INF 311

Introduction to Java programming

Lecture 5: Classes and Objects

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Agenda de la semaine (INF311)

- Maintenant, **Amphi 5**: programmation objet (OO)
- Cet apres-midi: **TD3** (fonctions et recursion)
- Mercredi 28 Mai (**8h-12h15**) : **TD4** (tableaux et chaines)

So far...: Executive summary

- **Lecture 1**: Variable, Expression, Assignment
- **Lecture 2**: Loops (`for while do`)
  Conditional structures (`if else switch`)
  Boolean predicate and connectors (`|| &&`)
  Loop escape break
- **Lecture 3**: functions (`static`) and recursion (terminal or not)
- **Lecture 4**: Objects

2 Juin: Revisions generales pour la pale machine

Indenting source code (`.java`)

- Increase code readibility
- Avoid mistyping bugs (matching { })

Source code formatter, pretty printer, beautifier

Different conventions are possible (but choose one)
Implemented more or less in Software (S/W) Nedit, Jcreator, Jindent, etc...

Identing source code (`.java`)

http://java.sun.com/docs/codeconv/

```
if (condition) {
    statements;
}

if (condition) {
    statements;
} else {
    statements;
}

if (condition) {
    statements;
} else if (condition) {
    statements;
} else {
    statements;
}
```

Examples for `if else` conditions

Indenting source code (`.java`)

```
for (initialization; condition; update) {
    statements;
}
```

```
while (condition) {
    statements;
}
```

```
do {
    statements;
} while (condition);
```

http://java.sun.com/docs/codeconv/

Indenting source code (`.java`)

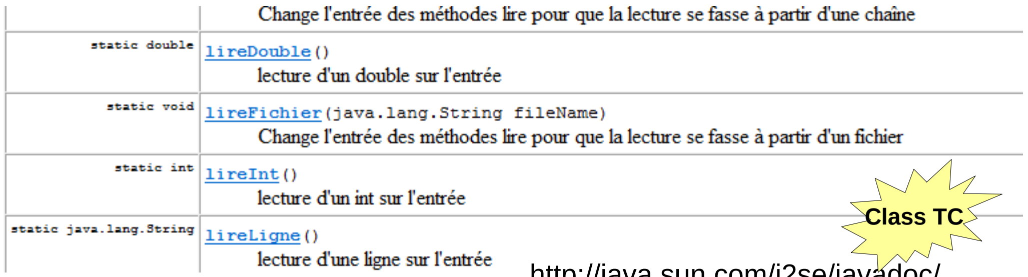
- Bytecode size and indentation:
  Does not change fundamentally
- Bytecode is not human readable

Demo `Indent.java`:
notepad
Jcreator
& produced bytecode `Indent.class`
open bytecode

Identing source code (`.java`)

Sometimes in Java code (Internet), comments include commands for generating automatically documentation by other tools:
... Like **javadoc** (paradigm literate programming, etc.)

La classe TC se trouve a:
http://www.enseignement.polytechnique.fr/informatique/profs/Julien.Cervelle/TC/



	Change l'entrée des méthodes lire pour que la lecture se fasse à partir d'une chaîne
`static double`	`lireDouble()` lecture d'un double sur l'entrée
`static void`	`lireFichier(java.lang.String fileName)` Change l'entrée des méthodes lire pour que la lecture se fasse à partir d'un fichier
`static int`	`lireInt()` lecture d'un int sur l'entrée
`static java.lang.String`	`lireLigne()` lecture d'une ligne sur l'entrée

Class TC

http://java.sun.com/j2se/javadoc/

Functions in Java

- Static functions that returns a `type` (eventually `void`)
- Functions are called inside the `main` procedure
  (or in other function body)
- Displaying and calling function are different
  (be not confused with SciLab or Maple
  `System.out.println(function());`
- Java is a compiled OO language , not an interpreter

Functions: void/display

**Java cannot cast void type into a String,
so the compiler `javac` generates an error.
(type checking)**

```
class Functions
{
   static void PascalTriangle(int depth)
   {//...
   return ;
   }

   public static void main(String[] toto)
   {
      System.out.println(PascalTriangle(5));
      }
}
```

'void' type not allowed here

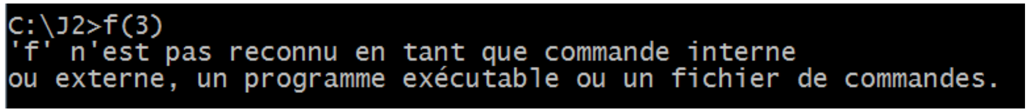
Functions: void/display

Java is *not an interpreter* like SciLab or Maple

Functions are called within a block of instructions...

... not in the console!!!!

```
class Functions
{

   static double f(double x)
   {return x;}

   static void main(String[] args)
   { }
   }
```



```
C:\J2>f(3)
'f' n'est pas reconnu en tant que commande interne
ou externe, un programme exécutable ou un fichier de commandes.
```

Variables: static or not...

