

JAVA

Introduction

Course information

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- <https://d3s.mff.cuni.cz/teaching/nprg013/>
- **2/2 Zk/Z**
- exam
 - written test
- “zápočet”
 - practical test **in the lab**
 - “zápočtový” program
 - "reasonable" size
 - **topic till 8. 1. 2021**
 - by email
 - homeworks – 225 points (450 max)
 - ~~presence~~
 - ~~> 3 absences – 315 points~~

Course information

- Virtual practical for repeated “subscription”
 - and those who do not want to attend
- List of “forbidden” topics for the “započtový” program
 - tick-tack-toe (“piškvorky”)
 - battleships
 - tetris
 - ...
 - homeworks for courses like Algorithms, Graphics,...
 - ...
- always agree on the topic with a particular teaching assistant

Literature, links

- “Homepage”
 - <https://www.oracle.com/java/>
- Java tutorial (warning – for Java 8)
 - <https://docs.oracle.com/javase/tutorial/tutorialLearningPaths.html>
- Java Language Specification
 - <http://docs.oracle.com/javase/specs/>

Java

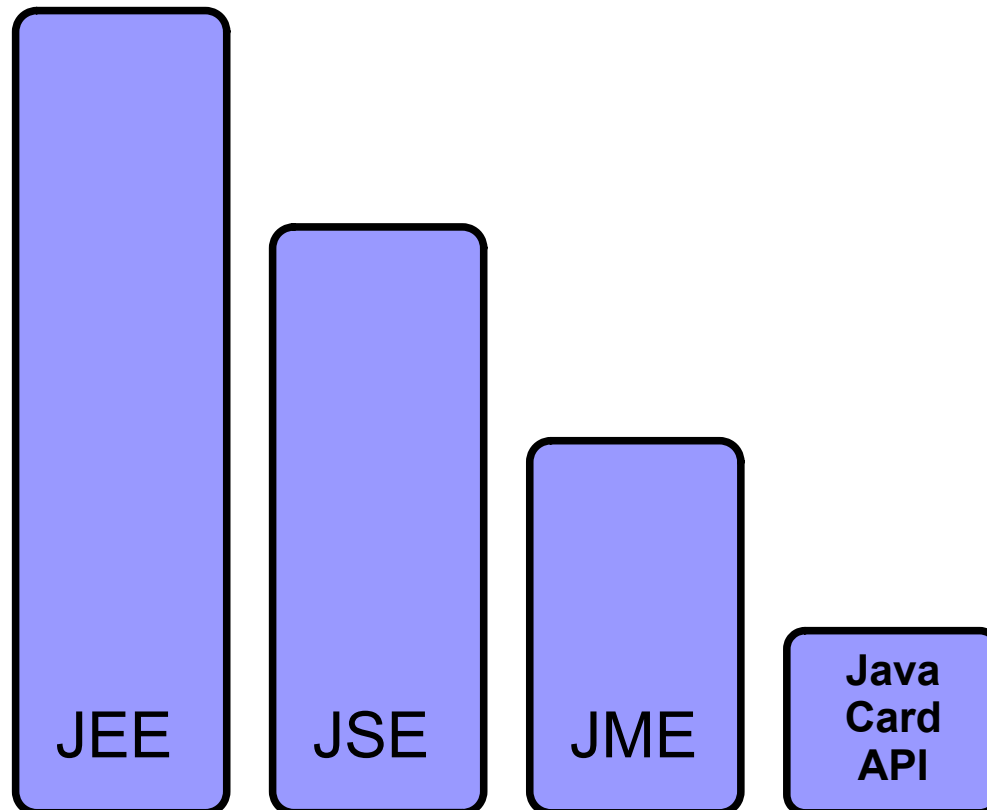
- object oriented
 - (almost) all is object
- interpreted
 - source code (.java) – compiled to the *bytecode*
 - bytecode (.class) – interpreted by the *virtual machine*
 - just-in-time compilation
 - compilation of the bytecode to a native code before/during program execution
- platform independent
 - programs run in the *virtual machine*
- since Java 9
 - ahead-of-time compilation

