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Introduction to JAVA
- slides -

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Introduction to Java

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Introduction

- Java is a very powerful language that has generated a lot of interest in the last years.
Introduction

- It is a general purpose concurrent object oriented language, with a syntax similar to C and C++, but omitting features that are complex and unsafe.

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Introduction

• The world wide web has popularized the use of Java, because programs can be transparently downloaded with web pages and executed in any computer with a Java capable browser.

• A Java application is a standalone Java program that can be executed independently of any web browser.

• A Java applet is a program designed to be executed under a Java capable browser.
The Java platform

- Java programs are compiled to Java byte-codes, a kind of machine independent representation. The program is then executed by an interpreter called the Java Virtual Machine (JVM).
The Java platform

- The compiled code is independent of the architecture of the computer.
- The price to pay is a slower execution.
A first example

```java
/**
 * Hello World Application
 * Our first example
 */
public class HelloWorld {
    public static void main(String[] args) {
        System.out.println("Hello World!"); // display output
    }
}
```

$ javac HelloWorld.java

$ ls
HelloWorld.class
HelloWorld.java

$ java HelloWorld
Hello World
The **javadoc** utility can be used to generate automatically documentation for the class.

```java
/**
 * My first <b>Test</b>
 * @author Carlos Kavka
 * @version 1.1
 */
public class HelloWorld {
    /**
     * @param args the command line arguments
     * @since 1.0
     */
    public static void main(String[] args) {
        System.out.println("Hello World");
    }
}
```
Documentation

Method Summary

static void main(java.lang.String[] args)
Main function

Methods inherited from class java.lang.Object

clone, equals, finalize, getClass, hashCode, notify, notifyAll, toString, wait, wait, wait

Constructor Detail

Main

public Main();
Creates a new instance of Main

Method Detail

main

public static void main(java.lang.String[] args);
Main function

Parameters:
args - the command line arguments

Since:
1.0
Fundamental types

- Java provides ten fundamental types:
  - integers: `byte`, `short`, `int` and `long`
  - floating point: `float` and `double`.
  - characters: `char`.
  - `boolean`
  - `void`
  - String
Variables

The variables are declared specifying its type and name, and initialized in the point of declaration, or later with the assignment expression:

```java
int x;
double f = 0.33;
char c = 'a';
String s = "abcd";

x = 55;
```
Literals

- The integer values can be written in decimal, hexadecimal, octal and long forms:

```plaintext
int x = 34;       // decimal value
int y = 0x3ef;    // hexadecimal
int z = 0772;     // octal
long m = 240395922L; // long
```

- The floating point values are of type `double` by default:

```plaintext
double d = 6.28;       // 6.28 is a double value
float f = 6.28F;       // 6.28F is a float value
```
Literals

- The character values are specified with the standard C notation, with extensions for Unicode values:

```java
char c = 'a';  // character lowercase a
char d = '\n';  // newline
char e = '\u2122'  // unicode character (TM)
```

- The boolean values are `true` and `false`:

```java
boolean ready = true;  // boolean value true
boolean late = false;  // boolean value false
```
Constants

- Constants are declared with the word `final` in front. The specification of the initial value is compulsory:

```java
final double pi = 3.1415;  // constant PI
final int maxSize = 100;   // integer constant
final char lastLetter = 'z';  // last lowercase letter
final String word = "Hello";  // a constant string
```
Expressions

- Java provides a rich set of expressions:
  - Arithmetic
  - Bit level
  - Relational
  - Logical
  - Strings related
Arithmetic expressions

- Java provides the usual set of arithmetic operators:
  - addition (+)
  - subtraction (-)
  - division (/)
  - multiplication (*)
  - modulus (%)
Arithmetic operators

class Arithmetic {
    public static void main(String[] args) {
        int x = 12;
        int y = 2 * x;
        System.out.println(y);
        int z = (y - x) % 5;
        System.out.println(z);
        final float pi = 3.1415F;
        float f = pi / 0.62F;
        System.out.println(f);
    }
}

$ java Arithmetic
24
2
5.0669355
Arithmetic operators

- Shorthand operators are provided:

```java
class ShortHand {
    public static void main(String[] args) {
        int x = 12;

        x += 5; // x = x + 5
        System.out.println(x);

        x *= 2; // x = x * 2
        System.out.println(x);
    }
}
```

```
$ java ShortHand
17
34
```
Arithmetic operators

- Pre and post operators are also provided:

```java
class Increment {
    public static void main(String[] args) {
        int x = 12, y = 12;

        System.out.println(x++); // printed and then incremented
        System.out.println(x);

        System.out.println(++y); // incremented and then printed
        System.out.println(y);
    }
}
```

```
$ java Increment
12 13 13 13
```
Relational expressions

• Java provides the following relational operators:
  - equivalent (==)
  - not equivalent (!=)
  - less than (<)
  - greater than (>)
  - less than or equal (<=)
  - greater than or equal (>=)

• Important: relational expressions always return a **boolean** value.
Relational Expressions

class Boolean {
    public static void main(String[] args) {
        int x = 12, y = 33;

        System.out.println(x < y);
        System.out.println(x != y - 21);

        boolean test = x >= 10;
        System.out.println(test);
    }
}

$ java Boolean
true
false
true
Bit level operators

• Java provides the following operators:
  - and (&)
  - or (|)
  - not (~)
  - shift left (<<)
  - shift right with sign extension (>>)
  - shift right with zero extension (>>>)

• **Important**: char, short and byte arguments are promoted to int before and the result is an int.
class Bits {
    public static void main(String[] args) {
        int x = 0x16; // 00000000000000000000000000010110
        int y = 0x33; // 00000000000000000000000000110011
        System.out.println(x & y); // 00000000000000000000000000010010
        System.out.println(x | y); // 00000000000000000000000000110111
        System.out.println(~x); // 11111111111111111111111111101001
        x &= 0xf; // 00000000000000000000000000000110
        System.out.println(x); // 00000000000000000000000000000110
        short s = 7; // 0000000000000111
        System.out.println(~s); // 11111111111111111111111111111000
    }
}
class Bits2 {
    public static void main(String[] args) {
        int x = 0x16; //00000000000000000000000000010110
        System.out.println(x << 3);//0000000000000000000000001011000

        int y = 0xfe;  //00000000000000000000000011111110
        y >>= 4; //00000000000000000000000000001111
        System.out.println(y); //00000000000000000000000000001111

        x = 9;    //00000000000000000000000000001001
        System.out.println(x >> 3);//00000000000000000000000000000001
        System.out.println(x >>>3);//00011111111111111111111111111110

        x = -9;      //11111111111111111111111111111110
        System.out.println(x >> 3);//11111111111111111111111111111110
        System.out.println(x >>>3);//00011111111111111111111111111110
    }
}
Logical operators

• Java provides the following operators:
  - and (&&)
  - or (||)
  - not(!)

• **Important**: The logical operators can only be applied to **boolean** expressions and return a **boolean** value.
Logical operators

class Logical {
    public static void main(String[] args) {
        int x = 12, y = 33;
        double d = 2.45, e = 4.54;

        System.out.println(x < y && d < e);
        System.out.println(!(x < y));

        boolean test = 'a' > 'z';
        System.out.println(test || d - 2.1 > 0);
    }
}

$ java Logical
true
false
true
String operators

• Java provides many operators for Strings:
  - Concatenation (+)
  - many more...

• *Important*: If the expression begins with a string and uses the + operator, then the next argument is converted to a string.