Static variables are declared in the **class body**

```
class Toto
{
static int count1, count2;
...
}
```

Otherwise non-static variables (usual) are
declared in **function bodies** (main, etc.)

```
public static void main(String[] args)
  {double x;int i;}
```

- Variables are kept in memory in their function scope `{...}`
- Static variables are kept in memory and can be shared by several functions...

static or not...

```
class Functions
{
static int count1, count2;

   static void f1(){count1++;}
   static void f2(){count2++;}

   public static void main(String[] args)
   {
   count1=0;
   count2=0;

   for(int i=0;i<1000;i++)
      {
      double rand=Math.random();
      if (rand<0.5)
         {f1();}
         else
          {f2();}
      }
   System.out.println("count1:"+count1);
   System.out.println("count2:"+count2);
      }
   }
```

Java is pass by value

```
class BadSwap
{
   static void swap(int arg1, int arg2)
   {
   int tmp;

   tmp=arg1;
   arg1=arg2;
   arg2=tmp;
   }

   public static void main(String[] toto)
   {
      int a=3;
      int b=2;

      System.out.println("a:"+a+" b:"+b);
      swap(a,b);
      System.out.println("After the swap...");
      System.out.println("a:"+a+" b:"+b);
   }
}
```

...and arrays and objects are pass by reference

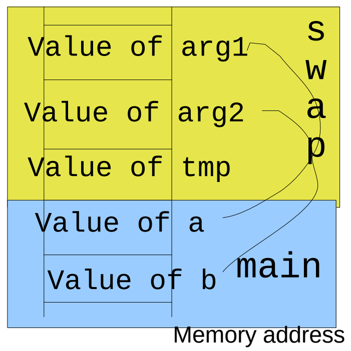
Managing memory & functions

When calling a function `f`, the current function (`main`) indicates .....where to write the **value** of the result

To obtain the result, function `f` uses a local memory

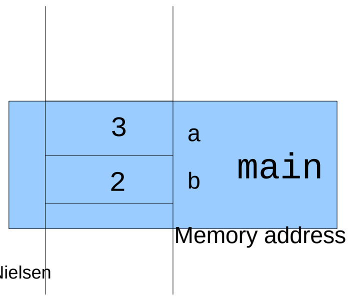
In that local memory, values of arguments are available

```
//current function body {}
int a=3,b=2;
swap(a,b)
```



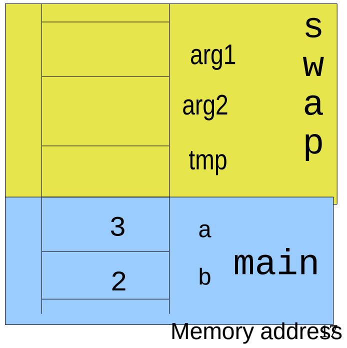
1. Create memory for local variables of function main
2. Assign values for a and b

```
static void swap(int arg1, int arg2)
   {
   int tmp;

   tmp=arg1;
   arg1=arg2;
   arg2=tmp;
   }

   public static void main(String[] toto)
   {
      int a=3;
      int b=2;
      swap(a,b);

}
```



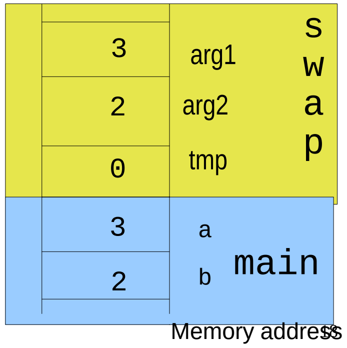
3. create local space for function swap

```
static void swap(int arg1, int arg2)
   {
   int tmp;

   tmp=arg1;
   arg1=arg2;
   arg2=tmp;
   }

   public static void main(String[] toto)
   {
      int a=3;
      int b=2;
      swap(a,b);

}
```



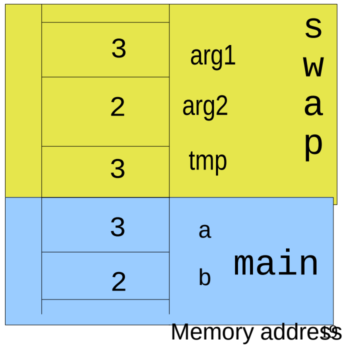
4. evaluate expression for getting values of arg1 and arg2 swap(a,b) becomes swap(3,2)

```
static void swap(int arg1, int arg2)
   {
   int tmp; // 0 is default value

   tmp=arg1;
   arg1=arg2;
   arg2=tmp;
   }

   public static void main(String[] toto)
   {
      int a=3;
      int b=2;
      swap(a,b);

}
```



