Java (basic concepts)

SOftEng http://softeng.polito.it

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Comments

- C-style comments (multi-lines)

```
/* this comment is so long
   that it needs two lines */
```

- Comments on a single line

```
// comment on one line
```


Code blocks and Scope

- Java code blocks are the same as in C language
- Each block is enclosed by braces { } and starts a new scope for the variables
- Variables can be declared both at the beginning and in the middle of block code

```
for (int i=0; i<10; i++){
   int x = 12;
   ...
   int y;
   ...
}
```


Control statements

- Same as C
  - if-else,
  - switch,
  - while,
  - do-while,
  - for,
  - break,
  - continue

Boolean

- Java has an explicit type (boolean) to represent logic values (**`true`**, **`false`**)
- Conditional constructs evaluate boolean conditions
  - Note well – It's not possible to evaluate this condition

```
int x = 7; if(x){…}  //NO
```

  - Use relational operators

```
if (x != 0)
```


Passing parameters

- Parameters are always passed by value
- …they can be primitive types or object references
- Note well: only the object reference is copied not the value of the object

Constants

- The final modifier

```
final float PI = 3.14;

PI = 16.0;       // ERROR, no changes
final int SIZE; // ERROR, init missing
```

- Use uppercases (coding conventions)

Elements in a OO program

Structural elements (types) (compile time)	Dynamic elements (data) (run time)
▪ Class	▪ Reference
▪ Primitive type	▪ Variable

Classes and primitive types

▪ Class (descriptor) `class Exam {}`	▪ type primitive `int, char, float`

▪ Variable of type reference (instance)
`Exam e;`
`e = new Exam();`
	▪ Variable of type primitive
	`int i;`

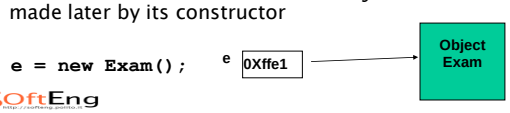
Primitive type

- Defined in the language:
  - int, double, boolean
- Instance declaration:
  - Declares instance name
  - Declares the type
  - Allocates memory space for the reference

Class

- Defined by developer (eg, Exam) or by the Java environment (eg, String)
- the following declaration

- …allocates memory space for the *reference* ('pointer')
  …and *sometimes* it initializes it with null by default
- Allocation and initialization of the *object* value are made later by its constructor



Primitive types

Primitive types

- Have a unique dimension and encoding
  - Representation is platform-independent

type	Dimension	Encoding
boolean	1 bit	-
char	16 bits	Unicode
byte	8 bits	Signed integer 2C
short	16 bits	Signed integer 2C
int	32 bits	Signed integer 2C
long	64 bits	Signed integer 2C
float	32 bits	IEEE 754 sp
double	64 bits	IEEE 754 dp
void	-	-

Constants

- Constants of type int, float, char, strings follow C syntax
  - `123 256789L 0xff34 123.75 0.12375e+3`
  - `'a' '%' '\n' "prova" "prova\n"`
- Boolean constants (do not exist in C) are
  - `true`, `false`

Operators (integer and floating-point)

- Operators follow C syntax:
  - arithmetical `+ - * / %`
  - relational `== != > < >= <=`
  - bitwise (int) `& | ^ << >> ~`
  - Assignment `= += -= *= /= %= &= |= ^=`
  - Increment `++ --`
- Chars are considered like integers (e.g. switch)

Logical operators

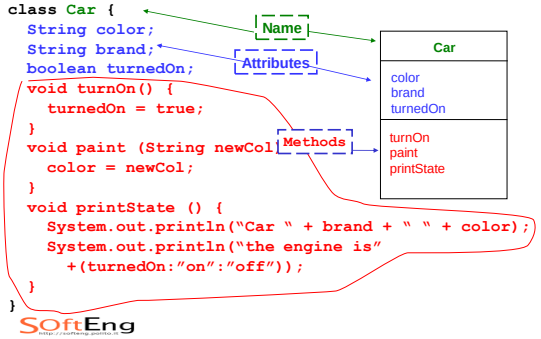
- Logical operators follows C syntax:
  `&& || ! ^`
- Note well: Logical operators work ONLY on booleans
  - Type int is NOT considered a boolean value like in C
  - Relational operators work with boolean values