• *Important*: Strings cannot be compared with == and !=.
String operators

class Strings {
    public static void main(String[] args) {

        String s1 = "Hello" + " World!";
        System.out.println(s1);

        int i = 35, j = 44;
        System.out.println("The value of i is " + i + " and the value of j is " + j);
    }
}

$ java Strings
Hello World!
The value of i is 35 and the value of j is 44
String operators

class Strings2 {
    public static void main(String[] args) {

        String s1 = "Hello";
        String s2 = "Hello";

        System.out.println(s1.equals(s2));
        System.out.println(s1.equals("Hi"));
    }
}

$ java Strings2
true
false
Casting

- Java performs a automatic type conversion in the values when there is no risk for data to be lost.

```java
class TestWide {
    public static void main(String[] args) {
        int a = 'x'; // 'x' is a character
        long b = 34; // 34 is an int
        float c = 1002; // 1002 is an int
        double d = 3.45F; // 3.45F is a float
    }
}
```
Casting

In order to specify conversions where data can be lost it is necessary to use the cast operator.

class TestNarrow {
    public static void main(String[] args) {
        long a = 34;
        int b = (int)a; // a is a long
        double d = 3.45;
        float f = (float)d; // d is a double
    }
}
Control structures

- Java provides the same set of control structures than C.

- *Important*: the value used in the conditional expressions must be a **boolean**.
class If {
    public static void main(String[] args) {
        char c = 'x';

        if ((c >= 'a' && c <= 'z') || (c >= 'A' && c <= 'Z'))
            System.out.println("letter: " + c);
        else
            if (c >= '0' && c <= '9')
                System.out.println("digit: " + c);
            else {
                System.out.println("the character is: " + c);
                System.out.println("it is not a letter");
                System.out.println("and it is not a digit");
            }
    }
}

$ java If
letter: x
Control structures (while)

class While {
    public static void main(String[] args) {
        final float initialValue = 2.34F;
        final float step = 0.11F;
        final float limit = 4.69F;
        float var = initialValue;

        int counter = 0;
        while (var < limit) {
            var += step;
            counter++;
        }
        System.out.println("Incremented " + counter + " times");
    }
}

$ java While
Incremented 22 times
Control structures (for)

class For {
    public static void main(String[] args) {
        final float initialValue = 2.34F;
        final float step = 0.11F;
        final float limit = 4.69F;
        int counter = 0;

        for (float var = initialValue; var < limit; var += step)
            counter++;
        System.out.println("Incremented " + counter + " times");
    }
}

$ java For
Incremented 22 times
class BreakContinue {
    public static void main(String[] args) {
        for (int counter = 0; counter < 10; counter++) {
            // start a new iteration if the counter is odd
            if (counter % 2 == 1) continue;

            // abandon the loop if the counter is equal to 8
            if (counter == 8) break;

            // print the value
            System.out.println(counter);
        }
        System.out.println("done.");
    }
}

$ java BreakContinue
0 2 4 6 done.
class Switch {
    public static void main(String[] args) {

        boolean leapYear = true;
        int days = 0;

        for(int month = 1; month <= 12; month++) {
            switch(month) {
                case 1: // months with 31 days
                case 3:
                case 5:
                case 7:
                case 8:
                case 10:
                case 12:
                    days += 31;
                    break;

...
Control structures (switch)

case 2: // February is a special case
    if (leapYear)
        days += 29;
    else
        days += 28;
    break;
default: // it must be a month with 30 days
    days += 30;
    break;
}
}
System.out.println("number of days: " + days);

$ java Switch
number of days: 366
Arrays

- Arrays can be used to store a number of elements of the same type:

```java
int[] a; // an uninitialized array of integers
float[] b; // an uninitialized array of floats
String[] c; // an uninitialized array of Strings
```

- **Important**: The declaration does not specify a size. However, it can be inferred when initialized:

```java
int[] a = {13,56,2034,4,55}; // size: 5
float[] b = {1.23F,2.1F}; // size: 2
String[] c = {"Java","is","great"}; // size: 3
```
Arrays

• Other possibility to allocate space for arrays consists in the use of the operator `new`:

```java
int i = 3, j = 5;
double[] d; // uninitialized array of doubles
d = new double[i+j]; // array of 8 doubles
```

• Components of the arrays are initialized with default values:
  - 0 for numeric type elements,
  - '\0' for characters
  - `null` for references.
Arrays

- Components can be accessed with an integer index with values from 0 to length minus 1.

  ```java
  a[2] = 1000; // modify the third element of a
  ```

- Every array has a member called `length` that can be used to get the length of the array:

  ```java
  int len = a.length; // get the size of the array
  ```
Arrays

class Arrays {
   public static void main(String[] args) {
      int[] a = {2,4,3,1};

      // compute the summation of the elements of a
      int sum = 0;
      for(int i = 0;i < a.length;i++) sum += a[i];

      // create an array of the size computed before
      float[] d = new float[sum];
      for(int i = 0;i < d.length;i++) d[i] = 1.0F / (i+1);

      // print values in odd positions
      for(int i = 1;i < d.length;i += 2)
         System.out.println("d[" + i + "]=" + d[i]);
   }
}

$ java Arrays
Command line arguments

- We have seen that the method **main** has to be defined as follows:

  ```java
  public static void main(String[] args)
  ```

- Through the array argument, the program can get access to the command line arguments
class CommandArguments {
    public static void main(String[] args) {
        for(int i = 0; i < args.length; i++)
            System.out.println(args[i]);
    }
}

$ java CommandArguments Hello World
Hello
World

$ java CommandArguments

$ java CommandArguments I have 25 cents
I
have
25
cents
class Add {
    public static void main(String[] args) {
        if (args.length != 2) {
            System.out.println("Error");
            System.exit(0);
        }
        int arg1 = Integer.parseInt(args[0]);
        int arg2 = Integer.parseInt(args[1]);
        System.out.println(arg1 + arg2);
    }
}

$ java Add 234 12
246

$ java Add 24
Error
• A class is defined in Java by using the class keyword and specifying a name for it:

```java
class Book {
}
```

• New instances of the class can be created with new:

```java
Book b1 = new Book();
Book b2 = new Book();
b3 = new Book();
```
Classes

- Inside a class it is possible to define:
  - data elements, usually called instance variables
  - functions, usually called methods
- Class **Book** with instance variables:

  ```java
class Book {
    String title;
    String author;
    int numberOfPages;
}
```

- The instance variables can be accessed with the dot notation.
class Book {
    String title;
    String author;
    int numberOfPages;
}

class ExampleBooks {
    public static void main(String[] args) {
        Book b = new Book();
        b.title = "Thinking in Java";
        b.author = "Bruce Eckel";
        b.numberOfPages = 1129;
        System.out.println(b.title + " : " + b.author + " : " + b.numberOfPages);
    }
}
Constructors

• The constructors allow the creation of instances that are properly initialized.

• A constructor is a method that:
  – has the same name as the name of the class to which it belongs
  – has no specification for the return value, since it returns nothing.
class ExampleBooks2 {
    public static void main(String[] args) {
        Book b = new Book("Thinking in Java", "Bruce Eckel", 1129);
        System.out.println(b.title + " : " + b.author + " : " + b.numberOfPages);
    }
}

class Book {
    String title;
    String author;
    int numberOfPages;
    Book(String tit, String aut, int num) {
        title = tit;
        author = aut;
        numberOfPages = num;
    }
}
Default constructors

- Java provides a default constructor for the classes.
  
