Programming in Java – Introduction

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Hello, World!

The Java platform

Data types

Operators

Control structures

Hello, World!

Hello, World!

HelloWorld.java

```java
public class HelloWorld {

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

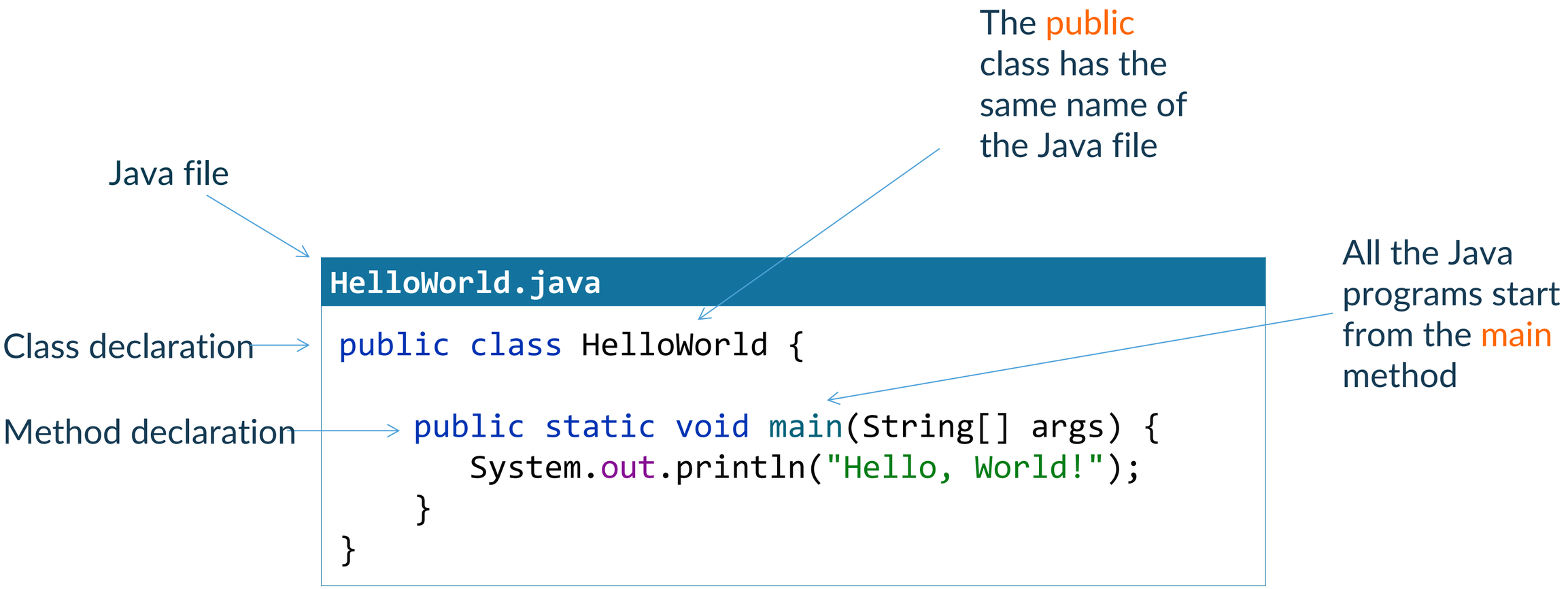
Launch Single-File Source-Code Programs

```
$ java HelloWorld.java
Hello, World!
```

Compile and Run

```
$ javac HelloWorld.java
$ ls
HelloWorld.class  HelloWorld.java
$ java HelloWorld
Hello, World!
```

Hello, World! – Analysis of the program



Hello, World! - Compilation

The java compiler javac takes a list of source Java files and it compiles the corresponding class files

A class file is compiled for each class defined in the source files