Classes

Class

- Object descriptor
- It consists of attributes and methods

Class - definition



Methods

- Methods are the messages that an object can accept
  - turnOn
  - paint
  - printState
- Method may have parameters
  - paint("Red")

Overloading

- In a Class there may be different methods with the same name
- But they have a different signature
- A signature is made by:
  - Method name
  - Ordered list of parameters types
- the method whose parameters types list matches, is then executed

```
class Car {
  String color;
  void paint(){
    color = "white";
  }
  void paint(int i){}
  void paint(String
             newCol){
    color = newCol;
  }
}
```


Overloading

```
public class Foo{
  public void doIt(int x, long c){
    System.out.println("a");
  }
  public void doIt(long x, int c){
    System.out.println("b");
  }
  public static void main(String args[]){
    Foo f = new Foo();
    f.doIt(       5 ,(long)7 ); // "a"
    f.doIt( (long)5 ,       7 ); // "b"
  }
}
```


Objects

- An object is identified by:
  - Its class, which defines its structure (attributes and methods)
  - Its state (attributes values)
  - An internal unique identifier
- Zero, one or more reference can point to the same object

Objects

```
class Car {
  String color;
  void paint(){
    color = "white";
  }
  void paint(String newCol) {
    color = newCol;
  }
}
Car a1, a2;
a1 = new Car();
a1.paint("green");
a2 = new Car();
```

Objects and references

```
Car a1, a2;   // a1 and a2 are uninitialized
a1 = new Car();
a1.paint("yellow");// Car "yellow" generated,
  // a1 is a reference pointing to "yellow"
a2 = a1; //now two references point to "yellow"
a2 = null; // a reference points to "yellow"
a1 = null;// no more references point to "yellow"
// Object exists but it is no more reachable
// then it will be freed by
// the garbage collector
```

- Note Well: a reference IS NOT an object

Objects Creation

- Creation of an object is made with the keyword new
- It returns a reference to the piece of memory containing the created object

```
Motorcycle m = new Motorcycle();
```


The keyword new

- Creates a new instance of the specific Class, and it allocates the necessary memory in the heap
- Calls the constructor method of the object (a method without return type and with the same name of the Class)
- Returns a reference to the new object created
- Constructor can have parameters
  - String s = new String("ABC");

Heap

- It is a part of the memory used by an executing program…
- …to store data dynamically created at run-time

- C: malloc, calloc and free
  - Instances of types in static memory or in heap
- Java: new
  - Instances (Objects) are always in the heap

Constructor

- Constructor method contains operations (initialization of attributes etc.) we want to execute on each object as soon as it is created
- Attributes are always initialized
  - Attributes are initialized with default values
- If a Constructor is not declared, a default one (with no parameters) is defined
- Overloading of constructors is often used

Constructors with overloading

```
class Window {
  String title;
  String color;
  Window() {
    // creates a window with no title and no
  color
  }
  Window(String t) {
   // creates a window with title but no color
  ...
    title = t;
  }
  Window(String t, String c) {
     // creates a window with title and color...
    title = t;
    color = c;
  }
```

Destruction of objects

- It is no longer a programmer concern
- See section on Memory management
- Before the object is really destroyed if exists method finalize is invoked:

```
public void finalize()
```


Methods invocation

- A method is invoked using dotted notation

```
objectReference.Method(parameters)
```

- Example:

```
Car a = new Car();
a.turnOn();
a.paint("Blue");
```


Caveat

- If a method is invoked within another method of the same object
  - DO NOT need to use dotted notation

```
class Book {
     int pages;
     void readPage(int n)
{…      }
     void readAll() {
      for (int i=0; i<pages; i++)
           readPage(i);
        }
 }
```