  ```
  b = new Book();
  ```

- This default constructor is only available when no constructors are defined in the class.
Multiple constructors

- It is possible to define more than one constructor for a single class, only if they have different number of arguments or different types for the arguments.

```
  a = new Book("Thinking in Java", "Bruce Eckel", 1129);
  b = new Book("Thinking in Java", "Bruce Eckel", 1129, "0-13-027363");
```
Multiple constructors

class Book {
    String title;
    String author;
    int numberOfPages;
    String ISBN;

    Book(String tit, String aut, int num) {
        title = tit; author = aut;
        numberOfPages = num;
        ISBN = "unknown";
    }

    Book(String tit, String aut, int num, String isbn) {
        title = tit; author = aut;
        numberOfPages = num;
        ISBN = isbn;
    }
}
class ExampleBooks3 {
    public static void main(String[] args) {
        Book b1, b2;

        b1 = new Book("Thinking in Java","Bruce Eckel",1129);
        System.out.println(b1.title + " : " + b1.author + 
                           " : " + b1.numberOfPages + " : " + b1.ISBN);
        b2 = new Book("Thinking in Java","Bruce Eckel",1129,
                       "0-13-027363-5");
        System.out.println(b2.title + " : " + b2.author + 
                           " : " + b2.numberOfPages + " : " + b2.ISBN);
    }
}

$ java ExampleBooks3
Thinking in Java : Bruce Eckel : 1129 : unknown
Thinking in Java : Bruce Eckel : 1129 : 0-13-027362-5
Methods

- A method is used to implement the messages that an instance (or a class) can receive.
- It is implemented as a function, specifying arguments and type of the return value.
- It is called by using the dot notation.
class Book {
    String title;
    String author;
    int numberOfPages;
    String ISBN;
    ...

    // compute initials of author's name
    public String getInitials() {
        String initials = "";
        for(int i = 0;i < author.length();i++) {
            char currentChar = author.charAt(i);
            if (currentChar >= 'A' && currentChar <='Z')
                initials = initials + currentChar + ".";
        }
        return initials;
    }
}
class ExampleBooks4 {
    public static void main(String[] args) {
        Book b;

        b = new Book("Thinking in Java","Bruce Eckel",1129);
        System.out.println("Initials: " + b.getInitials());
    }
}

$ java ExampleBooks4
Initials: B.E.
class ExampleBooks5 {
    public static void main(String[] args) {

        Book[] a = new Book[3];
        a[0] = new Book("Thinking in Java","Bruce Eckel",1129);
        a[1] = new Book("Java in a nutshell","David Flanagan",353);
                        "Elliott Rusty Harold",649);

        for(int i = 0;i < a.length;i++)
            System.out.println("Initials: " + a[i].getInitials());
    }
}

$ java ExampleBooks5
Initials: B.E.
Initials: D.F.
Initials: E.R.H.
Methods

Initials: B.E.

Title: "Thinking in Java"
Author: "Bruce Eckel"
Number of pages: 1129
ISBN: "unknown"

Initials: D.F.

Title: "Java in a nutshell"
Author: "David Flanagan"
Number of pages: 353
ISBN: "unknown"

Initials: E.R.H.

Title: "Java network programming"
Author: "Elliot Rusty Harold"
Number of pages: 649
ISBN: "unknown"
Equality and equivalence

class ExampleBooks6 {
    public static void main(String[] args) {

        Book b1,b2;

        b1 = new Book("Thinking in Java","Bruce Eckel",1129);
        b2 = new Book("Thinking in Java","Bruce Eckel",1129);

        if (b1 == b2)
            System.out.println("The two books are the same");
        else
            System.out.println("The two books are different");
    }
}

$ java ExampleBooks6
The two books are different
Equality and equivalence

```
b1 = new Book("Thinking in Java","Bruce Eckel",1129);
b2 = new Book("Thinking in Java","Bruce Eckel",1129);

if (b1 == b2)
    System.out.println("The two books are the same");
else
    System.out.println("The two books are different");
```
```java
class ExampleBooks6a {
    public static void main(String[] args) {

        Book b1, b2;

        b1 = new Book("Thinking in Java","Bruce Eckel",1129);
        b2 = b1;

        if (b1 == b2)
            System.out.println("The two books are the same");
        else
            System.out.println("The two books are different");
    }
}
```

$ java ExampleBooks6a
The two books are the same
Equality and equivalence

b1 = new Book("Thinking in Java","Bruce Eckel",1129);
b2 = b1;

if (b1 == b2)
    System.out.println("The two books are the same");
else
    System.out.println("The two books are different");
class Book {
    String title;
    String author;
    int numberOfPages;
    String ISBN;

    ...

    // compare two books
    public boolean equals(Book b) {
        return (title.equals(b.title) &&
                author.equals(b.author) &&
                numberOfPages == b.numberOfPages &&
                ISBN.equals(b.ISBN));
    }
}
Equality and equivalence

class ExampleBooks7 {
    public static void main(String[] args) {

        Book b1,b2;

        b1 = new Book("Thinking in Java","Bruce Eckel",1129);
        b2 = new Book("Thinking in Java","Bruce Eckel",1129);

        if (b1.equals(b2))
            System.out.println("The two books are the same");
        else
            System.out.println("The two books are different");
    }
}

$ java ExampleBooks7
The two books are the same
Class variables

- Class variables are fields that belong to the class and do not exist in each instance.
- It means that there is always only one copy of this data member, independent of the number of the instances that were created.
class Book {
    String title;
    String author;
    int numberOfPages;
    String ISBN;
    static String owner;

    ...

    public void setOwner(String name) {
        owner = name;
    }
    public String getOwner() {
        return owner;
    }
}
Class variables

class ExampleBooks8 {
    public static void main(String[] args) {

        Book b1, b2;
        b1 = new Book("Thinking in Java", "Bruce Eckel", 1129);
        b2 = new Book("Java in a nutshell", "David Flanagan", 353);
        b1.setOwner("Carlos Kavka");
        System.out.println("Owner of book b1: " + b1.getOwner());
        System.out.println("Owner of book b2: " + b2.getOwner());
    }
}

$ java ExampleBooks8
Owner of book b1: Carlos Kavka
Owner of book b2: Carlos Kavka
Class methods

• With the same idea of the static data members, it is possible to define class methods or static methods.
• These methods do not work directly with instances but with the class.
class Book {
    String title;
    String author;
    int numberOfPages;
    String ISBN;
    static String owner;

    ... 

    public static String description() {
        return "Book instances can store information on books";
    }
}
Class methods

class ExampleBooks9 {
    public static void main(String[] args) {
        Book b1 = new Book("Thinking in Java", "Bruce Eckel", 1129);
        System.out.println(b1.description());
        System.out.println(Book.description());
    }
}

$ java ExampleBooks9
Book instances can store information on books
Book instances can store information on books
A static application

• All the examples we have seen till now define a class that contains a static method called main, where usually instances from other classes are created.