```
$ javac HelloWorld.java
$ ls
HelloWorld.class  HelloWorld.java
$ java HelloWorld
Hello, World!
```

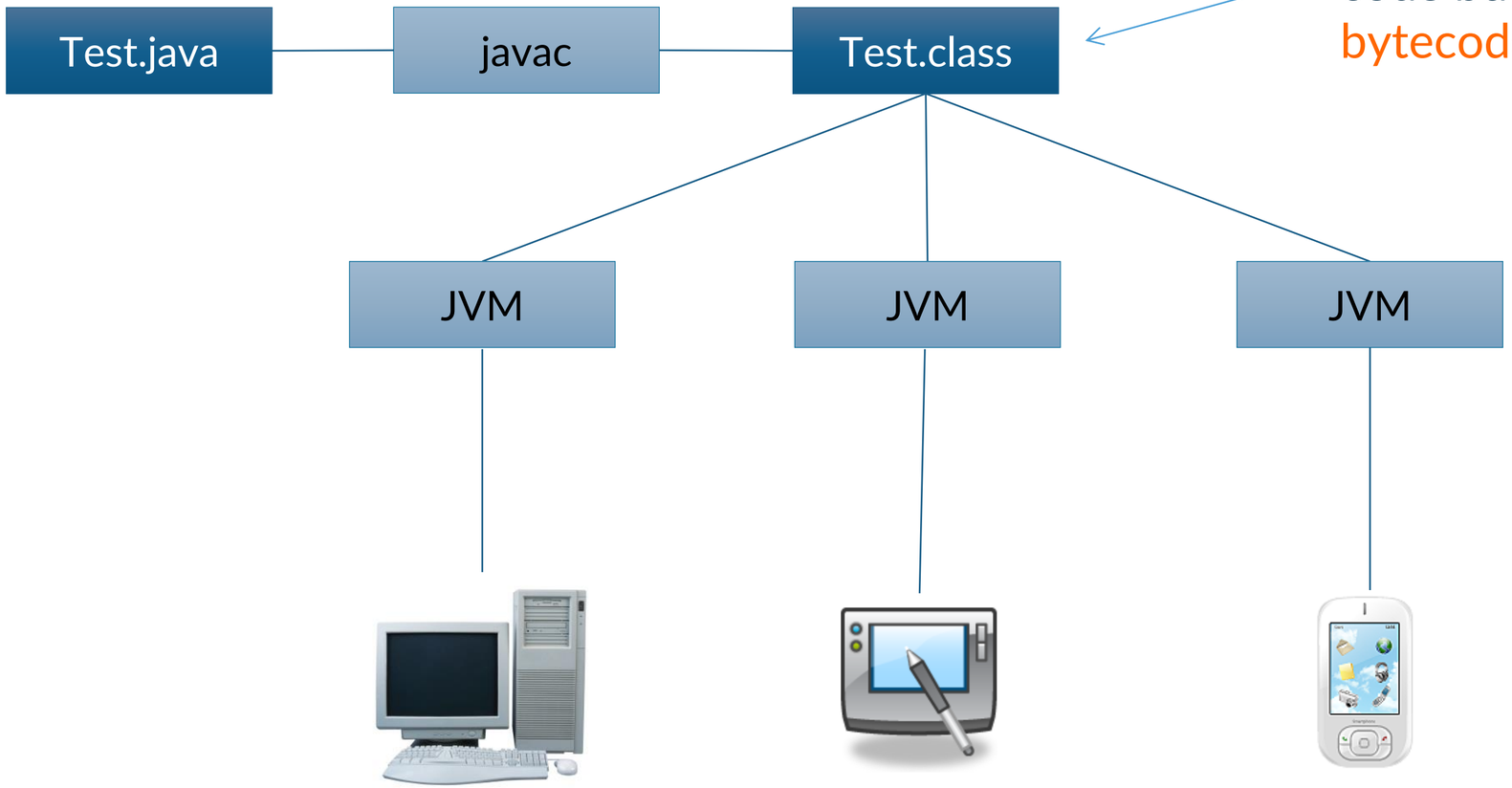
A java program is run invoking the java virtual machine (JVM) on the class containing the main method

Why do we need both java and javac to run a Java program?

The Java platform

The Java platform

The output of the java compiler is not executable code but it is the so-called bytecode



The compiled code is independent of the processor of the device in which is running

Which Java?

- The latest Java version is Java 19
  - Released in September 2022
  - Will be superseded by Java 20 in March 2023
- Java releases follow a 6 months cycle
- Java 17 is the latest Long Term Support (LTS) release
  - Initially released on 14 September 2021
  - LTS are planned every 2 years
- There are many “vendors”
  - Oracle
  - Amazon
  - IBM
  - openJDK

https://www.oracle.com/java/technologies/java-se-support-roadmap.html

JRE or JDK

Java Runtime Environment (JRE)

The JRE is the Java distribution that includes the JVM used to run Java programs

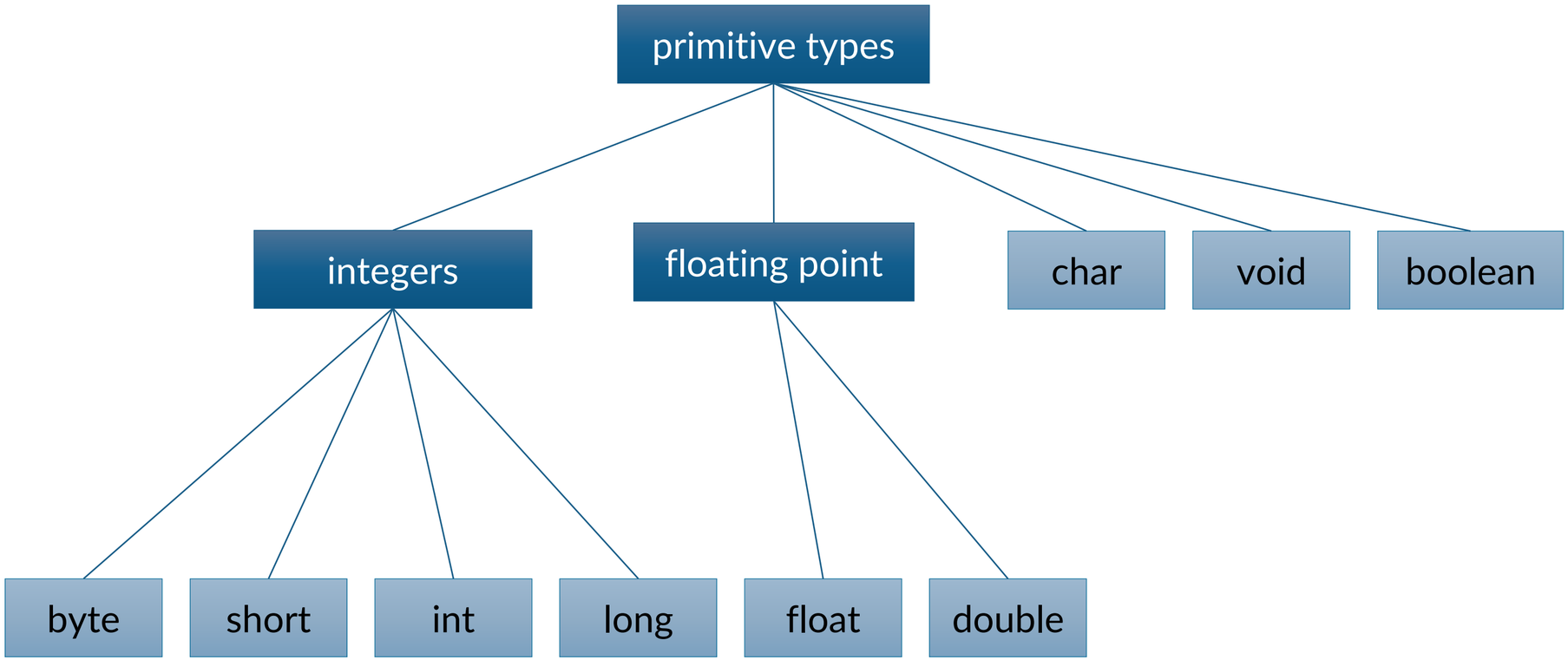
Java Development Kit (JDK)

The JDK is the Java distribution that includes the compiler used to compile the Java files, it includes the JRE

Data types

Primitive types

Java provides the following primitive types



Data type ranges

Type	Width [bits]	Range
byte	8	-128 to 127
short	16	-32,768 to 32767
int	32	-2,147,483,648 to 2,147,483,647
long	64	-9,223,372,036,854,775,808 to 9,223,372,036,854,775,807
char	16	0 to 65535
float	32	1.4e-45 to 3.4e+38
double	64	4.9e-324 to 1.8e+308

Variable and constant definition

```
int x;
double d = 0.33;
float f = 0.22F;
char c = 'a';
boolean ready = true;

x = 15;
```

Variables are declared specifying their type and name, and initialized in the point of declaration, or later with the assignment expression

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

```
final double pi = 3.1415;
final int maxSize = 100_000;
final char lastLetter = 'z';
```

```
var f = 10.0; // a double variable
var i = 50;     // an int variable
```

Only local variables can be declared without an explicitly declared type by using the so-called type inference

Type conversion and casting

Java performs automatic conversions when there is no risk for data to be lost, widening conversion

- from int to long
- from long to double
- from float to double
- …

When there is the risk for data to be lost, you must declare the explicit type conversion, narrowing conversion or casting

Narrowing conversion	Rules
from integer to integer (e.g., long to int)	Integer component is reduced modulo the target type size
from floating point to integer (e.g., double to int)	Fractional component is truncated Integer component is reduced modulo the target type size
from double to float	The number is rounded to the closest float, including +Infinity and -Infinity

Test

Conversion	Widening or narrowing?
`long e = 34;` `int f = e;`	
`long e = 34;` `float h = e;`	
`float h = 3.14F;` `double g = h;`	
`double g = 3.1415;` `float h = g;`	
`double g = 3.1415;` `int f = g;`	
`float h = 3.14F;` `long g = h;`	

Casting

TestCast.java

```
public class TestCast {
  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

    long e = 34;
    int f = (int) e;             // e is a long
    double g = 3.45;
    float h = (float) g;         // g is a double
  }
}
```

To specify conversions where data can be lost it is necessary to use the cast operator

The perils of casting

TestCast.java

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

    double d = 128.0;
    byte b = (byte) d;

    System.out.println(b);
  }
}
```

What is the output?