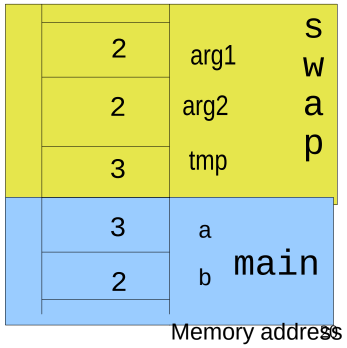
5. Execute instruction `tmp=arg1`

```
static void swap(int arg1, int arg2)
   {
   int tmp; // 0 is default value

   tmp=arg1;
   arg1=arg2;
   arg2=tmp;
   }

   public static void main(String[] toto)
   {
      int a=3;
      int b=2;
      swap(a,b);

}
```



6. Execute instruction `arg1=arg2`

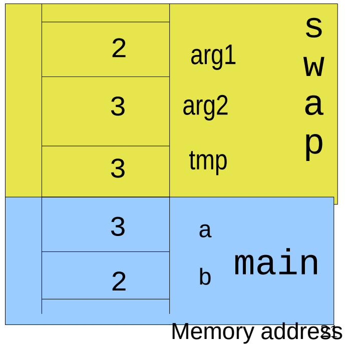
```
static void swap(int arg1, int arg2)
   {
   int tmp; // 0 is default value

   tmp=arg1;
   arg1=arg2;
   arg2=tmp;
   }

   public static void main(String[] toto)
   {
      int a=3;
      int b=2;
      swap(a,b);

}
```



7. Execute the sequence of instructions in the swap block

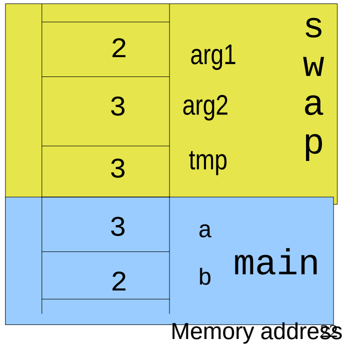
Notice that here the swapped has been performed

```
static void swap(int arg1, int arg2)
   {
   int tmp; // 0 is default value

   tmp=arg1;
   arg1=arg2;
   arg2=tmp;
   }

   public static void main(String[] toto)
   {
      int a=3;
      int b=2;
      swap(a,b);

}
```



5. Execute the sequence of instructions in the swap block

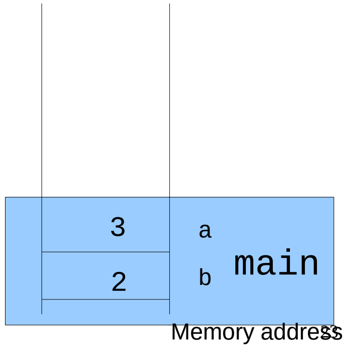
```
static void swap(int arg1, int arg2)
   {
   int tmp; // 0 is default value

   tmp=arg1;
   arg1=arg2;
   arg2=tmp;
   }

   public static void main(String[] toto)
   {
      int a=3;
      int b=2;
      swap(a,b);

}
```



8. Return result of function swap (here void!!!)
9. Release memory allocated for swap

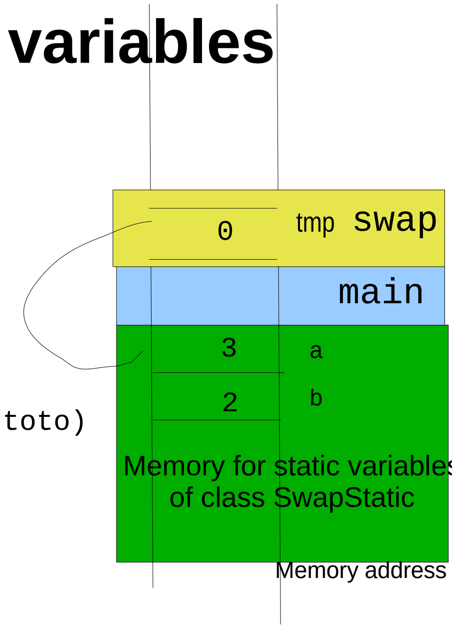
```
static void swap(int arg1, int arg2)
   {
   int tmp; // 0 is default value

   tmp=arg1;
   arg1=arg2;
   arg2=tmp; // we omitted return ;
   }

   public static void main(String[] toto)
   {
      int a=3;
      int b=2;
      swap(a,b);

}
```

Variables a and b have kept their original values



Memory for static variables

```
class SwapStatic
{
static int a,b;

   static void swap()
   {
   ...
   }

public static void main(String[] toto)
   {
      a=3;
      b=2;
      swap();
   }
}
```



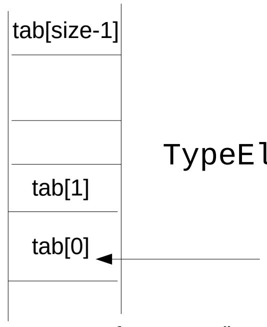
By passing using static

```
class SwapStatic
{
static int a,b;

   static void swap()
   {
   int tmp;// ok not to be static

   tmp=a;
   a=b;
   b=tmp;
   }

   public static void main(String[] toto)
   {
      a=3;
      b=2;

      System.out.println("a:"+a+" b:"+b);
      swap();
      System.out.println("After the swap...");
      System.out.println("a:"+a+" b:"+b);
   }
}
```