• It is possible to define a class with only static methods and static data members.
A static application

class AllStatic {
    static int x;
    static String s;

    public static String asString(int aNumber) {
        return "" + aNumber;
    }

    public static void main(String[] args) {
        x = 165;
        s = asString(x);
        System.out.println(s);
    }
}

$ java AllStatic
165
Instance initialization

- All data members in an object are guaranteed to have an initial value.
- There exists a default value for all primitive types:

<table>
<thead>
<tr>
<th>type</th>
<th>initial value</th>
</tr>
</thead>
<tbody>
<tr>
<td>byte</td>
<td>0</td>
</tr>
<tr>
<td>short</td>
<td>0</td>
</tr>
<tr>
<td>int</td>
<td>0</td>
</tr>
<tr>
<td>long</td>
<td>0</td>
</tr>
<tr>
<td>float</td>
<td>0.0F</td>
</tr>
<tr>
<td>double</td>
<td>0.0</td>
</tr>
<tr>
<td>char</td>
<td>‘\0’</td>
</tr>
<tr>
<td>boolean</td>
<td>false</td>
</tr>
<tr>
<td>references</td>
<td>null</td>
</tr>
</tbody>
</table>
Instance initialization

class Values {
    int x;
    float f;
    String s;
    Book b;
}

class InitialValues {
    public static void main(String[] args) {
        Values v = new Values();
        System.out.println(v.x);
        System.out.println(v.f);
        System.out.println(v.s);
        System.out.println(v.b);
    }
}

$ java InitialValues
0 0.0 null null
Instance initialization

class Values {
    int x = 2;
    float f = inverse(x);
    String s;
    Book b;
    Values(String str) { s = str; }
    public float inverse(int value) { return 1.0F / value; }
}

class InitialValues2 {
    public static void main(String[] args) {
        Values v = new Values("hello");
        System.out.println("" + v.x + "\t" + v.f);
        System.out.println("" + v.s + "\t" + v.b);
    }
}

$ java InitialValues2
2 0.5
hello null
This keyword **this**

- The keyword **this**, when used inside a method, refers to the receiver object.
- It has two main uses:
  - to return a reference to the receiver object from a method
  - to call constructors from other constructors.
The keyword **this**

- For example, the method `setOwner` in the previous `Book` class could have been defined as follows:

```java
public Book setOwner(String name) {
    owner = name;
    return this;
}
```

```java
Book b1 = new Book("Thinking in Java","Bruce Eckel",1129);
System.out.println(b1.setOwner("Carlos Kavka").getInitials());
System.out.println(b1.getOwner());
```

B.E.
Carlos Kavka
The keyword **this**

- The class `Book` has two constructors:

```java
Book(String tit, String aut, int num) {
    title = tit; author = aut; numberOfPages = num;
    ISBN = "unknown";
}
Book(String tit, String aut, int num, String isbn) {
    title = tit; author = aut; numberOfPages = num;
    ISBN = isbn;
}
```

- The second can be defined in terms of the first one:

```java
Book(String tit, String aut, int num, String isbn) {
    this(tit, aut, num);
    ISBN = isbn;
}
```
An example: complex class

class TestComplex {
    public static void main(String[] args) {
        Complex a = new Complex(1.33, 4.64);
        Complex b = new Complex(3.18, 2.74);
        Complex c = a.add(b);

        System.out.println("c=a+b= " + c.getReal() + " " + c.getImaginary());

        Complex d = c.sub(a);
        System.out.println("d=c-a= " + d.getReal() + " " + d.getImaginary());
    }
}

$ java TestComplex
  c=a+b= 4.51 7.38  d=c-a= 3.18 2.74
An example: complex class

```java
class Complex {
    double real; // real part
    double im;   // imaginary part

    Complex(double r, double i) {
        real = r;
        im = i;
    }

    public double getReal() {
        return real;
    }

    public double getImaginary() {
        return im;
    }
}
```

```java
a = Complex(1.33, 4.64)

double realPart = a.getReal()

double imPart = a.getImaginary()
```
An example: complex class

```java
// add two complex numbers
public Complex add(Complex x) {
    return new Complex(real + x.real, im + x.im);
}
```

Complex c = a.add(b);
// subtract two complex numbers
public Complex sub(Complex c) {
    return new Complex(real - c.real, im - c.im);
}

Complex d = c.sub(a);
An example: complex class

- The method `addReal` increments just the real part of the receptor of the message with the value passed as argument:

```java
public Complex addReal(double x) {
    real += x;
    return this;
}
```

```
Complex a = new Complex(1.33, 4.64);
a.addReal(2.0);
a.addReal(3.0).addReal(3.23);
```
An example: complex class

- We must be careful if we want to create one complex number as a copy of the other:

1. `Complex a = new Complex(1.33, 4.64);`
2. `Complex e = a;`

What will be the effect of

```
e.addReal(5.6);    
```
An example: complex class

- We can define a new constructor to avoid the problem:

```java
Complex(Complex x) {
    this(x.real, x.im);
}
```

1. Complex a = new Complex(1.33, 4.64);
2. Complex e = new Complex(a);
Inheritance

• Inheritance allows to define new classes by reusing other classes, specifying just the differences.

• It is possible to define a new class (subclass) by saying that the class must be *like* other class (superclass):

```java
class ScientificBook extends Book {
    String area;
    boolean proceeding = false;
}
```
Inheritance (hierarchy)

- **Object**
  - **String**
  - **Book**
    - **ScientificBook**
    - **ScienceFiction**
  - **AbstractCollection**
    - **Novel**
      - **Crime**
Inheritance (constructors)

class ScientificBook extends Book {
    String area;
    boolean proceeding = false;

    ScientificBook(String tit, String aut,
                   int num, String isbn, String a) {
        super(tit, aut, num, isbn);
        area = a;
    }
}

ScientificBook sb;

sb = new ScientificBook(
    "Neural Networks",
    "Simon Haykin", 696, "0-02-352761-7",
    "Artificial Intelligence");
Inheritance (constructors)

```
Book b = new Book("Thinking in Java","Bruce Eckel",1129);

ScientificBook sb = new ScientificBook(
    "Neural Networks",
    "Simon Haykin",696,"0-02-352761-7",
    "Artificial Intelligence");
```
Inheritance (methods)

- New methods can be defined in the subclass to specify the behavior of the objects of this class.
- When a message is sent to an object, the method is searched for in the class of the receptor object.
- If it is not found then it is searched for higher up in the hierarchy.
Inheritance (inheriting methods)

```java
ScientificBook sb;

sb = new ScientificBook("Neural Networks","Simon Haykin", 696,
  "0-02-352761-7","Artificial Intelligence");
System.out.println(sb.getInitials());

S.H.
```
Inheritance (overriding methods)

class ScientificBook extends Book {
    String area;
    boolean proceeding = false;

    ScientificBook(String tit, String aut,
                   int num, String isbn, String a) {
        super(tit, aut, num, isbn);
        area = a;
    }

    public boolean equals(ScientificBook b){
        return super.equals(b) &&
               area.equals(b.area) &&
               proceeding == b.proceeding;
    }
}

Book

equals(...)

ScientificBook

equals(...)
Inheritance (overriding methods)

- Two possible solutions:

```java
public boolean equals(ScientificBook b) {
    return super.equals(b) && area.equals(b.area) && proceeding == b.proceeding;
}
```

```java
public boolean equals(ScientificBook b) {
    return (title.equals(b.title) && author.equals(b.author) && numberOfPages == b.numberOfPages
            && ISBN.equals(b.ISBN) && area.equals(b.area) && proceeding == b.proceeding;
}
```

Which one is better?
class ScientificBook extends Book {
    String area;
    boolean proceeding = false;

    ScientificBook(String tit, String aut, int num, String isbn, String a) {
        ...
    }

    public boolean equals(ScientificBook b) {
        ...
    }

    public static String description() {
        return "ScientificBook instances can" +
                " store information on " +
                " scientific books";
    }
}
Inheritance (new methods)

```java
class ScientificBook extends Book {
    String area;
    boolean proceeding = false;

    ScientificBook(String tit, String aut,
                  int num, String isbn, String a) {
        super(tit, aut, num, isbn);
        area = a;
    }
    ...

    public void setProceeding() {
        proceeding = true;
    }

    public boolean isProceeding() {
        return proceeding;
    }
}
```

Book

equals(...)
description(...)