Caveat (cont'd)

- In such cases `this` is implied
- "this" is a reference to the current object

```
class Book {
  int pages;
  void readPage(int n){…}
  void readAll() {
    for(…)
      readPage(i);
  }
}
```

```
void readAll() {
  for(…)
    this.readPage(i);
}
```


Access to attributes

- Dotted notation

```
objectReference.attribute
```

  - Reference is used like a normal variable

```
Car a = new Car();
a.color = "Blue"; //what's wrong here?
boolean x = a.turnedOn;
```


Access to attributes

- Methods accessing attributes of the same object do not need using object reference

```
class Car {
   String color;

   void paint(){
     color = "green";
     // color refers to current obj
   }
 }
```

this

- It can be useful in methods to distinguish object attributes from local variables
  - this represents a reference to the current object

```
class Car{
  String color;
  ...
  void paint (String color) {
    this.color = color;
  }
}
```


Combining dotted notations

- Dotted notations can be combined

```
System.out.println("Hello world!");
```

  - `System` is a Class in package java.lang
  - `Out` is a (static) attribute of System referencing an object of type `PrintStream` (representing the standard output)
  - `Println()` is a method of `PrintStream` which prints a text line on the screen

Operations on references

- Only the relational operators == and != are defined
  - Note well: the equality condition is evaluated on the values of the references and NOT on the values of the objects !
  - The relational operators tell you whether the references points to the same object in memory
- Dotted notation is applicable to object references
- There is NO pointer arithmetic

Strings

String

- No primitive type to represent string
- String literal is a quoted text
- C
  - `char s[] = "literal"`
  - Equivalence between string and char arrays
- Java
  - `char[] != String`
  - String class in java.lang library

Operator +

- It is used to concatenate 2 strings

```
"This string" + " is made by two strings"
```

- Works also with other types (automatically converted to string)

```
System.out.println("pi = " + 3.14);
System.out.println("x = " + x);
```

String

- `int length()`
  - returns string length
- `boolean equals(String s)`
  - compares the values of 2 strings

```
String s1, s2;
s1 = new String("First string");
s2 = new String("First string");
System.out.println(s1);
System.out.println("Length of s1 = " +
s1.length());
if (s1.equals(s2))  // true
if (s1 == s2) // false
```


String

- `String  valueOf(int)`
  - Converts int in a String – available for all primitive types
- `String toUpperCase()`
- `String toLowerCase()`
- `String concat(String str)` – *like* `'+'`
- `int compareTo(String str)`
  - `Compare w.r.t alphabetical order`
  - `<0 if this < str`
  - `==0 if this == str`
  - `>0 if this > str`

String

- `String subString(int startIndex)`
  - `String s = "Human";`
  - `s.subString(2) returns "man"`
- `String subString(int start, int end)`
  - `Char 'start' included, 'end' excluded`
  - `String s = "Greatest";`
  - `s.subString(0,5) returns "Great"`
- `int indexOf(String str)`
  - Returns the index of the first occurrence of *str*
- `int lastIndexOf(String str)`
  - The same as before but search starts from the end

StringBuffer

- insert
- append
- delete
- reverse

Character

- Utility methods on the kind of char
  - `isLetter(), isDigit(), isSpaceChar()`
- Utility methods for conversions
  - `toUpper(), toLower()`

Scope and encapsulation

Example

- Laundry machine, design1
  - commands:
    - time, temperature, amount of soap
  - Different values depending if you wash cotton or wool, ….
- Laundry machine, design2
  - commands:
    - key C for cotton, W for wool, Key D for knitted robes

Example (cont'd)

- Washing machine, design3
  - command:
    - Wash!
  - insert clothes, and the washing machine automatically select the correct program
- Hence, there are different solutions with different level of granularity / abstraction