Memory for arrays and pass by reference

Arrays are allocated a continuous memory location for storing TYPE elements

The value of the array variable is a reference to the beginning of the array



`TypeElement [ ] tab= new TypeElement[size]`

Array variable tab is a reference

Memory for arrays (heap)

Memory management using new

```
Type [] tab=new Type[Expression];
```

- Evaluate `Expression` to get an integer value.
- Arrays are stored not in the local function memory, but rather in the **global program memory**: heap, tas en francais
- A cell (array element) in the heap (program memory) is accessible by any function which has as a local (non-static) variable a reference to the array.

```
class ArrayReference
{

   public static void swap(int [] t, int i, int j)
   {
   int tmp;
   tmp=t[i];
   t[i]=t[j];
   t[j]=tmp;
   }

   public static void Display(int [] tab){... »

   public static void main(String[] args)
   {
      //int [] array=new int[10];
      int [] array={0,1,2,3,4,5,6,7,8,9};
     Display(array);
      swap(array,1,2);
      Display(array);
   }
}
```

```
0 1 2 3 4 5 6 7 8 9
0 2 1 3 4 5 6 7 8 9
```

Memory management using new

```
class BuildArray{

  // Return a reference to an array
  public static int [] BuildArray(int size, int defaultval)
  {
     int [] result=new int[size];
     for(int i=0;i<size;i++) result[i]=defaultval;
     return result;
  }

  public static void Zero(int[] tab, int pos)
  {
     tab[pos]=0;
  }

  public static void main(String [] argarray)
  {
     int v []=BuildArray(10,4);
     Display(v);
     Zero(v,2);
     Display(v);
     }
```

```
4 4 4 4 4 4 4 4 4 4
4 4 0 4 4 4 4 4 4 4
```

Today...

Lecture 5: Classes and Objects

Synopsis of this lecture

- Objects and records (fields, *enregistrements*)
- Object constructors
- Class type variables: References
- Functions on objects: Methods
- Array of objects
- Examples

Why do we need objects?

Encapsulate functions/data acting on a same domain

For example, the `String` type

Allows one to work on complex entities: Data structures

For examples:
- Dates are triplets of numbers (MM/DD/YYYY)
- 2D point with co-ordinates (x,y)
- Student: Lastname, Firstname, Group, etc.

These are called object records (fields)

Java is an oriented-object (OO) programming language

Declaring classes and objects

- Choose record/field names (enregistrement)
- Define a type of each record
- Similar to variables but without keyword `static`
- Class is then a **new type** with name...
  ... the class name

Toy example

```
public class Date
{
int dd;
int mm;
int yyyy;
}
```

Fields (champs/enregistrements) are also called **object variables**
Do not have the leading keyword `static`

Let day be a variable of type `Date` then

`day.dd  day.mm dd.yyyy`

are variables of type `int`

Toy example

```
public class Student
{
String Lastname;
String Firstname;
int Company;
double [ ] Marks;
...
}
```

Class Student encapsulates data attached to a student identity.

Constructors

To use an object, we first need to build it

We construct an object using the instruction `new`

But first, we need to define a constructor for the class
A constructor is a method (non-static function) ...
...bearing the class' name

This method does not return a result but assigns...
...values to the object's field

Use **`this.field`** to access field of the object

Constructors

```
public class Date
{
int dd;
int mm;
int yyyy;
// Constructor
public Date(int day, int month, int year)
{this.dd=day;
this.mm=month;
this.yyyy=year;}
}
```

Create an object of type Date

```
Date day=new Date(23,12,1971);
```

Public class YYY stored in YYY.java

```
public class Date
{
int dd;
int mm;
int yyyy;

public Date(int day, int month, int year)
{
this.dd=day;
this.mm=month;
this.yyyy=year;
}

}
```

Filename: Date.java

```
class TestDate{
public static void main(String args)
{
Date day=new Date(23,12,1971);
}
}
```

Filename: TestDate.java

Constructors

- Possibly several constructors (with different signatures)
- Best, to define a single one with all fields initialized

- Keyword `this` means the currently built object
  (*not compulsory* to write it explicitly but recommended)

```
public Date(int day, int month, int year)
{dd=day;
 this.mm=month;
 yyyy=year;
}
```

- If no constructor is built, the system uses the by-default one
  (not recommended)

```
Date day=new Date();// see poly pp. 59-61
day.yyyy=1971;
```

The **`null`** object

- This object is common to all classes

- Not possible to assign its fields

- Nor retrieve values of its fields, either
  (exception `nullPointerException` raised)

- Used for initializing a variable of type object:
  `Student stud=null;`

- It is often recommender to check if an object is null or not:

```
if( stud!=null) stud.company=2;
```

Functions/methods on objects

Objects can be parameters of functions

```
static TypeF F(Object1 obj1, ..., ObjectN objN)
```

Functions may return an object as a result:

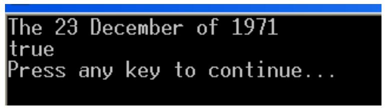
```
static boolean isBefore (Date d1, Date d2)
static Date readDate()
```

Example

```
public class Date
{
int dd;
int mm;
int yyyy;

public static final String[ ] months={
   "January", "February", "March", "April", "May",
    "June", "July", "August", "September", "October",
     "November", "December"
   };

// Constructor
public Date(int day, int month, int year)
{
this.dd=day;
this.mm=month;
this.yyyy=year;
}

}
```

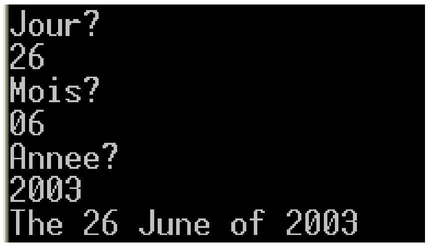
Example

```
class TestDate{
static void Display(Date d){
   System.out.println("The "+d.dd+"
"+Date.months[d.mm-1]+" of "+d.yyyy);
   }

static boolean isBefore(Date d1, Date d2)
{
boolean result=true;
if (d1.yyyy>d2.yyyy) result=false;
if (d1.yyyy==d2.yyyy && d1.mm>d2.mm) result=false;
if (d1.yyyy==d2.yyyy && d1.mm==d2.mm && d1.dd>d2.dd)
result=false;
return result;
}

public static void main(String[] args)
{
Date day1=new Date(23,12,1971);
Display(day1);
Date day2=new Date(23,6,1980);
System.out.println(isBefore(day1,day2));
}
}
```



```
The 23 December of 1971
true
Press any key to continue...
```

```
class TestDate{
...

static Date lireDate()
{
int jj, mm, aaaa;
System.out.println("Jour?");
jj=TC.lireInt();
System.out.println("Mois?");
mm=TC.lireInt();
System.out.println("Annee?");
aaaa=TC.lireInt();
Date day=new Date(jj,mm,aaaa);
return day;
}

public static void main(String[] args)
{
Display(lireDate());
}

}
```



```
Jour?
26
Mois?
06
Annee?
2003
The 26 June of 2003
```

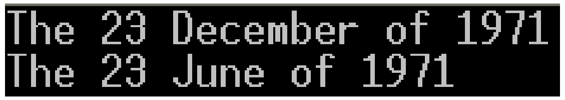
Variable of Type Object: Reference

A variable of type Object is a **reference** on that object

It stores the memory address of this referenced object

Thus when we write:

```
Date day1=new Date(23,12,1971);
Date day2=day1;

Display(day2);
day2.mm=6;
Display(day1);
```



```
The 23 December of 1971
The 23 June of 1971
```

The date d1 is not copied, only the reference of...
...d1 is assigned to d2

Copying objects...

To copy (clone) an object to another we need to do it fieldwise

```
// Two Scenarii:
// day2 has already been created...
day2.dd=day1.dd;
day2.mm=day1.mm;
day2.yyyy=day1.yyyy;

// day2 object has not yet been created...
static Date Copy(date day1)
{
Date newdate=new Date (day1.dd,day1.mm,day1.yyyy);
return newdate;
}
...
Date d2=Copy(d1);
```

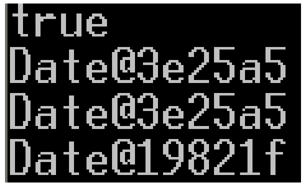
Comparing two objects...

Do not use == for object equality
To compare objects, use a **tailored predicate**:

```
static boolean isEqual(Date d1, Date d2)
{
return (d1.dd == d2.dd &&
    d1.mm == d2.mm &
    d1.yyyy== d2.yyyy);
}
```

Comparing two objects...

```
public static void main(String[] args)
{
Date day1=new Date(23,12,1971);
Date day2=day1; // beware not copying here.
Just memory reference
Date day3=new Date(23,12,1971);

System.out.println(isEqual(day1,day3));

System.out.println(day1);
System.out.println(day2);
System.out.println(day3);
}
```



```
true
Date@3e25a5
Date@3e25a5
Date@19821f
```

Physical (memory) versus logical equality

Array of objects

- Since classes defines new types...
  ... we can create **array of objects**

- To build an array of objects: `new nameT[sizearray]`

```
Date [ ] tabDates=new Date[31];
```

- When an array of object is built, the elements `Date[i]` are all initialized to the `null` object.