ScientificBook

equals(...)
description(...)
setProceeding(...)
isProceeding(...)

Carlos Kavka  First Latin American Workshop on Distributed Laboratory Instrumentation Systems  96
Inheritance (new methods)

class TestScientificBooks {
    public static void main(String[] args) {
        ScientificBook sb1, sb2;

        sb1 = new ScientificBook("Neural Networks","Simon Haykin",
                                 696,"0-02-352761-7",
                                 "Artificial Intelligence");

        sb2 = new ScientificBook("Neural Networks","Simon Haykin",
                                 696,"0-02-352761-7",
                                 "Artificial Intelligence");

        sb2.setProceeding();
        System.out.println(sb1.getInitials());
        System.out.println(sb1.equals(sb2));
        System.out.println(sb2.description());
    }
}

$ java TestScientificBooks
S.H.   false
ScientificBook instances can store information on scientific books
instanceof

- **instanceof** is an operator that determines if an object is an instance of a specified class:

```java
Book b1 = new Book("Thinking in Java","Bruce Eckel",1129);
System.out.println(b1 instanceof Book);
```

> True
**getClass()**

- **getClass()** returns the runtime class of an object:

```java
Book b1 = new Book("Thinking in Java","Bruce Eckel",1129);
System.out.println(b1.getClass().getName());
```

```
Book
```
```
class TestClass {
    public static void main(String[] args) {
        Book b1 = new Book("Thinking in Java","Bruce Eckel",1129);
        ScientificBook sb1 = new ScientificBook("Neural Networks",
                          "Simon Haykin",696,"0-02-352761-7",
                          "Artificial Intelligence");

        System.out.println(b1.getClass().getName());
        System.out.println(sb1.getClass().getName());
        System.out.println(b1 instanceof Book);
        System.out.println(sb1 instanceof Book);
        System.out.println(b1 instanceof ScientificBook);
        System.out.println(sb1 instanceof ScientificBook);
    }
}
```

```
$ java TestClass
class Book
class ScientificBook
true true false true
```
Packages

• A package is a structure in which classes can be organized.

• It can contain any number of classes, usually related by purpose or by inheritance.

• If not specified, classes are inserted into the default package.
Packages

- The standard classes in the system are organized in packages:

```java
import java.util.*; // or import java.util.Date

class TestDate {
    public static void main(String[] args) {
        System.out.println(new Date());
    }
}

$ java TestDate
```
Packages

- Package name is defined by using the keyword `package` as the first instruction:

```java
package myBook;

class Book {
    String title;
    String author;
    int numberOfPages;
}
```

```java
package myBook;

class ExampleBooks {
    public static void main(String[] args) {
        Book b = new Book();
        b.title = "Thinking in Java";
        b.author = "Bruce Eckel";
        b.numberOfPages = 1129;
        System.out.println(b.title + " : " + b.author + " : " + b.numberOfPages);
    }
}
```
Packages

- Files have to be stored in special directories accessible on the class path ($CLASSPATH):

Example of use:

```java
package it.infn.ts;

class Book {
    ...
}

import it.infn.ts.Book;

class TestBook {
    ...
        Book b = new Book(...);
    ...
}
```
Access control

- It is possible to control the access to methods and variables from other classes with the modifiers:
  - public
  - private
  - protected
Access control

• The default access allows full access from all classes that belong to the same package.

• For example, it is possible to set the proceeding condition of a scientific book in two ways:

  ```java
  sbl.setProceeding();
  ```

• or by just accessing the data member:

  ```java
  sbl.proceeding = true;
  ```
Access control

- Usually we do not want direct access to a data member in order to guarantee encapsulation:

```java
class ScientificBook extends Book {
    private String area;
    private boolean proceeding = false;
    ..............
}
```

- Now, the proceeding condition can only be asserted with the message:

```java
sb1.setProceeding();    // fine
sb1.proceeding = true;  // wrong
```
Access control

- The same access control can be applied to methods.

```java
class ScientificBook extends Book {
    private String area;
    private boolean proceeding = false;
    ................

    private boolean initialized() {
        return title != null && author != null &&
                numberOfPages != 0 && area != null;
    }
}
```

Where can initialized() be called from?
Final and abstract

- The modifiers **final** and **abstract** can be applied to classes and methods:
  - **final:**
    - A final class does not allow subclassing.
    - A final method cannot be redefined in a subclass.
  - **abstract:**
    - An abstract class is a class that cannot be instantiated.
    - An abstract method has no body, and it must be redefined in a subclass.
Final and abstract

- An example: the class IOBoard and its subclasses.
abstract class IOBoard {
    String name;
    int  numErrors = 0;

    IOBoard(String s) {
        System.out.println("IOBoard constructor");
        name = s;
    }
    final public void anotherError() {
        numErrors++;
    }
    final public int getNumErrors() {
        return numErrors;
    }
    abstract public void initialize();
    abstract public void read();
    abstract public void write();
    abstract public void close();
}
class IOSerialBoard extends IOBoard {
    int port;

    IOSerialBoard(String s, int p) {
        super(s); port = p;
        System.out.println("IOSerialBoard constructor");
    }

    public void initialize() {
        System.out.println("initialize method in IOSerialBoard");
    }

    public void read() {
        System.out.println("read method in IOSerialBoard");
    }

    public void write() {
        System.out.println("write method in IOSerialBoard");
    }

    public void close() {
        System.out.println("close method in IOSerialBoard");
    }
}
```java
class IOEthernetBoard extends IOBoard {
    long networkAddress;

    IOEthernetBoard(String s, long netAdd) {
        super(s); networkAddress = netAdd;
        System.out.println("IOEthernetBoard constructor");
    }
    public void initialize() {
        System.out.println("initialize method in IOEthernetBoard");
    }
    public void read() {
        System.out.println("read method in IOEthernetBoard");
    }
    public void write() {
        System.out.println("write method in IOEthernetBoard");
    }
    public void close() {
        System.out.println("close method in IOEthernetBoard");
    }
}
```
Final and abstract

- Creation of a serial board instance:

```java
class TestBoards1 {
   public static void main(String[] args) {
      IOSerialBoard serial = new IOSerialBoard("my first port", 0x2f8);
      serial.initialize();
      serial.read();
      serial.close();
   }
}
```

$ java TestBoards1
IOBoard constructor
IOSerialBoard constructor
initialize method in IOSerialBoard
read method in IOSerialBoard
close method in IOSerialBoard
class TestBoards2 {
    public static void main(String[] args) {
        IOBoard[] board = new IOBoard[3];

        board[0] = new IOSerialBoard("my first port", 0x2f8);
        board[1] = new IOEthernetBoard("my second port", 0x3ef8dda8);
        board[2] = new IOEthernetBoard("my third port", 0x3ef8dda9);

        for(int i = 0; i < 3; i++)
            board[i].initialize();

        for(int i = 0; i < 3; i++)
            board[i].read();

        for(int i = 0; i < 3; i++)
            board[i].close();
    }
}
Interfaces

• An interface describes what classes should do, without specifying how they should do it.