What if d is 256.0?

How can we play safe?

Assignment: explain the results obtained when d = 128 and d = 256

Hint: consider the binary representation of signed numbers

Strings

Strings are not a basic type but they are defined as a class, more details later!

```
String a = "abc";
```

The string concatenation operator ‘+’ converts the argument on the right to a String

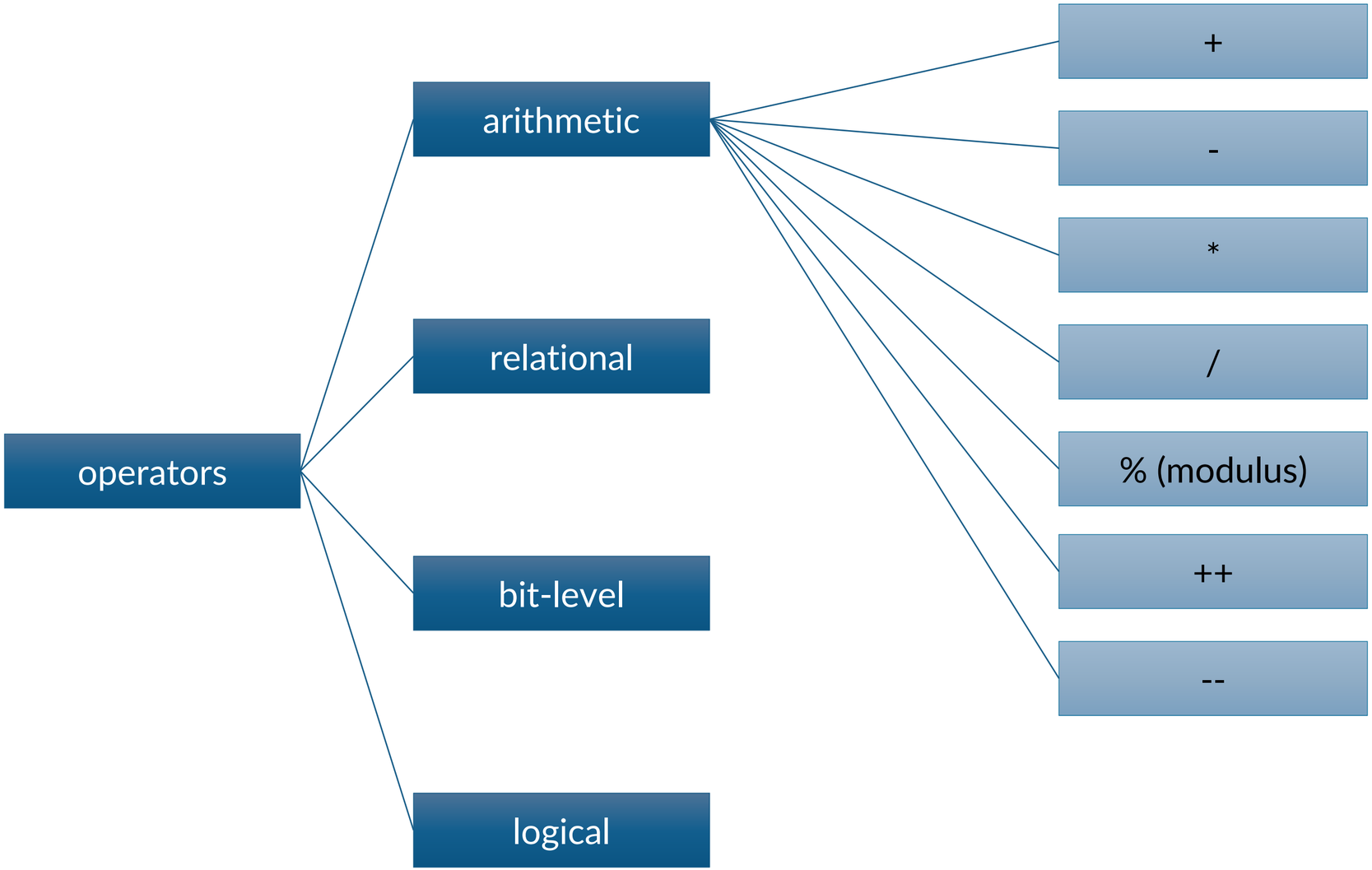
```
int cost = 2;
String b = "the cost is " + cost + " euro";
```

What’s the output of

```
int cost = 2;
String b = "the cost is " + cost + cost + " euro";
System.out.println(b);
```

Operators

Arithmetic operators



Type promotion in arithmetic expressions

byte, short and char operands are always converted to int in arithmetic expressions

If an operand is a long, the whole expression is converted to long

If one operand is a float, the whole expression is converted to float

If one operand is a double, the whole expression is converted to double

```
byte b1 = 3;
byte b2 = 4;
byte b3 = b1 * b2; // Incompatible types
byte b4 = (byte) (b1 * b2);
```

