxml

```
<?xml version="1.0" encoding="UTF-8"?>

<?import javafx.scene.layout.BorderPane?>

<BorderPane xmlns:fx="http://javafx.com/fxml/1">
    <!-- TODO Add Nodes -->
</BorderPane>
```

☑ Reformat according to style ☐ Enable Live Templates

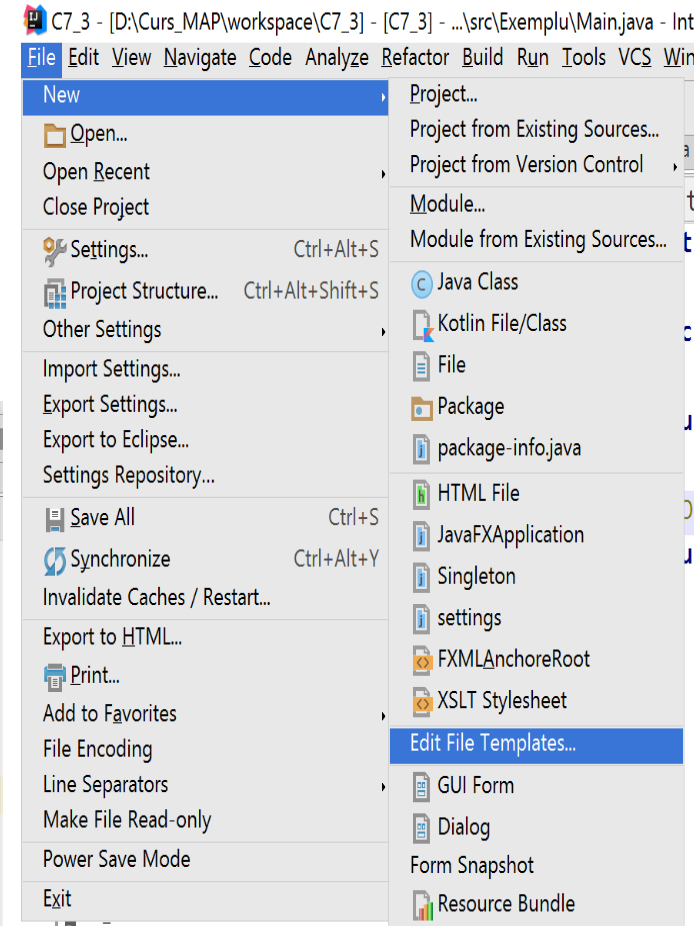
Description

Along with static text, code and comments, you can also use predefined variables (listed below) that will then be expanded like macros into the corresponding values.
It is also possible to specify an arbitrary number of custom variables in the format **${<VARIABLE_NAME>}**. In this case, before the new file is created, you will be prompted with a dialog where you can define particular values for all custom variables.
Using the **#parse** directive, you can include templates from the *Includes* tab, by specifying the full name of the desired template as a parameter in quotation marks. For example:
#parse("File Header.java")

Predefined variables will take the following values:

${PACKAGE_NAME}	name of the package in which the new file is created
${NAME}	name of the new file specified by you in the *New <TEMPLATE_NAME>* dialog
${USER}	current user system login name

OK | Close | Apply | Help



FXML File templates

New
Cut Ctrl+X
Copy Ctrl+C
Copy Path Ctrl+Shift+C
Copy as Plain Text
Copy Reference Ctrl+Alt+Shift+C
Paste Ctrl+V
Find Usages Alt+F7
Find in Path... Ctrl+Shift+F
Replace in Path... Ctrl+Shift+R
Analyze
Refactor
Add to Favorites
Show Image Thumbnails Ctrl+Shift+T
Reformat Code Ctrl+Alt+L
Optimize Imports Ctrl+Alt+O
Delete... Delete
Make Module 'C7_3'
Recompile 'Exemplu' Ctrl+Shift+F9
Local History
Synchronize 'Exemplu'
Show in Explorer
Directory Path Ctrl+Alt+F12
Compare With... Ctrl+D
Mark Directory as
Create Gist...

Java Class
Kotlin File/Class
File
Package
package-info.java
HTML File
JavaFXApplication
Singleton
settings
FXMLAnchoreRoot
FXMLBorderPane
XSLT Stylesheet
Edit File Templates...
GUI Form
Dialog
Form Snapshot
Resource Bundle

t code 0

FXML - Controller

- Define the GUI in the fxml file

- Events are treated in the Controller file. How?