• An interface looks like a class definition where:
  − all fields are static and final
  − all methods have no body and are public
  − no instances can be created from interfaces.
Interfaces

• An interface for specifying IO boards behavior:

```java
interface IOBoardInterface {
    public void initialize();
    public void read();
    public void write();
    public void close();
}
```

• An interface for specifying nice behavior:

```java
interface NiceBehavior {
    public String getName();
    public String getGreeting();
    public void sayGoodBye();
}
```
class IOSerialBoard2 implements IOBoardInterface {
    int port;

    IOSerialBoard(String s, int p) {
        super(s); port = p;
        System.out.println("IOSerialBoard constructor");
    }

    public void initialize() {
        System.out.println("initialize method in IOSerialBoard");
    }

    public void read() {
        System.out.println("read method in IOSerialBoard");
    }

    public void write() {
        System.out.println("write method in IOSerialBoard");
    }

    public void close() {
        System.out.println("close method in IOSerialBoard");
    }
}
A class can implement more than one interface.

```java
class IOSerialBoard2 implements IOBoardInterface,
               NiceBehavior {
    ....
}
```

Which methods should it implement?
Exceptions

• The usual behavior on runtime errors is to abort the execution:

```java
class TestExceptions1 {
    public static void main(String[] args) {
        String s = "Hello";
        System.out.print(s.charAt(10));
    }
}
```

$ java TestExceptions1
Exception in thread "main"
java.lang.StringIndexOutOfBoundsException:
String index out of range: 10
at java.lang.String.charAt(String.java:499)
at TestExceptions1.main(TestExceptions1.java:11)
Exceptions

• The exception can be trapped:

class TestExceptions2 {
   public static void main(String[] args) {

      String s = "Hello";
      try {
         System.out.print(s.charAt(10));
      } catch (Exception e) {
         System.out.println("No such position");
      }
   }
}

$ java TestExceptions2
No such position
Exceptions

• It is possible to specify interest on a particular exception:

```java
class TestExceptions3 {
    public static void main(String[] args) {
        String s = "Hello";
        try {
            System.out.print(s.charAt(10));
        } catch (StringIndexOutOfBoundsException e) {
            System.out.println("No such position");
        }
    }
}

$ java TestExceptions3
No such position
```
Exceptions

- It is possible to send messages to an exception object:

```java
class TestExceptions4 {
    public static void main(String[] args) {
        String s = "Hello";
        try {
            System.out.print(s.charAt(10));
        } catch (StringIndexOutOfBoundsException e) {
            System.out.println("No such position");
            System.out.println(e.toString());
        }
    }
}
```

$ java TestExceptions4
No such position
java.lang.StringIndexOutOfBoundsException:
String index out of range: 10
Exceptions

• We can add multiple catch blocks and a finally clause:

```java
class MultipleCatch {
    public void printInfo(String sentence) {
        try {
            // get first and last char before the dot
            char first = sentence.charAt(0);
            char last = sentence.charAt(sentence.indexOf("." ) - 1);
            String out = String.format("First: %c Last: %c", first, last);
            System.out.println(out);
        } catch (StringIndexOutOfBoundsException e1) {
            System.out.println("Wrong sentence, no dot");
        } catch (NullPointerException e2) {
            System.out.println("Non valid string");
        } finally {
            System.out.println("done");
        }
    }
}
```
class MultipleCatch {
    public void printInfo(String sentence) {
        try {
            // get first and last char before the dot
            char first = sentence.charAt(0);
            char last = sentence.charAt(sentence.indexOf(".")) - 1;
            String out = String.format("First: %c Last: %c", first, last);
            System.out.println(out);
        } catch (StringIndexOutOfBoundsException e1) {
            System.out.println("Wrong sentence, no dot?");
        } catch (NullPointerException e2) {
            System.out.println("Non valid string");
        } finally {
            System.out.println("done!");
        }
    }
    
    String sentence = "A test sentence.";
    MultipleCatch mc = new MultipleCatch();
    mc.printInfo(sentence);
}
class MultipleCatch {
    public void printInfo(String sentence) {
        try {
            // get first and last char before the dot
            char first = sentence.charAt(0);
            char last = sentence.charAt(sentence.indexOf("." ) - 1);
            String out = String.format("First: %c Last: %c", first, last);
            System.out.println(out);
        } catch (StringIndexOutOfBoundsException e1) {
            System.out.println("Wrong sentence, no dot?");
        } catch (NullPointerException e2) {
            System.out.println("Non valid string");
        }
        finally {
            System.out.println("done!");
        }
    }
}

String sentence = "A test sentence";
MultipleCatch mc = new MultipleCatch();
mc.printInfo(sentence);
class MultipleCatch {
    public void printInfo(String sentence) {
        try {
            // get first and last char before the dot
            char first = sentence.charAt(0);
            char last = sentence.charAt(sentence.indexOf(".") - 1);
            String out = String.format("First: %c Last: %c", first, last);
            System.out.println(out);
        } catch (StringIndexOutOfBoundsException e1) {
            System.out.println("Wrong sentence, no dot?");
        } catch (NullPointerException e2) {
            System.out.println("Non valid string");
        } finally {
            System.out.println("done!");
        }
    }
}

String sentence = null;
MultipleCatch mc = new MultipleCatch();
mc.printInfo(sentence);

Non valid string done!
Exceptions

• There exists a set of predefined exceptions that can be caught.
• In some cases it is compulsory to catch exceptions.
• It is also possible to express the interest to not to catch even compulsory exceptions.
Input - Output

• Input output in Java is rather complicated.
• However, input output from files, devices, memory or web sites is performed in the same way.
• It is based on the idea of streams:
  – An *input stream* is a data source that can be accessed in order to get data.
  – An *output stream* is a data sink, where data can be written.
Input - Output

- Streams can be classified in:
  - byte streams
    - provides support also for fundamental types.
  - character streams
    - Unicode, but with OS character support.

- Streams can be:
  - non buffered
  - buffered
import java.io.*;

class WriteBytes {
    public static void main(String[] args) {
        int data[] = { 10, 20, 30, 40, 255 };

        FileOutputStream f;
        try {
            f = new FileOutputStream("file1.data");
            for(int i = 0; i < data.length; i++)
                f.write(data[i]);
            f.close();
        } catch (IOException e) {
            System.out.println("Error with files:"+e.toString());
        }
    }
}
```java
import java.io.*;

class ReadBytes {
    public static void main(String[] args) {

        FileInputStream f;
        try {
            f = new FileInputStream("file1.data");
            int data;
            while((data = f.read()) != -1)
                System.out.println(data);
            f.close();
        } catch (IOException e) {
            System.out.println("Error with files:"+e.toString());
        }
    }
}
```

$ java ReadBytes
10 20 30 40 255
import java.io.*;

class WriteArrayBytes {
    public static void main(String[] args) {
        byte data[] = { 10, 20, 30, 40, -128 };