Can you explain this result?

```
double q = 3 / 2; // 1 !!!!
```

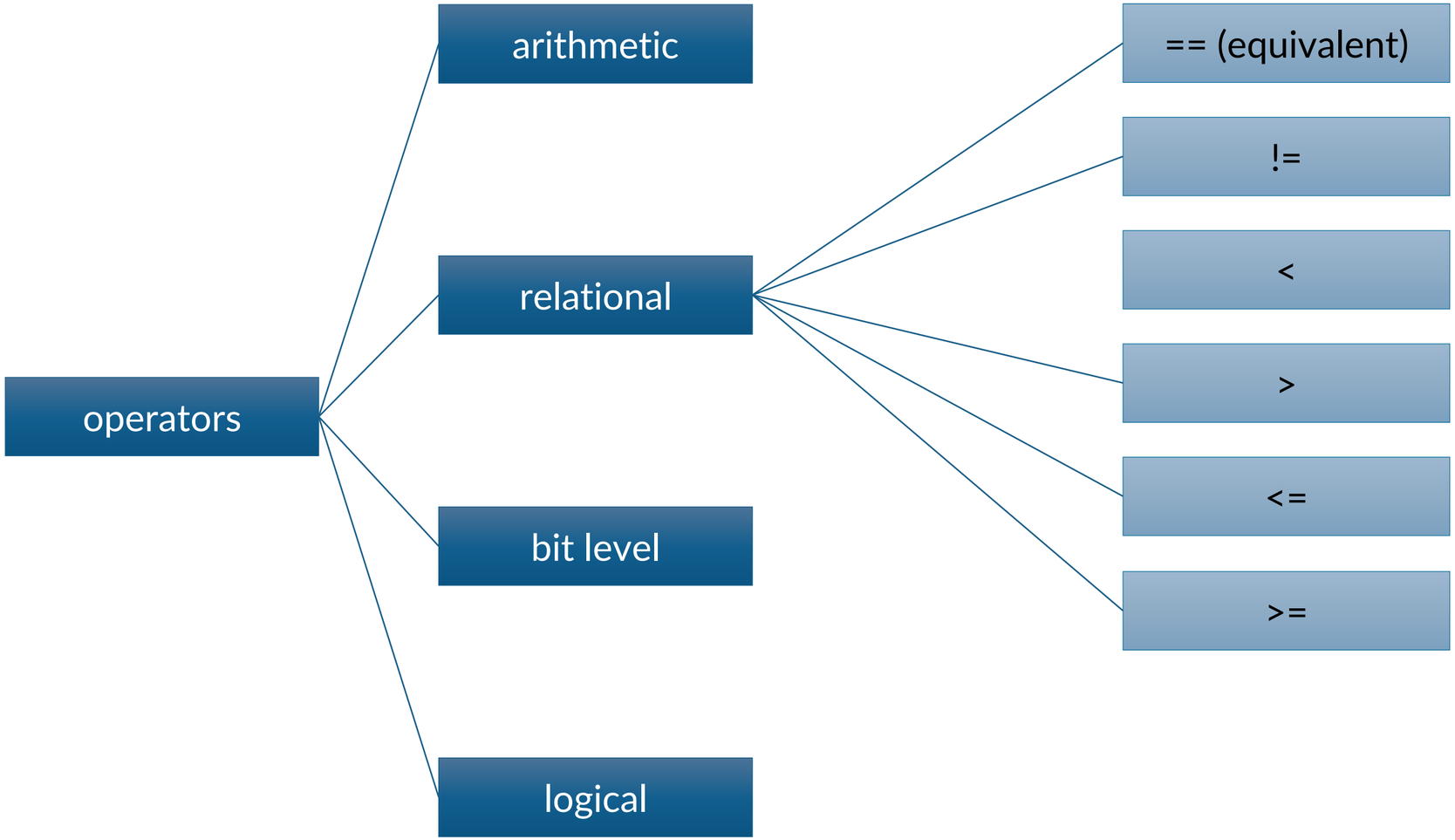
Example with arithmetic operators

Arithmetic.java

```
public class Arithmetic {
  public static void main(String[] args) {
    int x = 12;
    x += 5; // x = x + 5
    System.out.println(x);

    int a = 12, b = 12;
    System.out.print(a++);    // printed and then incremented
    System.out.print(a);

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

```
$ java Arithmetic
17
12 13 13 13
```

Relational operators



Example with relational operators

TestBoolean.java

```
public class TestBoolean {
  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 TestBoolean
true
false
true
```

Equivalence of (String) objects 1/2

Equals.java

```
public class Equals {
  public static void main(String[] args) {
        String s1 = "Java is great!";
        String s2 = "Java" + " is great!";
        String a = "Java";
        String b = " is great!";
        String s3 = a + b;

        System.out.println("s1: " + s1);
        System.out.println("s2: " + s2);
        System.out.println("s3: " + s3);

        System.out.println("s1 == s2: " + (s1 == s2));
        System.out.println("s1.equals(s2): " + s1.equals(s2));
        System.out.println("s1 == s3: " + (s1 == s3));
        System.out.println("s1.equals(s3): " + s1.equals(s3));
    }
}
```

Strings are objects not primitive types. In general, to compare objects we have to use the function equals()

```
$ java Equals.java
s1: Java is great!
s2: Java is great!
s3: Java is great!

s1 == s2: true
s1.equals(s2): true

s1 == s3: false
s1.equals(s3): true
```

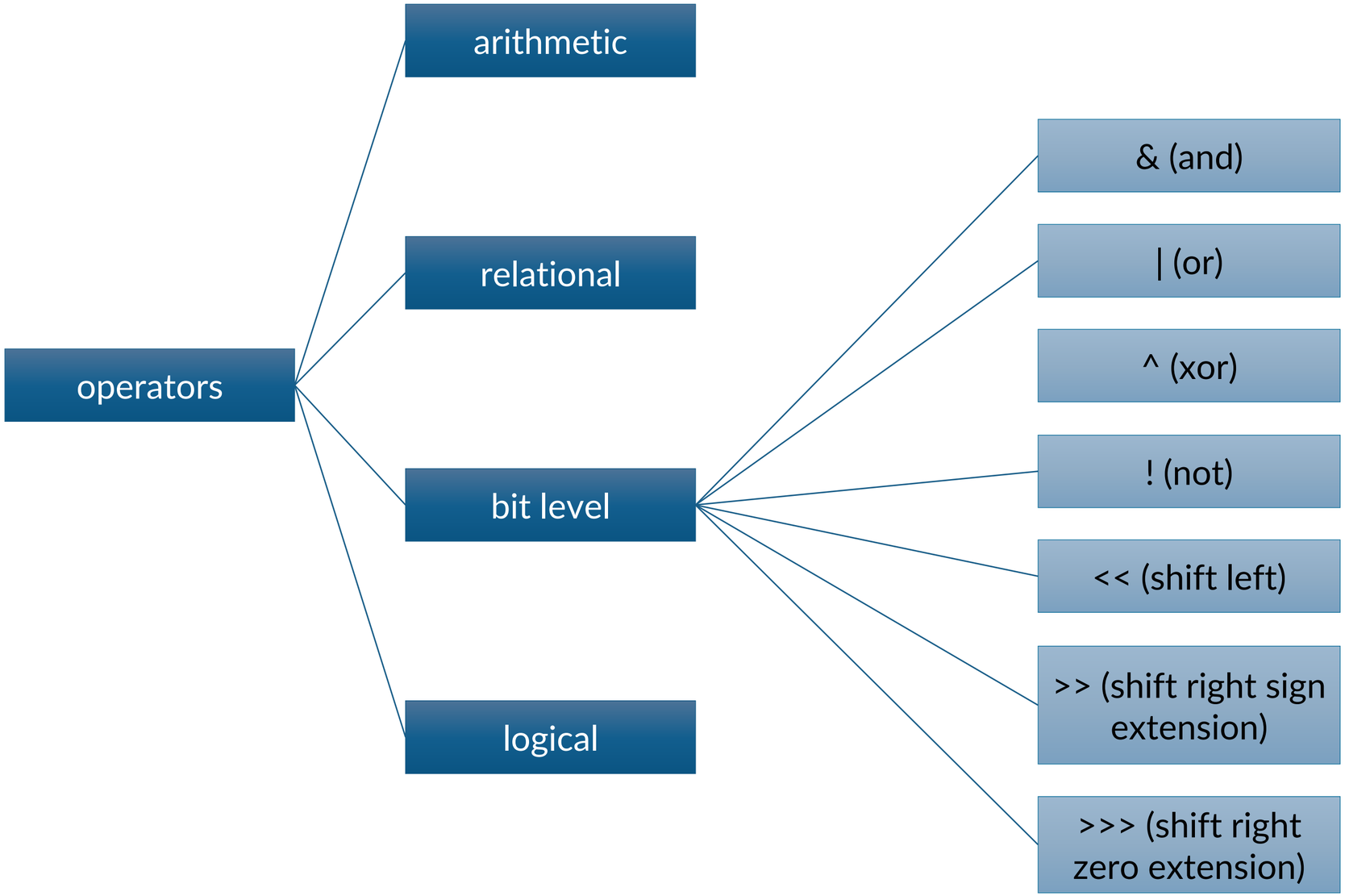
Equivalence of (String) objects 2/2

Equals.java

