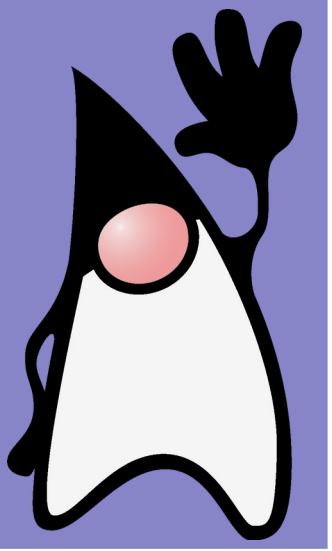
Java

Introduction



Course information

- Petr Hnětynka
  - hnetynka@d3s.mff.cuni.cz
- https://d3s.mff.cuni.cz/teaching/nprg013/

- **2/2 Zk/Z**

Exam/”Započet”

- exam
  - written test

- “zápočet”
  - home project
    - see the next slide
  - practical test (during the exam period)
  - homeworks
    - 12 (each week one of them)
    - necessary to submit at least half of them

    - 3 points each homework
    - 27 points (75%) → no need to attend the practical test
    - 32 points (90%) → test & -2 points for exam (i.e., a chance for better grade)

Course information

- Virtual practical for repeated “subscription”
  - and those who do not want to attend

- List of “forbidden” topics for the home project
  - tick-tack-toe (“piškvorky”)
  - battleships
  - tetris
  - …
  - homeworks for courses like Algorithms, Graphics,...
  - …

  - always agree on the topic with a particular practicals teacher
    - till 6th January 2023

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
  - https://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*

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, instanceof pattern matching)
- 15 (2020) – text blocks (preview: records, instanceof pattern matching, sealed classes)
- 16 (2021) – records, instanceof pattern matching
- 17 (2021) – sealed classes, ***long-term support***
- 18 (2022) – UTF-8 by default, extended javadoc (preview: switch pattern matching,…)
- 19 (2022) – (preview: record pattern matching, virtual threads,...)

Java platform

- JSE – standard edition
- JEE – enterprise edition (Jakarta EE since 2019)
- JME – micro edition

Obtaining Java

- https://www.oracle.com/java/technologies/javase-downloads.html
  - JDK – compiler, virtual machine, ...

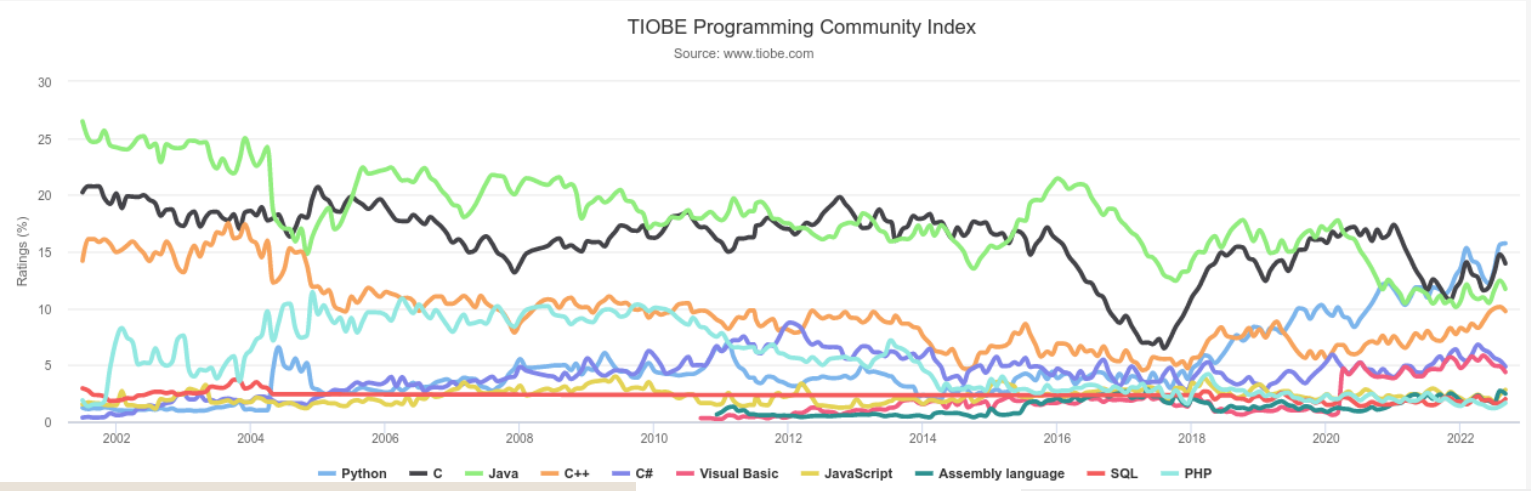
- IDE
  - Netbeans – http://www.netbeans.org/
  - Eclipse – http://www.eclipse.org/
  - IntelliJ IDEA – https://www.jetbrains.com/idea/

- 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



IEEE Spectrum
https://spectrum.ieee.org/top-programming-languages-2022

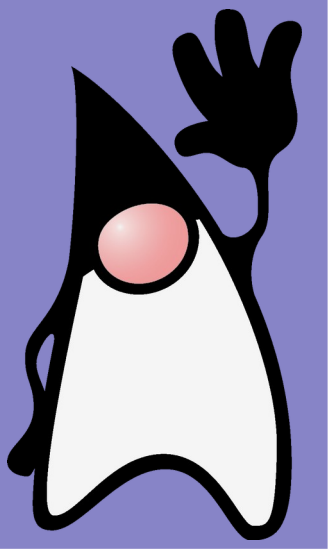
Worldwide, Sept 2022 compared to a year ago:

Rank	Change	Language	Share	Trend
1		Python	28.29 %	-1.8 %
2		Java	17.31 %	-0.7 %
3		JavaScript	9.44 %	-0.1 %
4		C#	7.04 %	-0.1 %
5		C/C++	6.27 %	-0.1 %
6		PHP	5.34 %	-1.0 %
7		R	4.18 %	+0.1 %
8	↑↑↑	TypeScript	3.05 %	+1.5 %
9	↑↑↑	Go	2.16 %	+0.6 %
10		Swift	2.11 %	+0.5 %

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

  - local variable ~ defined in a method body or in a block

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 pl = MARS;
```

- in detail later

Packages

- namespaces
- package
  - a set of types related in some way
  - like `namespace` in C#, C++

- every type 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 type
  - `packageName.ClassName`
- types from the same package – "short" name
- types 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
  }
}
```

Types and files

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

```
package packageName;

import ....;
import ....;

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

- non-public types (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 types 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 type 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?

```
String s1 = new String("hello");
String s2 = new String("hello");
if (s1 == s2) {
  System.out.println("YES");
} else {
  System.out.println("NO");
}
```

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 begging 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;
```

Operators: priority

Kind of operator	Operators
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 ommitted
- 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/

“Old” 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

“New” switch

```
switch (k) {
    case 1 -> System.out.println("one");
    case 2 -> System.out.println("two");
    case 3,4 -> System.out.println("many");
}
```

- since Java 14
- can be also used as an expression
  - details later