Motivation

- Modularity = cut-down inter-components interaction
- Info hiding = identifying and delegating responsibilities to components
  - components = Classes
  - interaction = read/write attributes
  - interaction = calling a method
- Heuristics
  - attributes invisible outside the Class
  - Visible methods are the ones that can be invoked from outside the Class

Scope and Syntax

- private (applied to attribute or method)
  - attribute/method visible by instances of the same class
- public
  - attribute / method visible everywhere
- protected
  - attribute / method visible by instance of the same class and sub-classes
- Forth type (later)

Info hiding

```
class Car {
  public String color;
}
Car a = new Car();
a.color = "white";  // ok
```

better

```
class Car {
  private String color;
  public void paint(String color)
    {this.color = color;}
}
Car a = new Car();
a.color = "white";  // error
a.paint("green");   // ok
```


Info hiding

```
class Car{
    private String color;
    public void paint();
}
```

no

yes

```
class B {
  public void f1(){
    ...
  };
}
```

Access

	Method in the same class	Method of another class
Private (attribute/ method)	yes	no
Public	yes	yes

Getters and setters

- Methods used to read/write a private attribute
- Allow to better control in a single point each write access to a private field

```
public String getColor() {
    return color;
}
public void setColor(String newColor) {
    color = newColor;
}
```


Example without getter/setter

```
public class Student {
   public String first;
   public String last;
   public int id;
   public Student(…){…}
}
public class Exam {
   public int grade;
   public Student student;
   public Exam(…){…}
}
```


Example without getter/setter

```
class StudentExample {
  public static void main(String[] args) {
    // defines a student and her exams
    // lists all student's exams
    Student s=new Student("Alice","Green",1234);
    Exam e = new Exam(30);
    e.student = s;
    // print vote
    System.out.println(e.grade);
    // print student
    System.out.println(e.student.last);
  }
}
```


Example with getter/setter

```
class StudentExample {
  public static void main(String[] args) {
    Student s = new Student("Alice", "Green",
                            1234);
    Exam e = new Exam(30);

    e.setStudent(s);
    // prints its values and asks students to
    // print their data
    e.print();
  }
}
```


Example with getter/setter

```
public class Student {

  private String first;
  private String last;
  private int id;

  public String toString() {
   return first + " " +
             last  + " " +
             id;
  }
}
```

Example with getter/setter

```
public class Exam {
    private int grade;
    private Student student;
    public void print() {
    System.out.println("Student " +
        student.toString() + "got " + grade);
    }
    public void setStudent(Student s) {
    this.student =s;
    }
}
```


Array

Array

- An array is an ordered sequence of variables of the same type which are accessed through an index
- Can contain both primitive types or object references (but no object values)
- Array dimension can be defined at run-time, during object creation (cannot change afterwards)

Array declaration

- An array reference can be declared with one of these equivalent syntaxes

```
int[] a;
int a[];
```

- In Java an array is an Object and it is stored in the heap
- Array declaration allocates memory space for a reference, whose default value is null

Array creation

- Using the new operator…

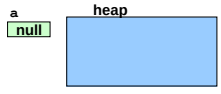
```
int[] a;
a = new int[10];
String[] s = new String[5];
```

- …or using static initialization, filling the array with values

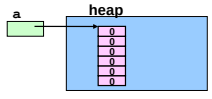
```
int[] primes = {2,3,5,7,11,13};
Person[] p = { new Person("John"),
        new Person("Susan") };
```


Example – primitive types

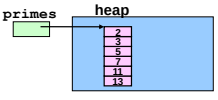
```
int[] a;
```




```
a = new int[6];
```

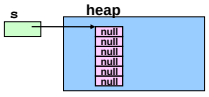



```
int[] primes =
  {2,3,5,7,11,13};
```