```
public class Equals {
  public static void main(String[] args) {
        String s1 = "Java is great!";
        String s2 = "Java" + " is great!";
        final String a = "Java";
        final String b = " is great!";
        String s3 = a + b;

        System.out.println("s1: " + s1);
        System.out.println("s2: " + s2);
        System.out.println("s3: " + s3);

        System.out.println("s1 == s2: " + (s1 == s2));
        System.out.println("s1.equals(s2): " + s1.equals(s2));
        System.out.println("s1 == s3: " + (s1 == s3));
        System.out.println("s1.equals(s3): " + s1.equals(s3));
    }
}
```

```
$ java Equals.java
s1: Java is great!
s2: Java is great!
s3: Java is great!

s1 == s2: true
s1.equals(s2): true

s1 == s3: true
s1.equals(s3): true
```

Bit level operators

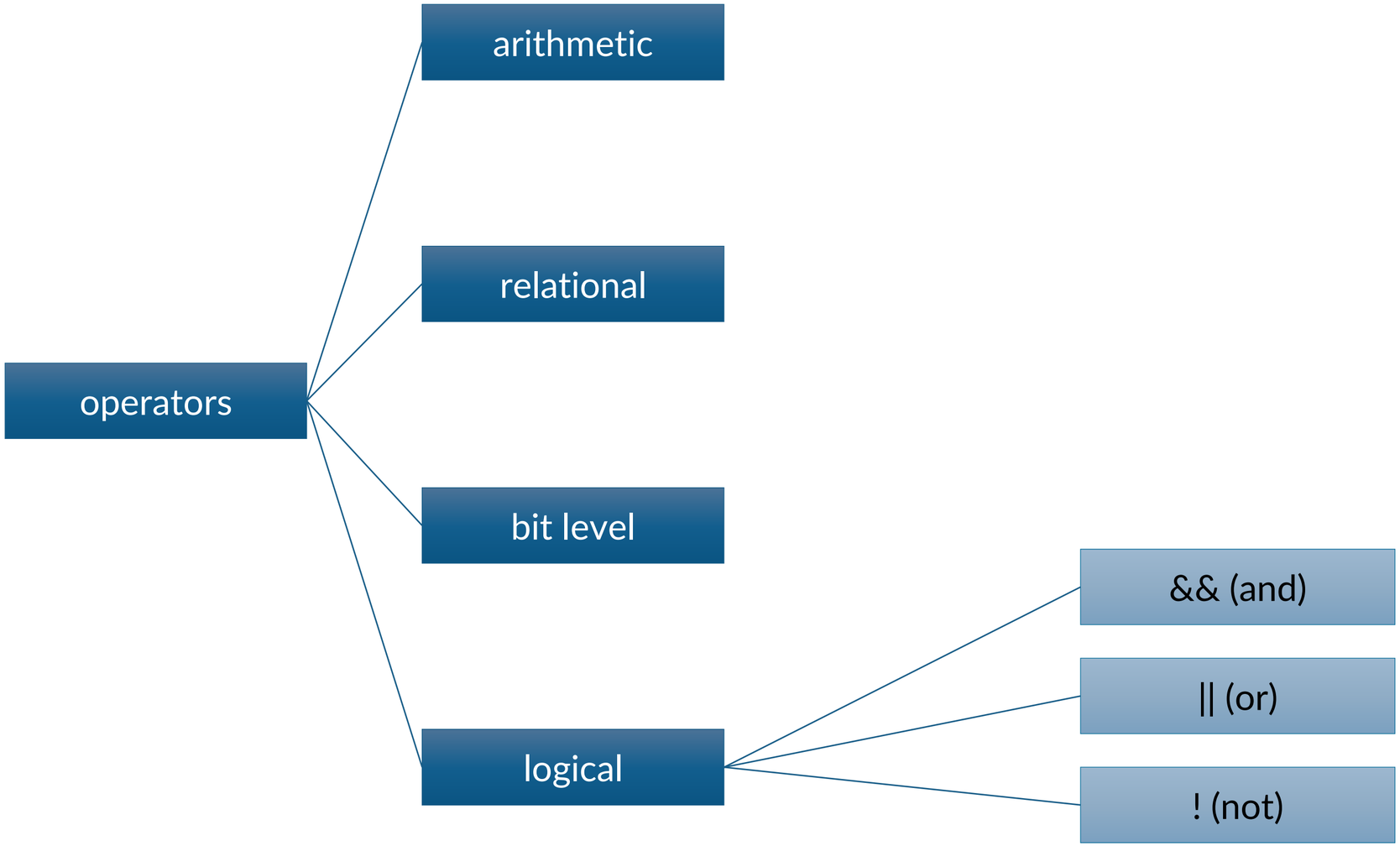


Example with bit-level operators

Bits.java

```
public class Bits {
  public static void main(String[] args) {
    int x = 0b00000000000000000000000000010110;
    int y = 0b00000000000000000000000000110011;

    System.out.println(x & y);                  // 00000000000000000000000000010010
    System.out.println(x | y);                  // 00000000000000000000000000110111
    System.out.println(x ^ y);                  // 00000000000000000000000000100101
    System.out.println(~x);                     // 11111111111111111111111111101001

    x = 0b00000000000000000000000000001001; // 9
    System.out.println(x >> 3);                 // 00000000000000000000000000000001
    System.out.println(x >>>3);                 // 00000000000000000000000000000001