Example

```
public class XEvent
{
Date when;
String what;

public XEvent(Date d, String text)
{
   this.when=d;
   this.what=text;
}

}
```

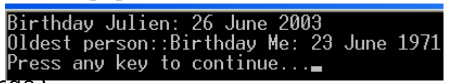
Filename XEvent.java

```
public class Date
{
...
void Display()
{
System.out.println(dd+" "+months[mm-1]+" "+yyyy);
}
...
}
```

Filename Date.java

```
public class TestXEvent
{
   public static void Display(XEvent e)
   {
      System.out.print(e.what+": ");
      e.when.Display();
      }

   public static void  main(String [] args)
   {
      Date d1=new Date(26,6,2008);
      XEvent e1=new XEvent(d1,"Birthday Julien");

      Display(e1);

      XEvent [] tabEvent=new XEvent[5];
      tabEvent[0]=e1;
      }

}
```

```
public class TestXEvent
{public static void Display(XEvent e)
   {  System.out.print(e.what+": ");
      e.when.Display();   }

   public static boolean older(XEvent e1, XEvent e2)
   {return Date.isBefore(e1.when,e2.when);}

   public static XEvent oldest(XEvent[] tab)
   {
      XEvent result=tab[0];
      for(int i=1;i<tab.length;++i)
         if (older(tab[i],result)) result=tab[i];
      return result;
   }

   public static void  main(String [] args)
   {
      Date d1=new Date(26,6,2003);
      XEvent e1=new XEvent(d1,"Birthday Julien");
      Date d2=new Date(20,11,2000);
      XEvent e2=new XEvent(d2,"Birthday Audrey");
      Date d3=new Date(23,6,1971);
      XEvent e3=new XEvent(d3,"Birthday Me");
      Display(e1);
      XEvent [] tabEvent=new XEvent[3];
      tabEvent[0]=e1;tabEvent[1]=e2;tabEvent[2]=e3;
      System.out.print("Oldest person::");Display(oldest(tabEvent));
      }
}
```



```
Birthday Julien: 26 June 2003
Oldest person::Birthday Me: 23 June 1971
Press any key to continue...
```

Objects with array members

Fields of objects may be arrays themselves

```
always built with new Type[sizearray]
// sizearray might be an expression, i.e., 3*n+2
```

It is not necessary at compile time to know statically...
.... the array sizes

```
class Polynome{
int degree;
double [ ] coefficients;
};
```

Strings: Basic objects in Java

- A string of character is **an object** with type **String**
- A variable of type String is a **reference** on that object:

String school= "Ecole Polytechnique";
String vars=school;

- Once built, a string object **cannot** be modified
- Beware: use only for moderate length strings,
otherwise use the **class StringBuffer**

Class String: Some methods

A method is a function or procedure on an object class

Method Length() : gives the number of characters

```
String s= ''anticonstitutionnellement'';
System.out.println(s.length());
```

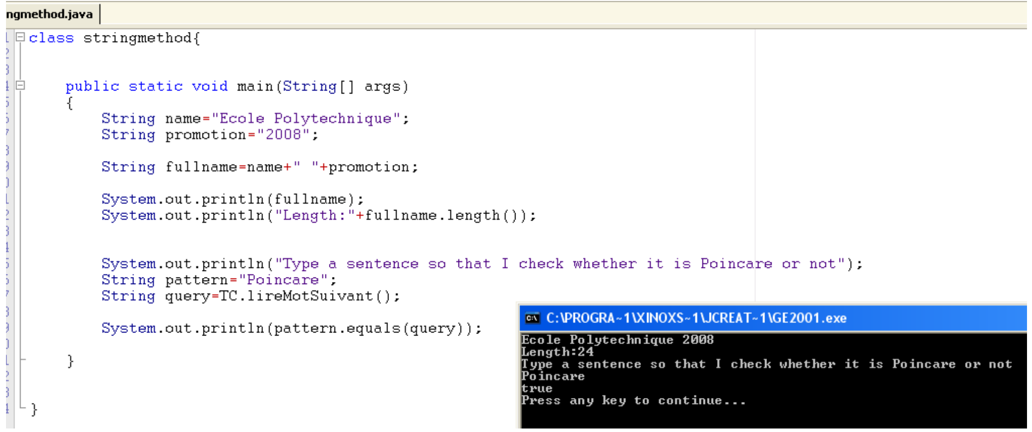
Method equals():

s1.equals(s2): Predicate that returns true **if and only if** the
two strings s1 and s2 are made of the same sequence of characters.

```
String s1=''Poincare'';
String s2=TC.lireMotSuivant();
System.out.println(s1.equals(s2));
```

Beware: s1==s2 is different!
It compares the **reference** of the strings.
(Physical versus logical equality test)

Class String in action...



ngmethod.java

```
class stringmethod{


    public static void main(String[] args)
    {
        String name="Ecole Polytechnique";
        String promotion="2008";

        String fullname=name+" "+promotion;

        System.out.println(fullname);
        System.out.println("Length:"+fullname.length());


        System.out.println("Type a sentence so that I check whether it is Poincare or not");
        String pattern="Poincare";
        String query=TC.lireMotSuivant();

        System.out.println(pattern.equals(query));

    }

}
```

C:\PROGRA~1\XINOXS~1\JCREAT~1\GE2001.exe

```
Ecole Polytechnique 2008
Length:24
Type a sentence so that I check whether it is Poincare or not
Poincare
true
Press any key to continue...
```

Class String: More methods

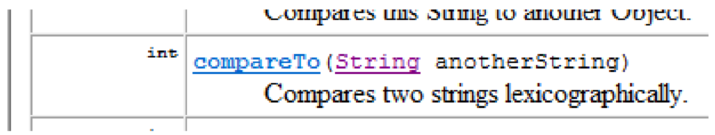
Method **charAt()**:
s.charAt(i) gives the character at the (i+1)th position in string s.

```
String s= ''3.14159265'';
System.out.println(s.charAt(1));
```

Method **compareTo()**:
u.compareTo(v) compares lexicographically the strings u with v.

```
String u=''lien'', v=''lit'', w=''litterie'';
System.out.println(u.compareTo(v));
System.out.println(v.compareTo(w));
```

From Javadoc...