  - Define a file with the name XXXController.java
  - The link to XXX.fxml file is specified as:

    ```
    <AnchorPane fx:controller=" XXXController.java“>
    ```
  - Define handlers in `XXXController.java` to treat the events

FXML – Controller example

```
<?xml version="1.0" encoding="UTF-8"?>
<AnchorPane
fx:controller="View2Controller"
>
   <children>
      <GridPane hgap="5.0" vgap="5.0">
        <columnConstraints> </columnConstraints>
        <rowConstraints></rowConstraints>
         <children>
            <Button text="Login" GridPane.rowIndex="2" GridPane.columnIndex= "0" />
            <Label text="Username"  GridPane.rowIndex="0" GridPane.columnIndex= "0" />
            <Label text="Password" GridPane.rowIndex="1"GridPane.columnIndex= "0" />
            <TextField GridPane.columnIndex="1" GridPane.rowIndex="0" />
            <TextField GridPane.columnIndex="1" GridPane.rowIndex="1" />
         </children>
         <padding>
            <Insets bottom="5.0" left="5.0" right="5.0" top="5.0" />
         </padding>
      </GridPane>
   </children>
</AnchorPane>
```

```
public class View2Controller {

    /**
     * Initializes the controller class. This method is
automatically called
     * after the fxml file has been loaded.
     */
    @FXML
    private void initialize() {

    }
}
```

FXML – Controller- events treatment

```
<?xml version="1.0" encoding="UTF-8"?>
<AnchorPane fx:controller="View2Controller">
   <children>
      <GridPane hgap="5.0" vgap="5.0">
        <rowConstraints></rowConstraints>
         <children>
            <Button fx:id="buttonLogin" onAction="#handleLogin" text="Login" GridPane.rowIndex="2"
GridPane.columnIndex= "0" />
            <Label text="Username"  GridPane.rowIndex="0" GridPane.columnIndex= "0" />
            <Label text="Password" GridPane.rowIndex="1"GridPane.columnIndex= "0" />
            <TextField fx:id="textFieldUsername" GridPane.columnIndex="1" GridPane.rowIndex="0" />
            <TextField fx:id="textFieldPasword" GridPane.columnIndex="1" GridPane.rowIndex="1" />
         </children>
         <padding>
            <Insets bottom="5.0" left="5.0" right="5.0" top="5.0" />
         </padding>
      </GridPane>
   </children>
</AnchorPane>
```

```
public class View2Controller {
    @FXML
    private TextField textFieldUsername;
    @FXML
    private TextField textFieldPasword;

    @FXML
    public void handleLogin() {
        User u=new User(textFieldUsername.getText(),
textFieldPasword.getText());
        //...
    }
}
```