    x = -9;                                     // 11111111111111111111111111110111
    System.out.println(x >> 3);                 // 11111111111111111111111111111110
    System.out.println(x >>>3);                 // 00011111111111111111111111111110
  }
}
```

Logical operators



Example with logical operators

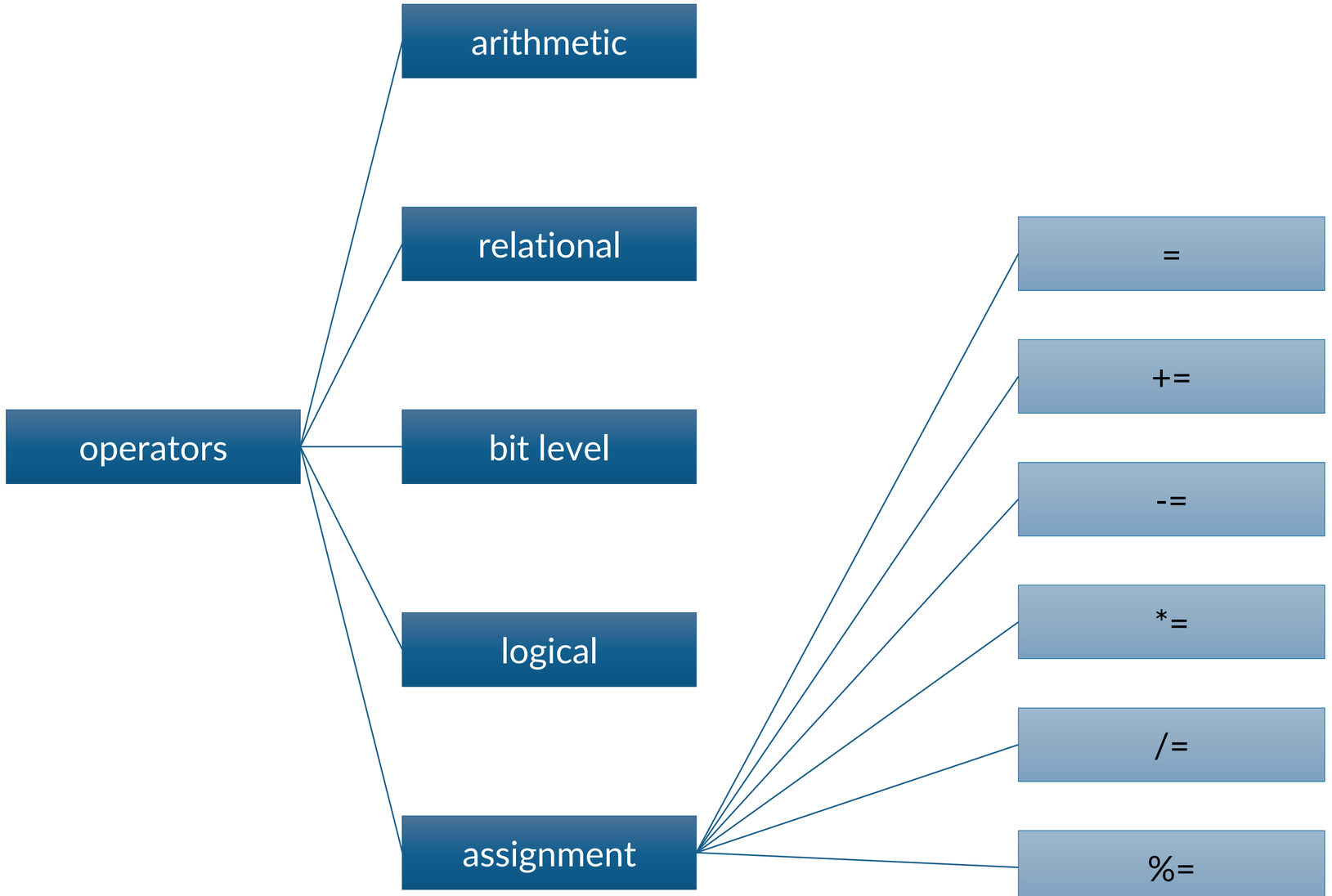
Logical.java

```
public 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
```

Please note that there are also logical non-short circuit operators. Investigate about them

Assignment operators



Example with assignment operators

Assignment.java

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

    y %= x;
    d -= e;
    System.out.println(y);
    System.out.println(d);
  }
}
```

a op= b is equivalent to
a = a op b

```
$ java Assignment
9
-2.09
```

Expressions, operator precedence, and parenthesis

An expression is something that once evaluated returns a value

```
"Hello," + " World!" -> "Hello, World!"
9 + 9 -> 18
9 / 3 -> 3
9 + 9 / 3 -> ?
9 + 9 / 3 * 2 -> ?
```

Operators follow the precedence rules

Parenthesis can be used to alter the precedence or to make the expression more readable

```
9 + 9 -> 18
9 / 3 -> 3
9 + (9 / 3) -> ?
(9 + 9) / 3 -> ?
9 + 9 / (3 * 2) -> ?
```

Operator precedence

Highest						
++ (postfix)	– – (postfix)					
++ (prefix)	– – (prefix)	~	!	+ (unary)	– (unary)	(*type-cast*)
*	/	%				
+	–					
>>	>>>	<<				
>	>=	<	<=	instanceof		
==	!=					
&						
^						
|						
&&						
||						
?:						
–>						
=	op=					
Lowest						

Note the assignment operator evaluates right-to-left

The ? operator

Sort of if-then-else that given a conditional expression chooses between two expressions

```
condition ? expression1 : expression2
```

If condition is true, expression1 is evaluated, otherwise expression2 is evaluated.

The ?-expression assumes the result of the evaluated expression.

```
System.out.println(expression ? "It rains" : "It doesn’t rain")
```

Control structures

Control structures: if

If.java

```
public 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 nor a digit");
      }
   }
}
```

```
$ java If
letter: x
```

Control structures: while

While.java

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

For.java

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

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

```
$ java For
Incremented 22 times
```

Control structures: break and continue

BreakContinue.java

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

    for (int counter = 0; counter < 10; counter++) {

      if (counter % 2 == 1) continue; // start a new iteration if the counter is odd
      if (counter == 8) break; // abandon the loop if the counter is equal to 8

      System.out.println(counter);
    }
    System.out.println("done.");
  }
}
```

```
$ java BreakContinue
0 2 4 6 done.
```

Control structures: switch

Switch.java

```
public 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;
        case 2: // February is a special case
          if (leapYear)
            days += 29;
          else
            days += 28;
          break;
        default: // a month with 30 days
          days += 30;
          break;
      }
    }
    System.out.println(days);
  }
}
```

```
$ java Switch
366
```

The switch-expression must evaluate to byte, short, char, int, enum, or String

Arrays

Arrays

Arrays can be used to store elements of the same type

```
int[] a;
double[] b;
String[] c;
```

```
int[] a = {13, 56, 2034, 4, 55};
double[] b = {1.23, 2.1};
String[] c = {"Java","is","great"};
```

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

Anther possibility to allocate space for arrays consists in the use of the operator new

```
int i = 3,j = 5;
double[] d;

d = new double[i+j];
```

Arrays

Java arrays are 0-based. The components can be accessed with an integer index with values from 0 to length-1.

```
a[2] = 1000;
```

```
int len = a.length;
```

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

Components of the arrays are initialized with default values

```
int[] a = new int[3];
for (int i = 0; i < a.length; i++) {
  System.out.println(a[i]);
}
```

```
0
0
0
```

Arrays

Arrays.java

```
public 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
    double[] d = new double[sum];
    for (int i = 0; i < d.length; i++) d[i] = 1.0 / (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
d[1]=0.5
d[3]=0.25
d[5]=0.16666667
d[7]=0.125
d[9]=0.1
```

The for-each iteration

ForEach.java

```
public class ForEach {
  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 x : a) sum += x;

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

     // print all values (note the use of type inference!!)
    for (var f : d)
      System.out.println(f);
  }
}
```

A revised «Hello, World!»

Hello.java

```
public class Hello {

    public static void main(String[] args) {
       System.out.println("Hello, " + args[0] + "!" );
    }
}
```

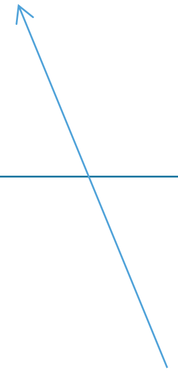
```
$ java Hello.java Paolo
Hello, Paolo!
```

Assigments

Assignment 1

Implement a Hello class to say hello to multiple people

```
$ java Hello Paolo Dario
Hello Paolo and Dario!

$ java Hello Francesco Joe Arthur
Hello Francesco, Joe, and Arthur!