History

- 1.0 (1996)
- 1.1 (1997)
 - Inner classes
- Java 2 platform (2000)
 - 1.2, 1.3 – changes in libraries only
- 1.4 (2002)
 - Assert
- 5.0 (2004) – changes in the language – generics, annotations,...
- 6 (2006) – changes in libraries only
- 7 (2011) – (small) changes in the language
- 8 (2014) – big changes in the language – lambdas,...
- 9 (2017) – changes in the language – modules
- 10 (2018) – changes in the lang. – loc. var. type inference (var)
- 11 (2018) – changes in libraries (reducing std lib.)
 - long-term support
- 12 (2019) – modified switch (a “preview” feature)
- 13 (2019) – further switch modifications, text blocks (still “preview”)
- 14 (2020) – switch (preview: plus records, text blocks, instanceoff pattern matching)
- 15 (2020) – text blocks (preview: records, instanceoff pattern matching, sealed classes)

Java platform

- JSE – standard edition
- JEE – enterprise edition
- JME – micro edition



Obtaining Java

- <https://www.oracle.com/java/technologies/javase-downloads.html>
 - JDK
 - compiler, virtual machine, debugger, ...
 - Windows, Linux, Solaris
 - JRE
 - without development tools (i.e. without compiler,...)
 - Windows, Linux, Solaris
 - documentation
- IDE
 - Netbeans – <http://www.netbeans.org/>
 - Eclipse – <http://www.eclipse.org/>
 - IntelliJ IDEA – <https://www.jetbrains.com/idea/>
- Ant – like the **make** program
 - <http://ant.apache.org/>
- Maven – „like Ant on Steroids“
 - <http://maven.apache.org/>
- Gradle – similar to Maven

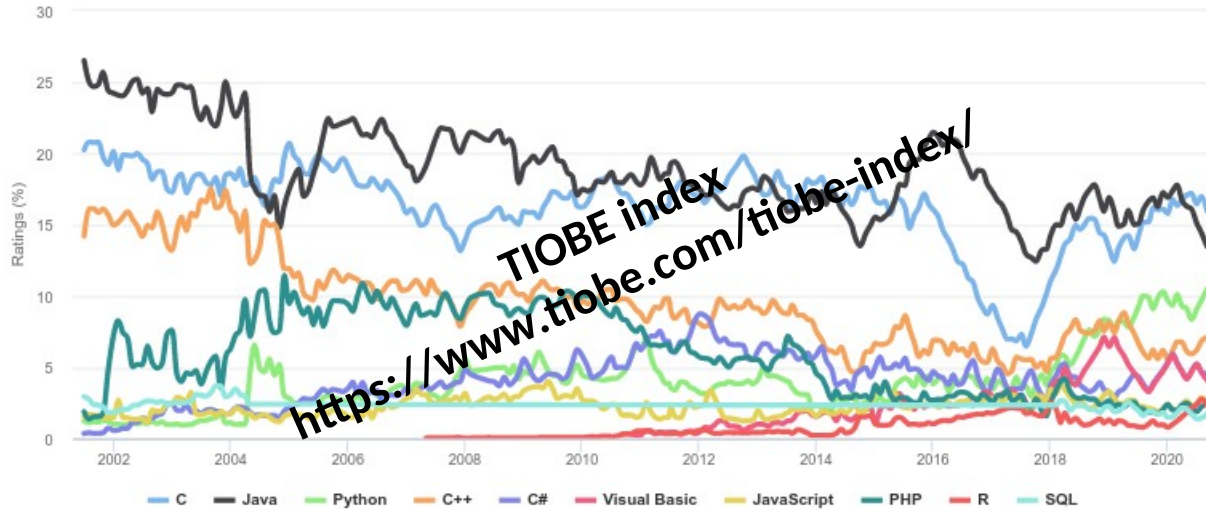
Approx. time-line of the course

- Language
 - classes, primitive types, programming constructions,...
- Basic tools
- Core classes from the std. library
 - threads, collection, I/O,...