        FileOutputStream f;
        try {
            f = new FileOutputStream("file1.data");
            f.write(data, 0, data.length);
            f.close();
        } catch (IOException e) {
            System.out.println("Error with files:" + e.toString());
        }
    }
}
import java.io.*;

class WriteBufferedBytes {
    public static void main(String[] args) {
        int data[] = { 10,20,30,40,255 };    
        FileOutputStream f;
        BufferedOutputStream bf;

        try {
            f = new FileOutputStream("file1.data");
            bf = new BufferedOutputStream(f);
            for(int i = 0;i < data.length;i++)
                bf.write(data[i]);
            bf.close();
        } catch (IOException e) {
            System.out.println("Error with files:"+e.toString());
        }
    }
}
import java.io.*;

class ReadBufferedBytes {
    public static void main(String[] args) {
        FileInputStream f; BufferedInputStream bf;
        try {
            f = new FileInputStream("file1.data");
            bf = new BufferedInputStream(f);
            int data;
            while((data = bf.read()) != -1)
                System.out.println(data);
            bf.close();
        } catch (IOException e) {
            System.out.println("Error with files:"+e.toString());
        }
    }
}

$ java ReadBufferedBytes
10 20 30 40 255
Input - Output

- A data buffered byte oriented stream can deal with data in small pieces (fundamental types).
- The following messages are provided:
  - `readBoolean()` `writeBoolean(boolean)`
  - `readByte()` `writeByte(byte)`
  - `readShort()` `writeShort(short)`
  - `readInt()` `writeInt(int)`
  - `readLong()` `writeLong(long)`
  - `readFloat()` `writeFloat(float)`
  - `readDouble()` `writeDouble(double)`
import java.io.*;

class WriteData {
    public static void main(String[] args) {
        double data[] = { 10.3, 20.65, 8.45, -4.12 };  
        FileOutputStream f; BufferedOutputStream bf;
        DataOutputStream ds;
        try {
            f = new FileOutputStream("file1.data");
            bf = new BufferedOutputStream(f);
            ds = new DataOutputStream(bf);
            ds.writeInt(data.length);
            for (int i = 0; i < data.length; i++)
                ds.writeDouble(data[i]);
            ds.writeBoolean(true); ds.close();
        } catch (IOException e) {
            System.out.println("Error with files:");
        }
    }
}
import java.io.*;

class ReadData {
    public static void main(String[] args) {
        FileInputStream f; BufferedInputStream bf;
        DataInputStream ds;
        try {
            f = new FileInputStream("file1.data");
            bf = new BufferedInputStream(f);
            ds = new DataInputStream(bf);
            int length = ds.readInt();
            for(int i = 0;i < length;i++)
                System.out.println(ds.readDouble());
            System.out.println(ds.readBoolean());
            ds.close();
        } catch (IOException e) {
            System.out.println("Error with files:"+e.toString());
        }
    }
}
The character oriented streams can be used to read and write characters.

There exists three methods that can be used to write data into this kind of streams:

- `write(String,int,int)`
- `write(char[],int,int)`
- `newLine()`
import java.io.*;

class WriteText {
    public static void main(String[] args) {
        FileWriter f;
        BufferedWriter bf;
        try {
            f = new FileWriter("file1.text");
            bf = new BufferedWriter(f);
            String s = "Hello World!";
            bf.write(s,0,s.length());
            bf.newLine();
            bf.write("Java is nice!!!",8,5);
            bf.newLine();
            bf.close();
        } catch (IOException e) {
            System.out.println("Error with files:");
        }
    }
}
import java.io.*;

class ReadText {
    public static void main(String[] args) {
        FileReader f;
        BufferedReader bf;
        try {
            f = new FileReader("file1.text");
            bf = new BufferedReader(f);
            String s;
            while ((s = bf.readLine()) != null)
                System.out.println(s);
            bf.close();
        } catch (IOException e) {
            System.out.println("Error with files:" + e.toString());
        }
    }
}
import java.io.*;

class StandardInput {
    public static void main(String[] args) {
        InputStreamReader isr;
        BufferedReader br;
        try {
            isr = new InputStreamReader(System.in);
            br = new BufferedReader(isr);
            String line;
            while ((line = br.readLine()) != null) {
                System.out.println(line);
            }
        } catch (IOException e) {
            System.out.println("Error with standard input");
        }
    }
}
import java.io.*;

class ReadWithScanner {
    public static void main(String[] args) {

        try {
            Scanner sc = new Scanner(System.in);
            int sum = 0;
            while (sc.hasNextInt()) {
                int anInt = sc.nextInt();
                sum += anInt;
            }
            System.out.println(sum);
        } catch (IOException e) {
            System.out.println("Error with standard input");
        }
    }
}
Threads

• It is possible to run concurrently different tasks called threads.
• The threads can communicate between themselves.
• Their access to shared data can be synchronized.
class CharThread extends Thread {
    char c;
    CharThread(char aChar) {
        c = aChar;
    }
    public void run() {
        while (true) {
            System.out.println(c);
            try {
                sleep(100);
            } catch (InterruptedException e) {
                System.out.println("Interrupted");
            }
        }
    }
}
class TestThreads {
    public static void main(String[] args) {
        CharThread t1 = new CharThread('a');
        CharThread t2 = new CharThread('b');

        t1.start();
        t2.start();
    }
}

$ java TestThreads
a
b
a
b
...

Threads
Threads

• A typical producer - consumer application:

class ProducerConsumer {
  public static void main(String[] args) {
    Buffer buffer = new Buffer(10);
    Producer prod = new Producer(buffer);
    Consumer cons = new Consumer(buffer);

    prod.start();
    cons.start();
  }
}
Threads

• Insertion and removal of elements in the buffer:
• Going beyond the limit of the buffer:

![Diagram showing the movement of elements in a buffer with head and tail pointers.](image-url)
class Producer extends Thread {
    Buffer buffer;
    public Producer(Buffer b) {
        buffer = b;
    }
    public void run() {
        double value = 0.0;
        while (true) {
            buffer.insert(value);
            value += 0.1;
        }
    }
}

class Consumer extends Thread {
    Buffer buffer;
    public Consumer(Buffer b) {
        buffer = b;
    }
    public void run() {
        while (true) {
            char element = buffer.delete();
            System.out.println(element);
        }
    }
}
class Buffer {
    double buffer[];
    int head = 0, tail = 0, size = 0, numElements = 0;

    public Buffer(int s) {
        buffer = new double[s];
        size = s;
    }
    public void insert(double element) {
        buffer[tail] = element; tail = (tail + 1) % size;
        numElements++;
    }
    public double delete() {
        double value = buffer[head]; head = (head + 1) % size;
        numElements--;
        return value;
    }
}
Threads

- The implementation does not work!

  - The methods `insert()` and `delete()` operate concurrently over the same structure.
  - The method `insert()` does not check if there is at least one slot free in the buffer
  - the method `delete()` does not check if there is at least one piece of data available in the buffer.

- There is a need for synchronization.
Synchronized access to a critical resource can be achieved with **synchronized** method:

- They are not allowed to be executed concurrently on the same instance.
- Each instance has a lock, used to synchronize the access.
Threads

- Threads are synchronized with `wait` and `notify`:
  - The message `wait` puts the calling thread to sleep, releasing the lock.
  - The message `notify` awakens a waiting thread on the corresponding lock.
Threads

Producer → Buffer → Consumer

synchronized insert() → notify() → synchronized delete()

wait() → empty buffer → synchronized delete()
public synchronized void insert(double element) {
    if (numElements == size) {
        try {
            wait();
        } catch(InterruptedException e) {
            System.out.println("Interrupted");
        }
    }
    buffer[tail] = element;
    tail = (tail + 1) % size;
    numElements++;
    notify();
}
public synchronized double delete() {
    if (numElements == 0) {
        try {
            wait();
        } catch (InterruptedException e) {
            System.out.println("Interrupted");
        }
    }
    double value = buffer[head];
    head = (head + 1) % size;
    numElements--;
    notify();
    return value;
}
Jar files

• When we were compiling the example of the Producer and Consumer, four class files were generated:

```bash
$ ls *.class
Buffer.class
Consumer.class
ProducerConsumer.class
Producer.class
```

• In order to distribute the executable application it is necessary to copy the four files.
Jar files

- A **JAR** (Java ARchive) file can be created and manipulated by the command jar.