$ java Hello
Hello everybody!
```



Note the usage of
the Oxford comma

Assignment 2

Implement a Calculator class to perform arithmetic operations.

```
$ java Calculator 6 + 4.1
10.1
$ java Calculator 3.6 / -2
-1.8
$ java Calculator 8.5 * 9
76.5
$ java Calculator -3.14
-3.14
```

I let you discover how to convert strings to numbers

Enhance the calculator so that it can handle concatenated operations

```
$ java Calculator 6 + 4.1 * 3
10.1
30.3
$ java Calculator 3.6 / 2 + -0.3 / .5
1.8
1.5
3
```

A few references

The Java specification

The Java Language and Virtual Machine Specification are available here
https://docs.oracle.com/javase/specs/

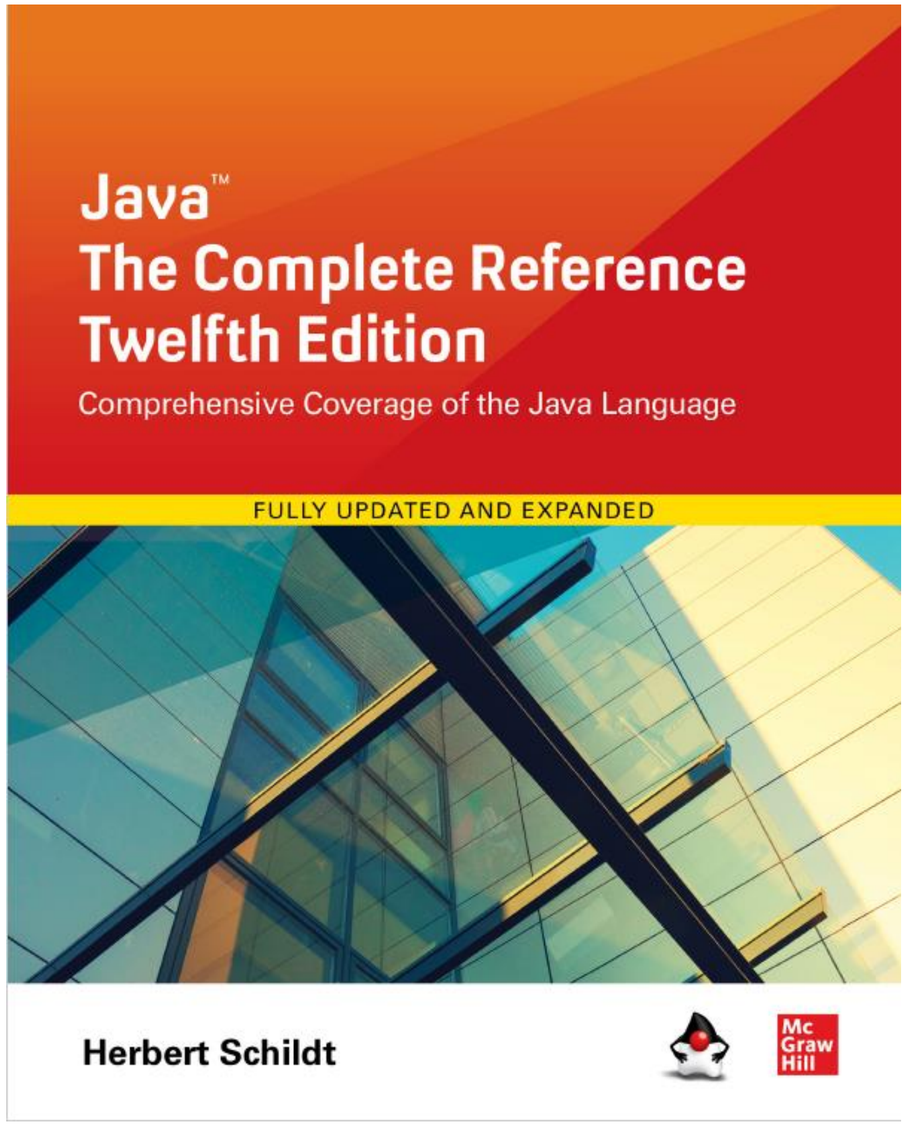
The API documentation is available here
https://docs.oracle.com/en/java/javase/17/docs/api/index.html

The Java language evolution is driven by the Java Community Process (JCP)
https://www.jcp.org/en/home/index

