CSCI 1102 Computer Science 2

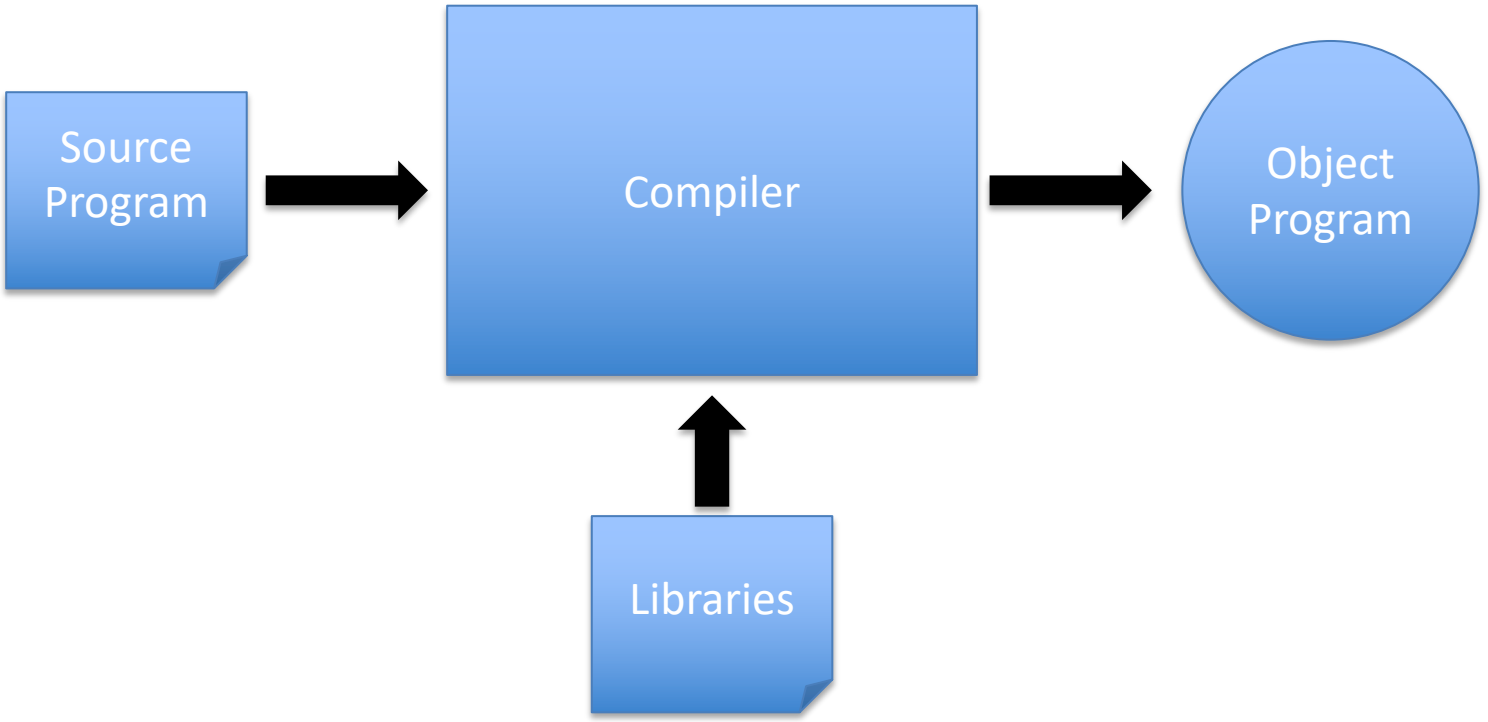
Meeting 2: Tuesday 2/2/2021

Getting Started with Java

Today

- Compilation, Compile-time & run-time
- The basic structure of a Java program
- Static & Dynamic functions
- Memory & Storage
- A Simple Example

Compilation



Object Program

1. Native code – a sequence of simple instructions in the language of a particular physical machine (processor)

2. Byte code – a sequence of simple (byte-sized) instructions in the language of a virtual computer -- a software program that can be implemented on any physical processor.