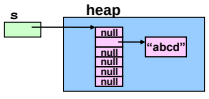


Example – object references

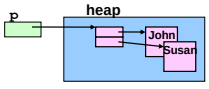
```
String[] s = new
  String[6];
```




```
s[1] = new
  String("abcd");
```




```
Person[] p =
{new Person("John") ,
 new Person("Susan")};
```



Operations on arrays

- Elements are selected with brackets [ ] (C-like)
  - But Java makes **bounds checking**
- Array length (number of elements) is given by attribute length

```
for (int i=0; i < a.length; i++)
    a[i] = i;
```


Operations on arrays

- An array reference is not a pointer to the first element of the array
- It is a pointer to the array object
- Arithmetic on pointers does not exist in Java

For each

- New loop construct:

  `for( Type var : set_expression )`
  - Notation very compact
  - *set_expression* can be
    - either an array
    - a class implementing `Iterable`
  - The compiler can generate automatically loop with correct indexes
  - Thus less error prone

For each – example

- Example:

```
for(String arg: args){
  //...
}
```

  - is equivalent to

```
for(int i=0; i<args.length;++i){
  String arg= args[i];
  //...
}
```

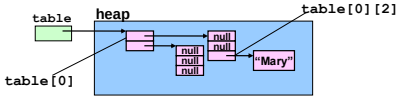

Homework

- Create an object representing an ordered list of integer numbers (at most 100)
- print()
  - prints current list
- add(int) and add(int[])
  - Adds the new number(s) to the list

Multidimensional array

- Implemented as array of arrays

```
Person[][] table = new Person[2][3];
table[0][2] = new Person("Mary");
```



Rows and columns

- As rows are not stored in adjacent positions in memory they can be easily exchanged

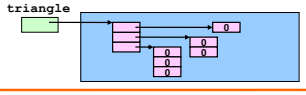
```
double[][] balance = new double[5][6];
...
double[] temp = balance[i];
balance[i] = balance[j];
balance[j] = temp;
```


Rows with different length

- A matrix (bidimen-sional array) is indeed an array of arrays

```
int[][] triangle = new int[3][]
```


```
for (int i=0; i< triangle.length; i++)
    triangle[i] = new int[i+1];
```



Tartaglia's triangle

- Write an application printing out the following Tartaglia's triangle

```
1
1  1
1  2  1
1  3  3  1
1  4  6  4  1
1  5 10 10  5  1
1  6 15 20 15  6  1
```

4 = 3 + 1

Package

Motivation

- Class is a better element of modularization than a procedure
- But it is still little
- For the sake of organization, Java provides the package feature

Package

- A package is a logic set of class definitions
- These classes are made of several files, all stored in the same directory
- Each package defines a new scope (i.e., it puts bounds to visibility of names)
- It's then possible to use same class names in different package without name-conflicts

Package name

- A package is identified by a name with a hierarchic structure (*fully qualified name*)
  - E.g. **java.lang** (String, System, …)
- Conventions to create unique names
  - Internet name in reverse order
  - `it.polito.myPackage`

Example

- java.awt
  - Window
  - Button
  - Menu
- java.awt.event (sub-package)
  - MouseEvent
  - KeyEvent

Creation and usage

- Creation:
  - Package statement at the beginning of each class file

```
package packageName;
```

- Usage:
  - Import statement at the beginning of class file (where needed)

```
import packageName.className;
import java.awt.*;
```

Import single class (class name is in scope)

Import all classes but not the sub packages

Access to a class in a package

- Referring to a method/class of a package

```
int i = myPackage.Console.readInt()
```

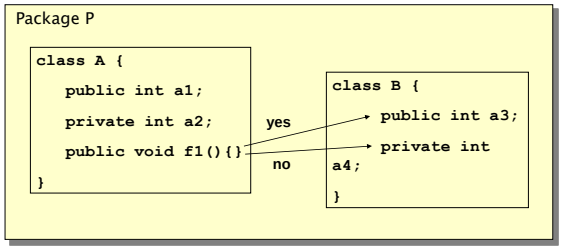
- If two packages define a class with the same name, they cannot be both imported
- If you need both classes you have to use one of them with its fully-qualified name:

```
import java.sql.Date;
Date d1; // java.sql.Date
java.util.Date d2 = new java.util.Date();
```