- In order to create a **JAR** file, it is necessary to define a manifest file, which contains information on the files included.

- The command jar creates a default manifest file in the directory **META-INF** with name **MANIFEST.MF**, just below the current directory.
Jar files

- The creation of the JAR file can be done as follows:

  $ jar cmf mylines.txt ProducerConsumer.jar \
  ProducerConsumer.class Producer.class \
  Consumer.class Buffer.class

- with:

  $ cat mylines.txt
  Main-Class: ProducerConsumer

- The application can be executed as follows:

  $ java -jar ProducerConsumer.jar
Jar files

• It contents can be displayed as follows:

   $ jar tf ProducerConsumer.jar
   META-INF/
   META-INF/MANIFEST.MF
   ProducerConsumer.class
   Producer.class
   Consumer.class
   Buffer.class

• Note that a manifest file was added:

   Manifest-Version: 1.0
   Main-Class: ProducerConsumer
   Created-By: 1.2.2 (Sun Microsystems Inc.)
Ant

- Ant is a building tool that provides support to compile, pack, deploy and document Java applications.
- In some sense, its functionality is similar to the make command, except that the approach is completely different.
- The specifications for the ant command are defined in term of XML sentences.
- Ant can be extended in an object oriented sense.
Ant

• An example of a **build.xml** file:

```xml
<?xml version="1.0"?>
<!-- first build file -->
<project name="HelloWorld" default="build" basedir="."/>
<target name="build">
<javac srcdir="." />
</target>
</project>
```

```
# ant
Buildfile: build.xml
build:
[javac] Compiling 1 source file
BUILD SUCCESSFUL
Total time: 3 seconds
```
Ant

• A *project* specifies three elements:
  - `name`
  - `target`
  - `basedir`

• A *target* specifies five elements:
  - `name`
  - `depends`
  - `if`
  - `unless`
  - `description`
Ant

- Properties are like variables:

```
<property name="conditionOK" value="yes"/>
<property name="src-dir" location="src"/>
```

- The values can be obtained by placing the property name between `$` and `$`.  

```
<javac srcdir="$\{src-dir\}"/>
```
Ant

• An example:

Complex

src

build

dist

Complex.java  TestComplex.java

Complex.class  TestComplex.class

complex.jar

four tasks:
• clean
• init
• build
• dist
<?xml version="1.0"?>
<!-- first build file -->
<project name="Complex" default="dist" basedir=".">

<!-- set global properties -->

<property name="src-dir" location="src"/>
<property name="build-dir" location="build"/>
<property name="dist-dir" location="dist"/>

<target name="init" description="initial task">

<!-- Create the build directory -->

<mkdir dir="${build-dir}"/>
</target>
</project>
<target name="build" depends="init"
    description="compile task">
    <javac srcdir="${src-dir}" destdir="${build-dir}"/>
</target>

<target name="dist" depends="build"
    description="build distribution">
    <mkdir dir="${dist-dir}"/>

    <jar jarfile="${dist-dir}/complex.jar"
        basedir="${build-dir}">
        <include name="*.class"/>
        <manifest>
            <attribute name="Main-Class" value="TestComplex"/>
        </manifest>
    </jar>
</target>
Ant

```xml
<target name="clean" description="clean up">
   <delete dir="${build-dir}"/>
   <delete dir="${dist-dir}"/>
</target>

</project>

$ ant
Buildfile: build.xml
init:
   [mkdir] Created dir: ComplexNumbers/build
build:
   [javac] Compiling 2 source files to ComplexNumbers/build
dist:
   [mkdir] Created dir: ComplexNumbers/dist
   [jar] Building jar: ComplexNumbers/dist/complex.jar
BUILD SUCCESSFUL
Total time: 11 seconds
```
Java on the TINI

- In order to be able to execute an application developed in Java on the TINI, it is necessary to follow a four steps process:

1. **Compilation**
   - Test.java

2. **Conversion**
   - Test.class

3. **Transfer**
   - Test.tini

4. **Execution**
   - Execution device image
Java on the TINI

• Step 1: compilation

  $ javac HelloWorld.java

• Step 2: conversion

  $ java -classpath /tini/bin/tini.jar TINIConvertor \
       -f HelloWorld.class \
       -d /tini/bin/tini.db -o HelloWorld.tini
Java on the TINI

• Step 3: transfer

$ ftp tini
Connected to tini.
220 Welcome to slush. (Version 1.17) Ready for user login.
User (tini:(none)): root
331 root login allowed. Password required.
Password:
230 User root logged in.
ftp> bin
200 Type set to Binary
ftp> put HelloWorld.tini
200 PORT Command successful.
150 BINARY connection open, putting HelloWorld.tini
226 Closing data connection.
ftp: 183 bytes sent in 0.00 Seconds.
ftp> bye
Java on the TINI

• Step 4: execution

```bash
# telnet tini
Connected to tini.
Escape character is '^['.
Welcome to slush. (Version 1.17)
tini00a93c login: root
tini00a93c password:

TINI /> java HelloWorld.tini
HelloWorld
```
<?xml version="1.0" encoding="UTF-8"?>

<project name="HelloWorld" default="convert" basedir=".">
    <taskdef name="tini" classname="net.geeba.ant.Tini"/>
    <property name="tini.dir" value="/tini"/>
    <property name="tini.db" value="${tini.dir}/bin/tini.db"/>
    <property name="tini.classes" value="${tini.dir}/bin/tiniclasses.jar"/>
    <property name="tini.jar" value="${tini.dir}/bin/tini.jar"/>
    <target name="init" description="initialize">
        <mkdir dir="build"/>
    </target>
</project>
<target name="build" depends="init" description="compile">
  <javac srcdir="src" destdir="build"
    bootclasspath="${tini.classes}"/>
</target>

<target name="convert" depends="build" description="convert">
  <tini outputfile="HelloWorld.tini" database="${tini.db}"
    classpath="${tini.jar}">
    <convert dir="build"/>
  </tini>
</target>

<target name="clean" description="clean">
  <delete dir="build"/>
  <delete file="HelloWorld.tini"/>
</target>
</project>
$ ant
Buildfile: build.xml
init:
  [mkdir] Created dir: HelloWorldAnt/build
build:
  [javac] Compiling 1 source file to HelloWorldAnt/build
convert:
  [tini] TINIConvertor (KLA)
  [tini] Version 1.24 for TINI 1.1 (Beta 2 and later ONLY!!!)
  [tini] Built on or around March 20, 2002
  [tini] Copyright (C) 1996 - 2002 Dallas Semiconductor Corp.
  [tini] Loading class HelloWorldAnt/build/HelloWorld.class
      from file HelloWorldAnt/build/HelloWorld.class
  [tini] Getting UNMT...there are 0 user native methods
  [tini] Class HelloWorld, size 125, CNUM 8000, TH Contrib: 19
  [tini] Initial length of the application: 125
  [tini] Output file size : 472
  [tini] Number of string table entries: 1
BUILD SUCCESSFUL
Total time: 8 seconds