See Exemplu. Main2 from part3 examples

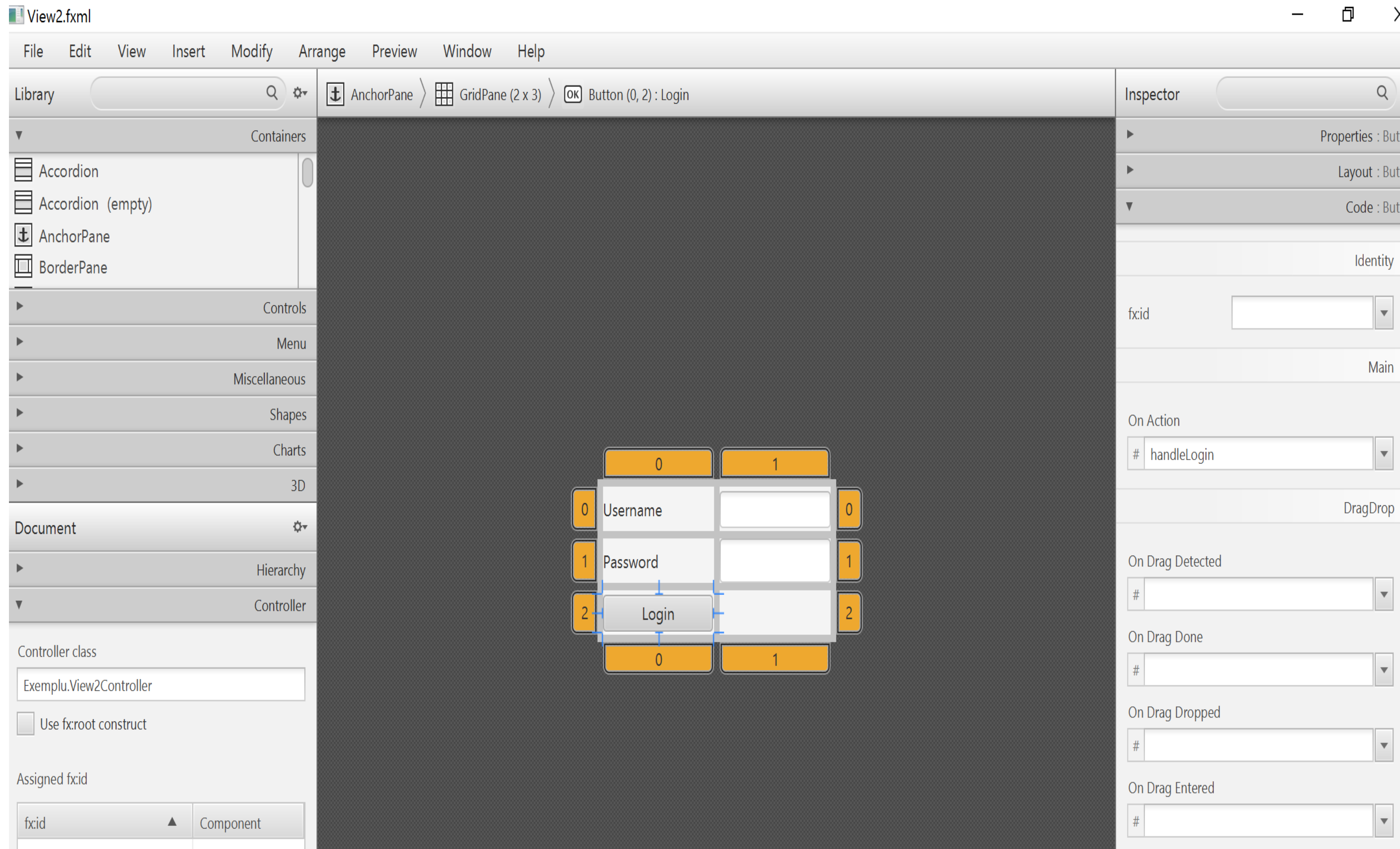
Getting the controller object

```
@Override
public void start(Stage primaryStage) {
    try {
        //Load root layout from fxml file.
        FXMLLoader loader=new FXMLLoader();
        loader.setLocation(Main2.class.getResource("View2.fxml")); //URL
        AnchorPane rootLayout= (AnchorPane) loader.load();

        View2Controller controller=loader.getController();

        // Show the scene containing the root layout.
        Scene scene = new Scene(rootLayout);
        primaryStage.setScene(scene);
        primaryStage.show();

    } catch (IOException e) {
        e.printStackTrace();
    }
}
```

FXML and Scene Builder

http://www.oracle.com/technetwork/java/javase/downloads/sb2download-2177776.html

http://gluonhq.com/labs/scene-builder/



Scene Builder

Specifying the path to the JavaFX Scene Builder executable:

In Eclipse:

Window -> Preferences ->Scene Builder

In InteliJ

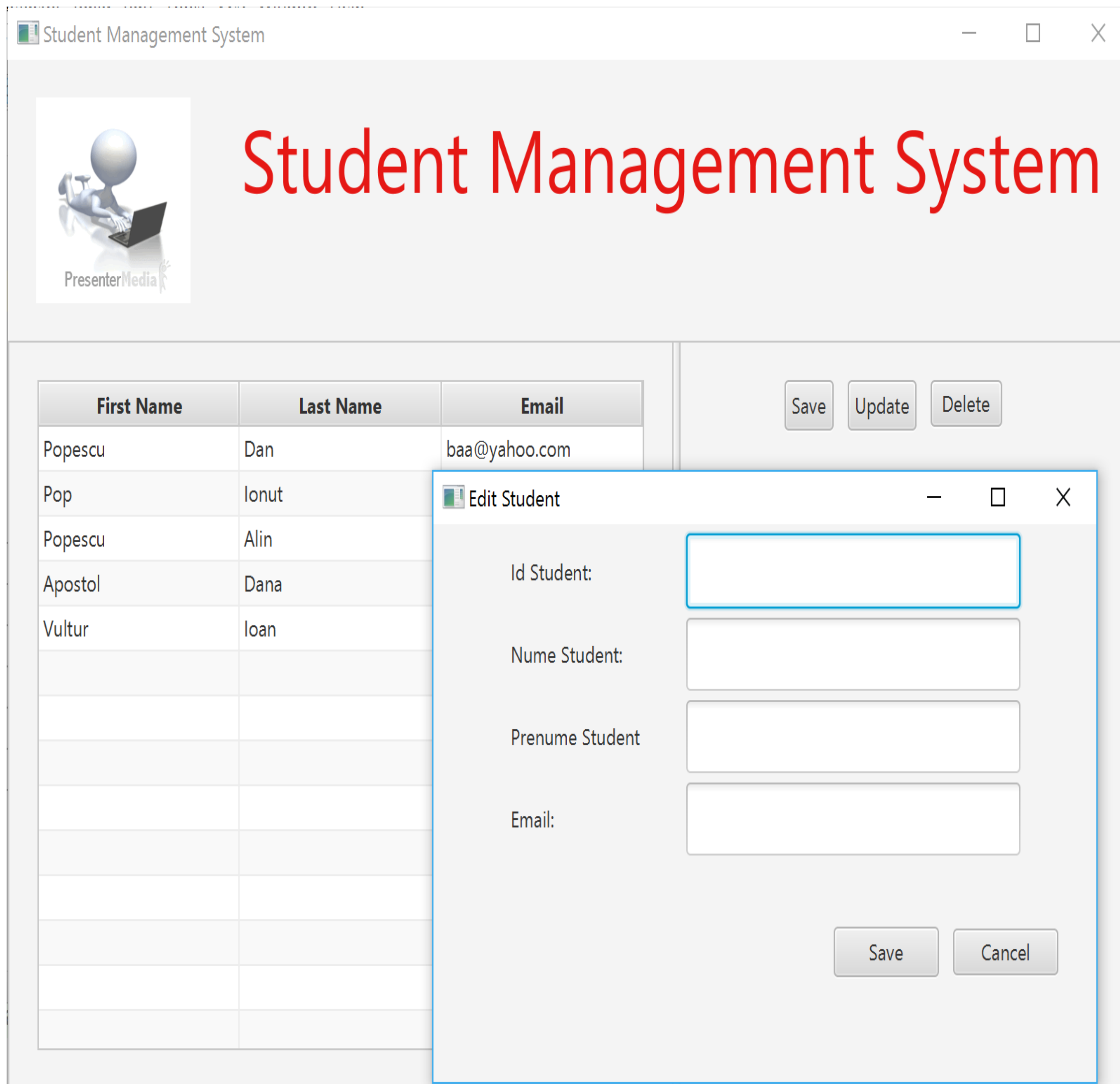
File->Settings-Languages and Frameworks->Java FX

Scene Builder download:

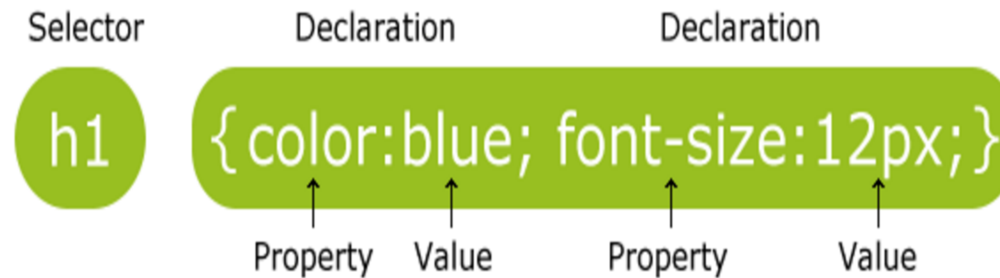
http://docs.oracle.com/javafx/scenebuilder/1/use_java_ides/sb-with-eclipse.htm

http://gluonhq.com/labs/scene-builder/#download

MVC FXML Example – see sample-Main from examples-part3



CSS



http://www.w3schools.com/css/

```
.button {
   -fx-padding: 5 22 5 22;
   -fx-border-color: #e2e2e2;
   -fx-border-width: 2;
   -fx-background-radius: 0;
   -fx-background-color: #1e2e2e2;
   -fx-font-family: "Segoe UI", Helvetica, Arial,
sans-serif;
   -fx-font-size: 11pt;
   -fx-text-fill: black;
   -fx-background-insets: 0 0 0 0, 0, 1, 2;
}

.button:hover {
   -fx-background-color: #3a3a3a;
}
```

```
.background {
   -fx-background-color:
#1d1d1d;
}

.label {
   -fx-font-size: 11pt;
   -fx-font-family: "Segoe UI
Semibold";
   -fx-text-fill: white;
   -fx-opacity: 0.6;
}
```

CSS FXML

```
<BorderPane prefHeight="550.0" prefWidth="800.0"
stylesheets="@Theme.css"
```