Compares this String to another Object.

int	compareTo(String anotherString) Compares two strings lexicographically.

http://java.sun.com/j2se/1.4.2/docs/api/java/lang/String.html

Lexicographic total order on strings

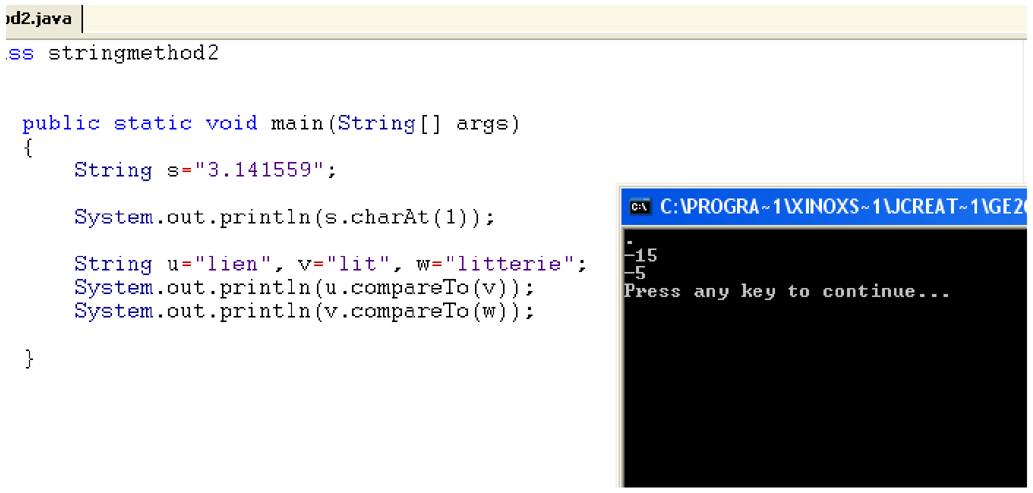
- If there is a position k at which strings differ:

```
this.charAt(k)-anotherString.charAt(k):
String s1="Marin",s2="Martin"; // -11 from i to t
int index=3;// meaning 4th pos
System.out.println(s1.compareTo(s2));
System.out.println(s1.charAt(index)-s2.charAt(index));
```

- else the difference of string lengths:

```
this.length()-anotherString.length():
String s3="Bien",s4="Bienvenue";
System.out.println(s3.compareTo(s4));
System.out.println(s3.length()-s4.length());
```

Class String: More methods



```
ss stringmethod2

 public static void main(String[] args)
 {
     String s="3.141559";

     System.out.println(s.charAt(1));

     String u="lien", v="lit", w="litterie";
     System.out.println(u.compareTo(v));
     System.out.println(v.compareTo(w));

 }
```

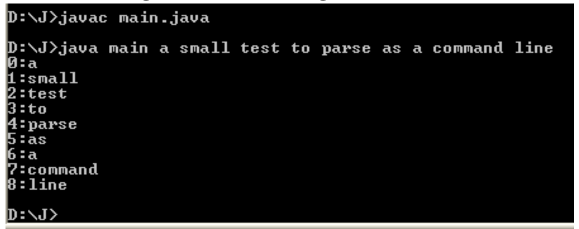
```
.
-15
-5
Press any key to continue...
```

Demystifying the main function

```
class ClassName
{
   public static void main(String[ ] args)
   {
   ...
   }
}
```

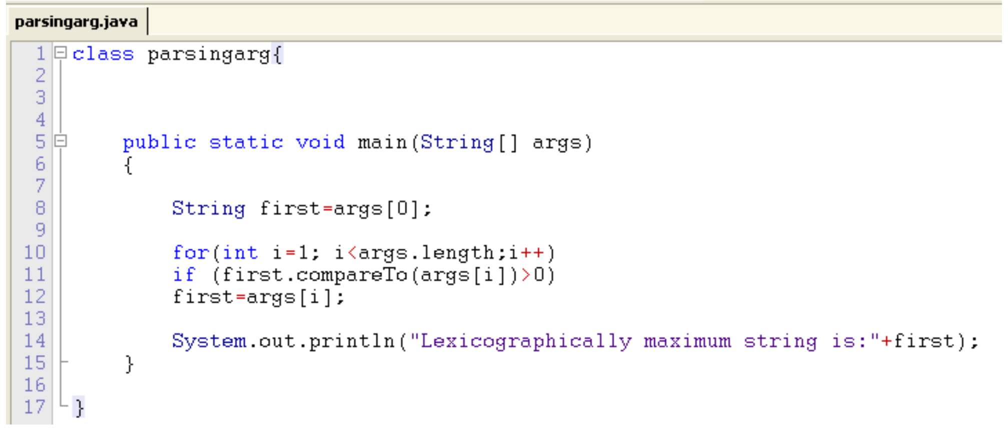
Function main has an array of string of characters as arguments
These strings are stored in args[0], args[1], ...
... when calling java main s0 s1 s2 s3