Popularity

TIOBE Programming Community Index

Source: www.tiobe.com



Rank	Language	Type	Score
1	Python	⊕	100.0
2	Java	⊕	95.3
3	C	☐	94.6
4	C++	☐	87.0
5	JavaScript	⊕	79.5
6	R	☐	78.6
7	Arduino	⊕	77.2
8	Go	☐	73.1
9	Swift	☐	70.5
10	Matlab	☐	68.4

Worldwide, Sept 2020 compared to a year ago:

Rank	Change	Language	Share	Trend
1		Python	31.56 %	+2.9 %
2		Java	16.4 %	-3.1 %
3		Javascript	8.38 %	+0.3 %
4		C#	6.5 %	-0.8 %
5		PHP	5.85 %	-0.5 %
6		C/C++	5.8 %	+0.0 %
7		R	4.08 %	+0.0 %
8		Objective-C	2.79 %	+0.2 %
9		Swift	2.45 %	-0.1 %
10		TypeScript	1.92 %	+0.1 %

<https://spectrum.ieee.org/at-work/tech-careers/top-programming-language-2020>
 IEEE Spectrum

Popularity Index
<http://pypl.github.io/>

JAVA

Language

Comments

- Comment

```
/* comment */
```

```
// comment till the end of the line
```

- "documentation" comments (javadoc)

```
/** comment */
```

Objects

- Everything is object
- Object – an instance of a class or array
 - new instances via the operator **new**
- Everything defined in a class
 - i.e. no functions outside classes (e.g. like in C++)
- Working with objects – references
 - no pointers

```
String s;
```

```
String s = new String("hello");
```

References

```
StringBuilder s1 =  
    new StringBuilder("hello");  
StringBuilder s2 = s1;  
  
s1.append(" world");  
  
System.out.println(s2);  
    // prints out "hello world"
```

Primitive types

- Exception – not everything is object
 - variables are not references
 - fixed size, signed only

```
int a = 10;
```

Type	Size	Min	Max	Wrapper
boolean	-	-	-	Boolean
char	16-bit	Unicode 0	Unicode $2^{16}-1$	Character
byte	8-bit	-128	+127	Byte
short	16-bit	-2^{15}	$+2^{15}-1$	Short
int	32-bit	-2^{31}	$+2^{31}-1$	Integer
long	64-bit	-2^{63}	$+2^{63}-1$	Long
float	32-bit	IEEE754	IEEE754	Float
double	64-bit	IEEE754	IEEE754	Double

Primitive types – variables

```
int i1 = 42;
```

```
int i2 = i1;
```

```
i1 += 1;
```

```
System.out.println(i2);
```

```
// prints out 42
```


Primitive types

- Internal representation of integer types
 - „signed two's-complement integers“
 - example for **byte**
 - 0 ~ 00000000
 - 127 ~ 01111111
 - -1 ~ 11111111
 - -128 ~ 10000000
- Floating point types
 - allow representation of the NaN value (not-a-number)
 - every comparison of NaNs is **false**

Autoboxing, autounboxing

- since Java 5
- automated conversion between primitive types and corresponding wrappers

```
int a = 5;  
Integer b = a;    // autoboxing  
int c = b;        // autounboxing
```

Arrays

- access checked at run-time
- definitions of arrays

```
int[] iArray;  
int i2Array[];
```
- multidimensional array

```
int[][] iiArray;
```
- instantiation of arrays – only dynamically

```
iArray = new int [10];
```
- array length

```
iArray.length
```

Object disposal

- garbage collector

Class definition

```
class MyClass {  
    /* class body */  
}
```

- class body
 - fields
 - methods
 - inner/nested classes

Class: Fields

```
class MyClass {  
    int i;  
    float f;  
    boolean b;  
    String s;  
}  
  
...  
MyClass m = new MyClass();  
m.i = 5;  
m.f = 3.7;  
m.b = true;  
m.s = new String();
```

Class: Fields

- Default values
 - boolean – false
 - other primitive types – 0
 - references – null
- Warning
 - local variables are not initialized
 - compilation error

Class: Methods

```
returnType methodName ( arguments ) {  
    method body;  
}
```

```
class MyClass {  
    int pow2(int a) {  
        return a*a;  
    }  
}
```

```
    void nothing() {}  
}
```


Class: Methods

- method call

```
object.methodName (arguments)
```

```
MyClass m = new MyClass();  
int a = m.pow2(5);
```

- Arguments passed *by value*

```
class Foo {  
    void plusOne(int a) {  
        a = a + 1;  
    }  
    void use() {  
        int a = 5;  
        plusOne(a);  
        System.out.println(a); // 5  
    }  
}
```

```
class Bar {  
    void appendA(StringBuilder sb) {  
        sb.append("A");  
    }  
    void use() {  
        StringBuilder sb =  
            new StringBuilder("A");  
        appendA(sb);  
        System.out.println(sb); // AA  
    }  
}
```

enum

```
enum Planet {  
    MERCURY, VENUS, EARTH, MARS,  
    JUPITER, SATURN, URANUS, NEPTUNE,  
    PLUTO };
```

...

```
public Planet p1 = MARS;
```

Packages

- namespaces
- package
 - a set of classes related in some way
 - like `namespace` in C#, C++
- every class belongs to exactly one package
 - an explicitly specified, or
 - the default unnamed package
- package specification
`package nameOfPackage;`