Package and scope

- Scope rules also apply to packages
- The "interface" of a package is the set of public classes contained in the package
- Hints
  - Consider a package as an entity of modularization
  - Minimize the number of classes, attributes, methods visible outside the package

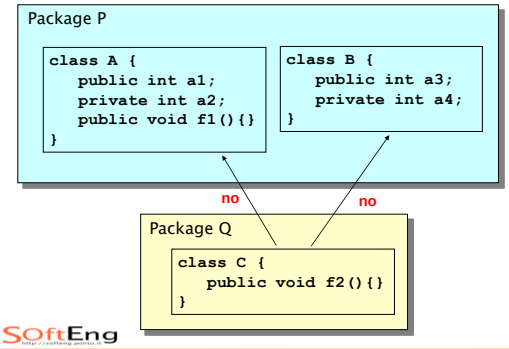
Package visibility



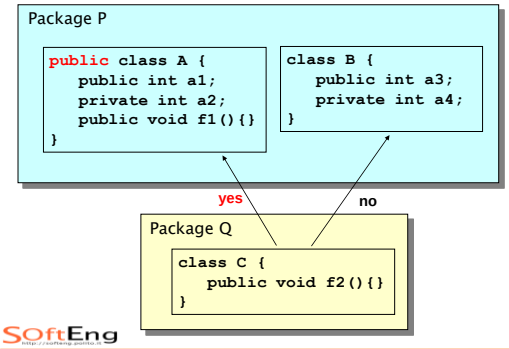
Visibility w/ multiple packages

- public class A { }
  - Public methods/attributes of A are visible outside the package
- class B { }
  - No method/attribute of B is visible outside the package

Multiple packages



Multiple packages



Access rules

	Method in the same class	Method of other class in the same package	Method of other class in other package
Private attribute/ method	Yes	No	No
Package attribute / method	Yes	Yes	No
Public attribute / method on package class	Yes	Yes	No
Public attribute / method on public class	Yes	Yes	Yes

Static attributes and methods

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Class variables

- Represent properties which are common to all instances of an object
- But they exist even when no object has been instantiated
- They are defined with the static modifier
- Access: *ClassName.attribute*

```
class Car {
  static int numberOfWheels = 4;
}

int y = Car.numberOfWheels;
```


Static methods

- Static methods are not related to any instance
- They are defined with the static modifier
- Access: *ClassName.method()*

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

```
double y = Math.cos(x);  // static method
```


Enum

- Defines an enumerative type

```
public enum Suits {
   SPADES, HEARTS, DIAMONDS, CLUBS
}
```

- Variables of enum types can assume only one of the enumerated values

```
Suits card = Suits.HEARTS;
```

- They allow much more strict static checking compared to integer constants (used e.g. in C)

Enum

- Enum can be declared outside or inside a class, but NOT within a method
- Enums are not Strings or ints, but more like a kind of class but constructor can't be invoked directly, conceptually like this:

```
class Suits {
  public static final Suits HEARTS= new Suits ("HEARTS",0);
  public static final Suits DIAMONDS= new Suits ("DIAMONDS",1);
  public static final Suits CLUBS= new Suits ("CLUBS", 2);
  public static final Suits SPADES= new Suits ("SPADES", 3);
  public Suits (String enumName, int  index) {…}
}
```


Wrapper classes for built-in types

Motivation

- In an ideal OO world, there are only classes and objects
- For the sake of efficiency, Java use primitive types (int, float, etc.)