Use Integer.parseInt() to convert a string into an integer



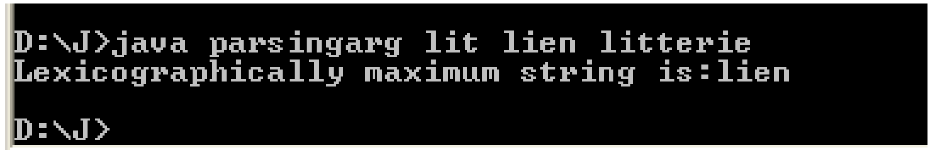
```
D:\J>javac main.java

D:\J>java main a small test to parse as a command line
0:a
1:small
2:test
3:to
4:parse
5:as
6:a
7:command
8:line

D:\J>
```

Parsing arguments in the main function



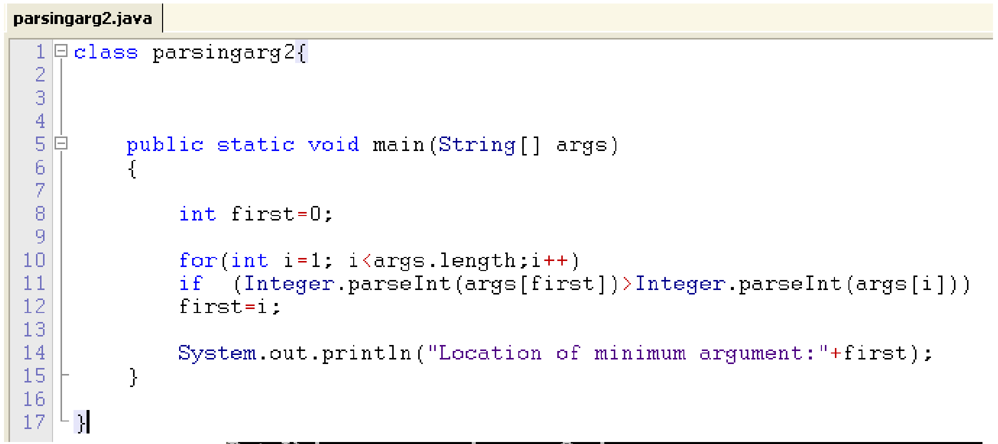
parsingarg.java

```
class parsingarg{


    public static void main(String[] args)
    {

        String first=args[0];

        for(int i=1; i<args.length;i++)
        if (first.compareTo(args[i])>0)
        first=args[i];

        System.out.println("Lexicographically maximum string is:"+first);
    }

}
```



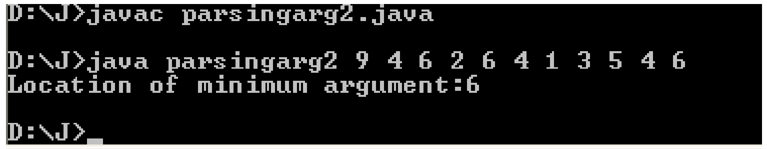
```
D:\J>java parsingarg lit lien litterie
Lexicographically maximum string is:lien

D:\J>
```

Parsing arguments in the main function



parsingarg2.java

```
class parsingarg2{


    public static void main(String[] args)
    {

        int first=0;

        for(int i=1; i<args.length;i++)
        if  (Integer.parseInt(args[first])>Integer.parseInt(args[i]))
        first=i;

        System.out.println("Location of minimum argument:"+first);
    }

}
```



```
D:\J>javac parsingarg2.java

D:\J>java parsingarg2 9 4 6 2 6 4 1 3 5 4 6
Location of minimum argument:6

D:\J>_
```

More evolved Java program skeleton...

```
class Point
{
int x,y;
Point(int xx, int yy){x=xx;y=yy;}

public void Display()
{System.out.println("("+x+","+y+")")}
} // end of class Point

class Skeleton
{
// Static class variables
static int nbpoint=0;
static double x;
static boolean [] prime;

static int f1(int p){return p/2;}
static int f2(int p){return 2*p;}

public  static void main(String [] argArray)
{
   System.out.println(f2(f1(3))+" versus (!=) "+f1(f2(3)));
   Point p,q;
   p=new Point(2,1); nbpoint++;
   q=new Point(3,4); nbpoint++;
   p.Display();q.Display();
}
}
```

```
2 versus (!=) 3
(2,1)
(3,4)
```