Packages

- hierarchical names
 - "reversed" internet domain name of a creator
 - `cz.cuni.mff.java.example01`
 - `org.w3c.dom`
- full name of a class
 - `packageName.ClassName`
- class from the same package – "short" name
- classes from another package – full name
- simplified usage by `import`

```
import packageName.ClassName;  
import packageName.*;
```

- `package java.lang` – always imported

Key-word static

- `static` fields and methods
 - not connected with a particular instance (object)
 - "*class data*", "*class methods*"

```
class MyClass {  
    static int i;  
}
```

```
class MyClass2 {  
    static void incr() {  
        MyClass.i++;  
    }  
}
```

static import

- import of static elements
- usage without the class name

```
import static java.lang.Math.PI;  
import static java.lang.Math.tan;  
...  
tan(PI/4);
```

Local variables visibility

```
{
  int x=10;
  // x is visible
  {
    int y=11;
    // x and y are visible
  }
  // x is visible only
}
```

```
{
  int x = 1;
  {
    int x = 2; // compile-time error
  }}
```

Classes and files

- every `public` class in a separated file
- the same name as the class + the `.java` extension
- packages ~ directories

```
package packageName;
```

```
import ....;  
import .....
```

```
public class ClassName {  
    ....  
}
```

- non-public classes (without `public`)
 - visible from the same package only

Program

```
package cz.cuni.mff.java.example01;

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

- **save to**
 - directory `.../cz/cuni/mff/java/example01`
 - file `Hello.java`

Program

- **compilation**
 - `javac Hello.java`
 - **creates** `Hello.class`
- **execution**
 - `java cz.cuni.mff.java.example01.Hello`
- ***CLASSPATH***
 - list of directories, where the compiler/virtual machine looks for classes
 - environment variable `CLASSPATH`
 - arguments `-cp`, `-classpath`
 - examples
 - `/home/petr/java/cz/cuni/mff/java/example01/Hello.class`
 - `java -cp /home/petr/java cz.cuni.mff.java.example01.Hello`

Executing “sources”

- since Java 11
- `java HelloWorld.java`

Modules – since Java 9

- a module
 - a named collection of classes (and other elements)
 - (a set of packages)
 - declares, which
 - other modules it requires
 - own packages exports
 - the visibility (accessibility) of classes is changed

- module-info.java

```
module com.foo.bar {  
    requires com.foo.baz;  
    exports com.foo.bar.alpha;  
    exports com.foo.bar.beta;  
}
```

Modules – since Java 9

- MODULEPATH
 - similar to CLASSPATH
- modules can be “ignored”
 - without a module specified => a class is in the ***unnamed*** module
 - requires all other modules
 - exports all of its packages
 - particularly for backward compatibility

Operators: assignment

- Assignment

```
int i;  
int[] array;
```

```
i = 4;  
array[4] = 5;  
4 = i; // compile-time error
```

- Primitive types
 - copying values
- Objects
 - copying references
 - not objects!

Operators: arithmetic

- unary
 - + -
- binary
 - + - * / %
- "short-cuts" for assignment
 - += -= *= /= %=
- increment and decrement
 - prefix and postfix
 - i-- i++ --i ++i
- overflows and underflows are "silent"
 - no exception

Operators: comparison

- **boolean** result

`==` `!=` all types

`<` `>` `<=` `>=` all primitive except **boolean**

- **test** – what is printed out?