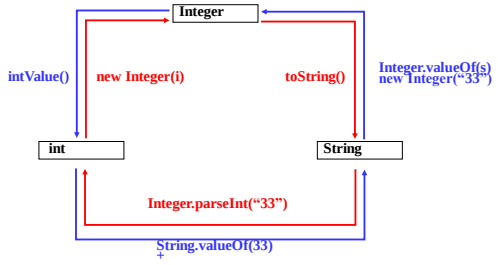
- Wrapper classes are object versions of the primitive types
- They define conversion operations between different types

Wrapper Classes

Defined in java.lang package

Primitive type	Wrapper Class
boolean	Boolean
char	Character
byte	Byte
short	Short
int	Integer
long	Long
float	Float
double	Double
void	Void

Conversions



Example

```
Integer obj = new Integer(88);
String s = obj.toString();
int i = obj.intValue();

int j = Integer.parseInt("99");
int k = (new Integer(99)).intValue();
```


Autoboxing

- In Java 5 an automatic conversion between primitive types and wrapper classes (autoboxing) is performed.

```
Integer i= new Integer(2); int j;
j = i + 5;
  //instead of:
j = i.intValue()+5;
i = j + 2;
   //instead of:
i = new Integer(j+2);
```


Variable arguments

- It is possible to pass a variable number of arguments to a method using the varargs notation

```
method( Object ... args )
```

- The compiler assembles an Object array that can be used to scan the passed parameters

Variable arguments – example

```
static void plst(String pre, Object...args){
   System.out.print(pre);
   for(Object o:args){
      if(o!=args[0]) System.out.print(", ");
      System.out.print(o);
   }
   System.out.println();
}
public static void main(String[] args) {
   plst("List:","A",'b',123, "ciao");
}
```

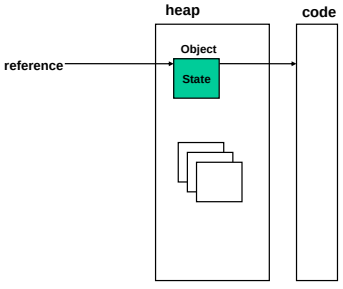
Memory management

Memory types

Depending on the kind of elements they include:

- Static memory
  - elements living for all the execution of a program (class definitions, static variables)
- Heap (dynamic memory)
  - elements created at run-time (with 'new')
- Stack
  - elements created in a code block (local variables and method parameters)

Objects are stored in the heap



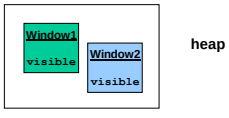
Types of variables

- **Instance variables** (or fields or attributes)
  - Stored within objects (in the heap)
- **Local Variables**
  - Stored in the Stack
- **Static Variables**
  - Stored in static memory

Instance Variables

- Declared within a Class (attributes)

```
Class Window {
   boolean visible;
…
```



- There is a different copy in each instance of the Class
- Create/initialized whenever a new instance of a Class is created

Local Variables

- Declared within a method or a code block
- Stored in the stack
- Created at the beginning of the code block where they are declared
- Automatically destroyed at the end of the code block

```
Class Window {
   …
   void resize () {
      int i;
      for (i=0; i<5; i++) { … }
   } // here i is destroyed
```

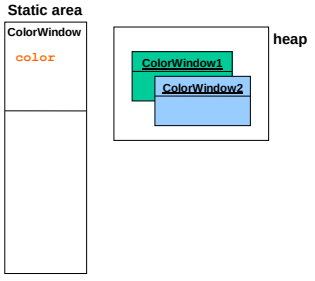
Static Variables

- Declared in classes or methods with **`static`** modifier

```
Class ColorWindow {
    static String color;
…
```

- Only ONE copy is stored in static memory
  - ♦ associated to a Class => also called Class variables
- Created/initialized during Class-loading in memory

Static variables in memory



Object destruction

- It's not made explicitely but it is made by the JVM when there are no more references to the object

  ⇒Programmer must not worry about objects destruction

Garbage collector

- Is a component of the JVM that has to clean heap memory from 'dead' objects
- After a period of time it analyzes references and objects in memory
- ...and then it deallocates objects with no active references