The JCP is the mechanism for developing standard technical specifications for Java technology. Anyone can register for the site and participate in reviewing and providing feedback for the Java Specification Requests (JSRs), and anyone can sign up to become a JCP Member and then participate on the Expert Group of a JSR or even submit their own JSR Proposals.

A more informal place to discuss the new features of Java is the JDK Enhancement Proposals (JEP)
https://openjdk.java.net/jeps/0

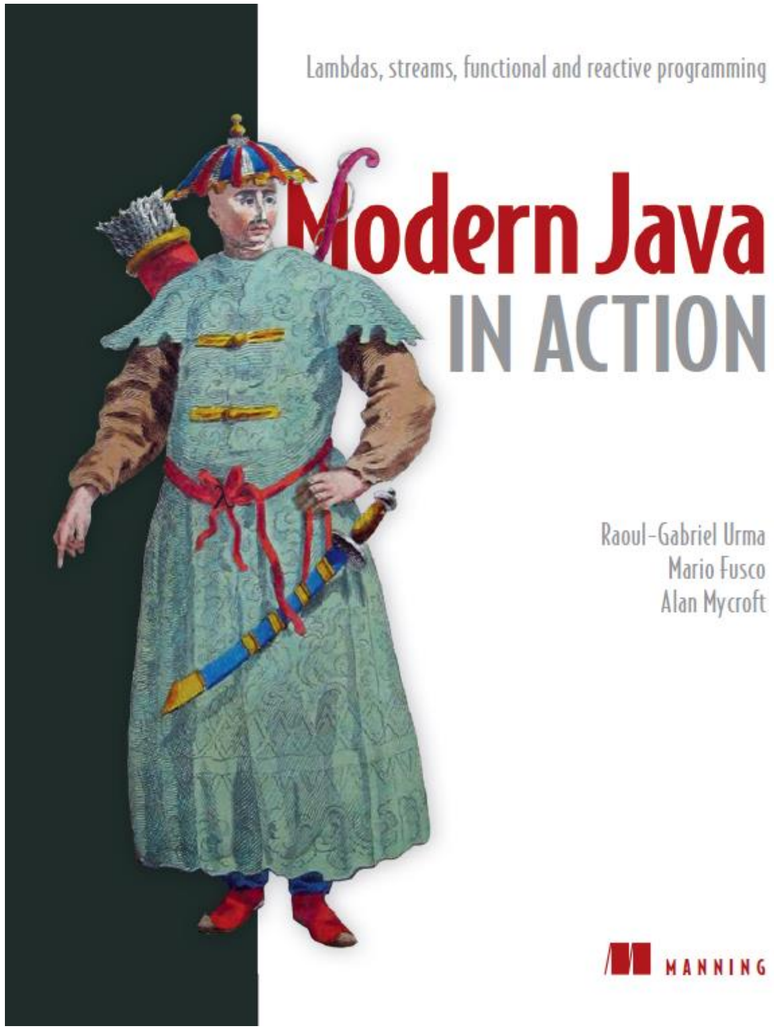
If you need a book reference



The list of good Java books is endless and continuously growing. They are good as introduction to the language at the beginning and as a reference later.

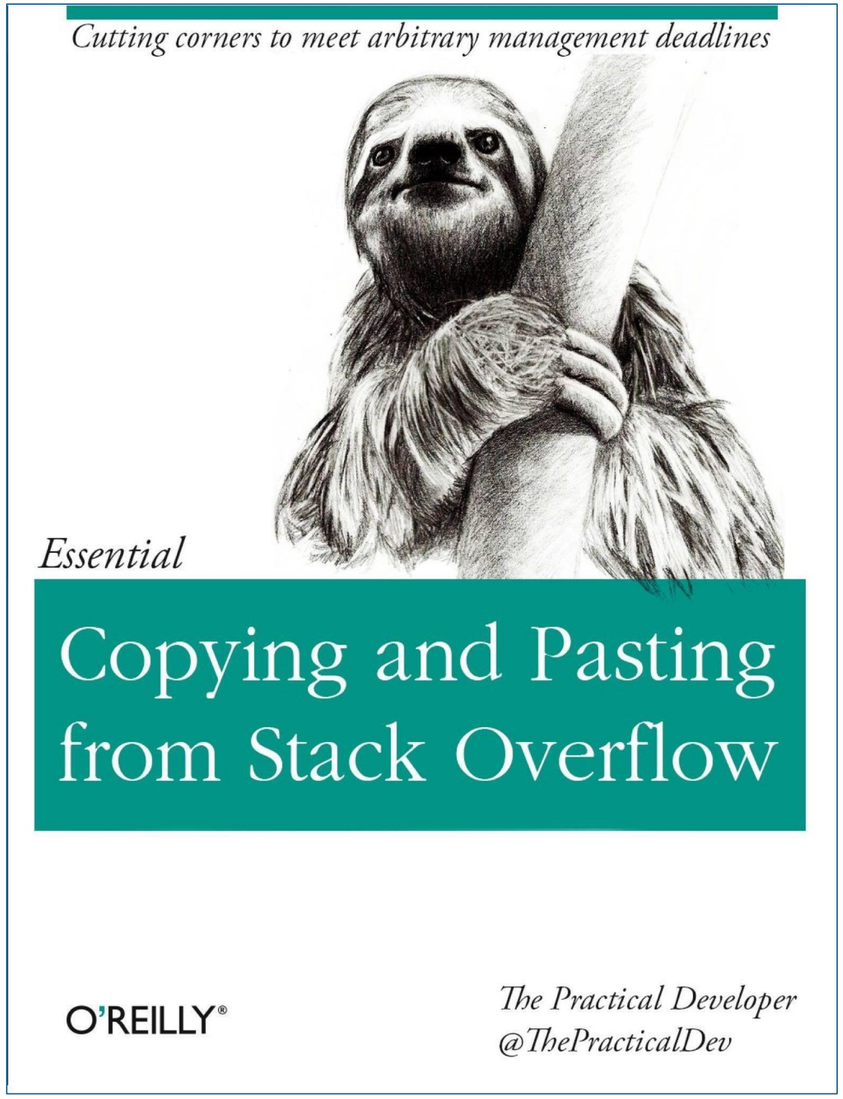
The same information they provide can be found by googling but usually in the web it is more fragmented and less structured.

To know more about functional programming



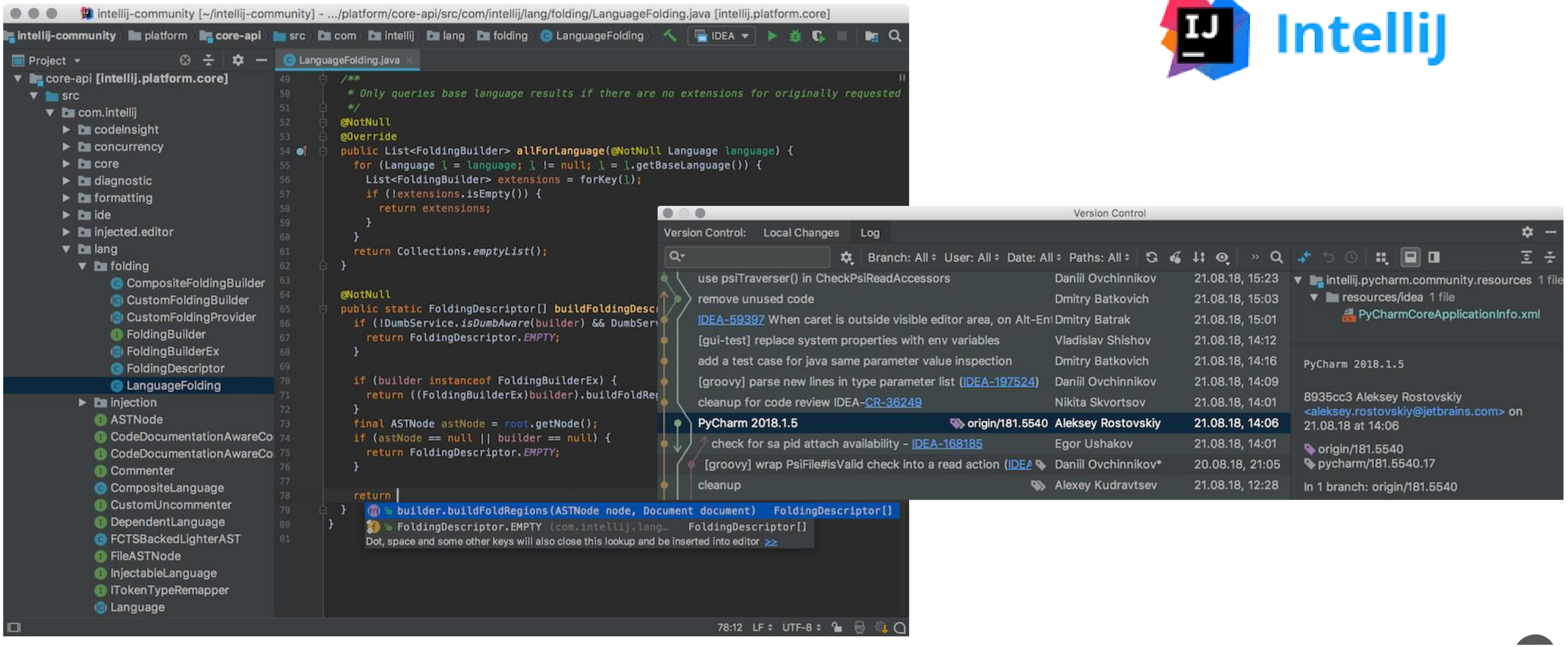
Raoul-Gabriel Urma, Mario Fusco, Alan Mycroft
Modern Java in Action

Don’t buy this book



Or at least don’t copy & paste code that is 12 years old…

Recommended development tool



Intellij

Thank you!

esteco.com