```
Integer i1 = new Integer(1);
Integer i2 = new Integer(1);
if (i1 == i2)
    System.out.println("YES");
else
    System.out.println("NO");
```

These constructors
are deprecated

Operators: logical

- **boolean** result
- can be used on **boolean** only

&& || !

- short-circuit evaluation

Operators: bitwise

- can be used on **short, int, long, char** and **boolean**

& | ^ ~

- short-cuts

&= |= ^=

- eager evaluation
- type **boolean**
 - considered as 1-bit value
 - operator ~ cannot be used on boolean

Operators: shifts

- can be used on **short, int, long, char**
 - left shift <<
 - adds zeros to lower bits
 - right shift >>
 - if number positive – ads zeros
 - if number negative – ads ones
 - unsigned right shift >>>
 - always adds zeros
- **char, byte, short**
 - first converted to **int**
 - result – always **int**
- **long**
 - result is **long**

Operators: misc

- Ternary operator

```
int a;  
a = a > 0 ? a : 0;
```

- Operator **comma**

- only in the beginning of the **for** cycle

- Operator **+** on **String**

- concatenates Strings

- if there is at least one String and only the **+** operators in an expression, then everything is converted to String and concatenated

- Cast

```
int i = 1;  
long x = (long) i;
```

- No sizeof operator

- no need

Operators: priority

unary	+ - ++ --
arithmetic and shift	* / % + - << >>
comparison	> < >= <= == !=
logical and bitwise	&& & ^
ternary	? :
assignment	= (shortcuts +=)

- In a case of the same priority, expression is evaluated from left

if - else

```
if (boolean-expression)
```

```
    statement
```

```
else
```

```
    statement
```

- **else** branch can be omitted
- **statement**
 - single statement, or
 - block { }

while, do - while

```
while (boolean-expression)  
    statement
```

do

```
    statement
```

```
while (boolean-expression) ;
```

- cycling while the boolean expression is true

for

```
for (initialization; boolean-expression;  
                                           step)  
    statement
```

- in the initialization and step, operator **comma** can be used

```
for (int i=1, j=1; i<5; i++, j=i*10) {  
    . . .  
}
```


for

```
int[] arr = new int [10];  
  
for (int i:arr) {  
    ...  
}
```

- arrays, or
- objects with the *iterator*

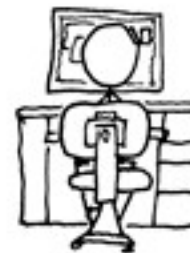
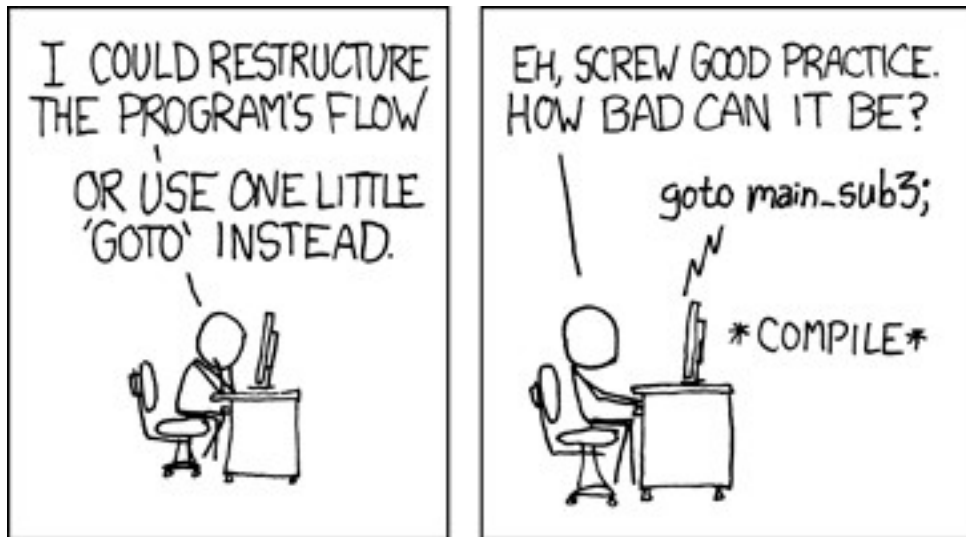
break, continue

- **break**
 - stops a cycle execution
- **continue**
 - stops the current round of a cycle and starts new one
- *labels* – have meaning only with cycles

```
label: outer-cycle {  
    inner-cycle {  
        break;  
        continue;  
        continue label;  
        break label;  
    }  
}
```

goto

- **goto**
 - reserved, but
 - not used



<http://xkcd.com/292/>

switch

```
int a;  
...  
switch (a) {  
    case 1:  
    case 2: System.out.println("1, 2");  
        break;  
    case 3: System.out.println("3");  
        break;  
    default: System.out.println("3..");  
}
```

- since Java 7, **switch** can be used with the **String** type
- since Java 14, extended **switch**



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