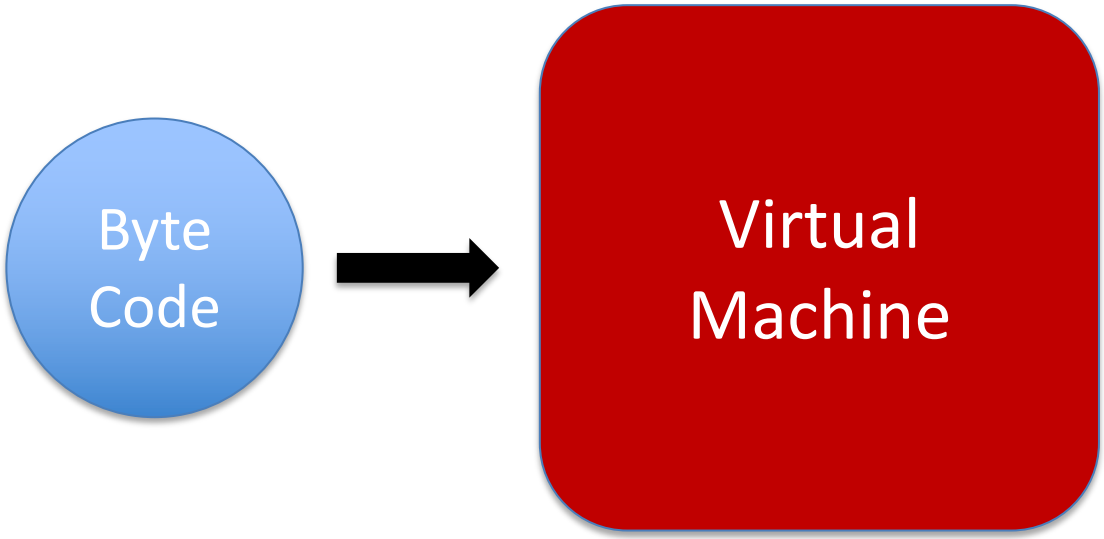
Object Program

1. Native code – fast but not portable;

2. Byte code – portable but slow.

Virtual Machine

Typically uses a stack as its primary tool to interpret/execute the byte-code program



Dis-compiling byte-codes: Python

```
def fact(n):
    if n == 0:
        return 1
    else:
        return n * fact(n - 1)
```

```
>>> dis.dis(fact)
  2           0 LOAD_FAST                0 (n)
              3 LOAD_CONST               1 (0)
              6 COMPARE_OP               2 (==)
              9 POP_JUMP_IF_FALSE       16

  3          12 LOAD_CONST               2 (1)
             15 RETURN_VALUE

  5     >>   16 LOAD_FAST                0 (n)
             19 LOAD_GLOBAL              0 (fact)
             22 LOAD_FAST                0 (n)
             25 LOAD_CONST               2 (1)
             28 BINARY_SUBTRACT
             29 CALL_FUNCTION            1
             32 BINARY_MULTIPLY
             33 RETURN_VALUE
             34 LOAD_CONST               0 (None)
             37 RETURN_VALUE
```

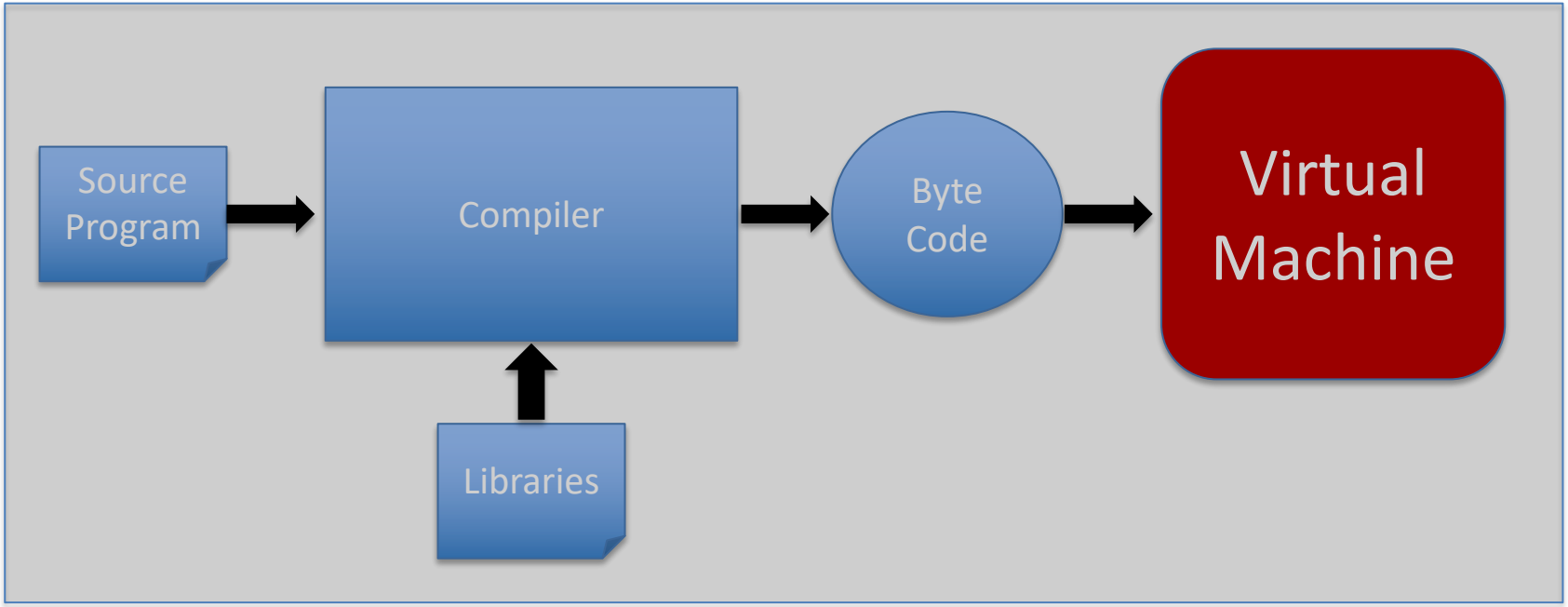
Dis-compiling byte-codes: Java

```
public class Fact {

  static int fact(int n) {
    if (n == 0)
      return 1;
    else
      return n * fact(n - 1);
  }
}
```

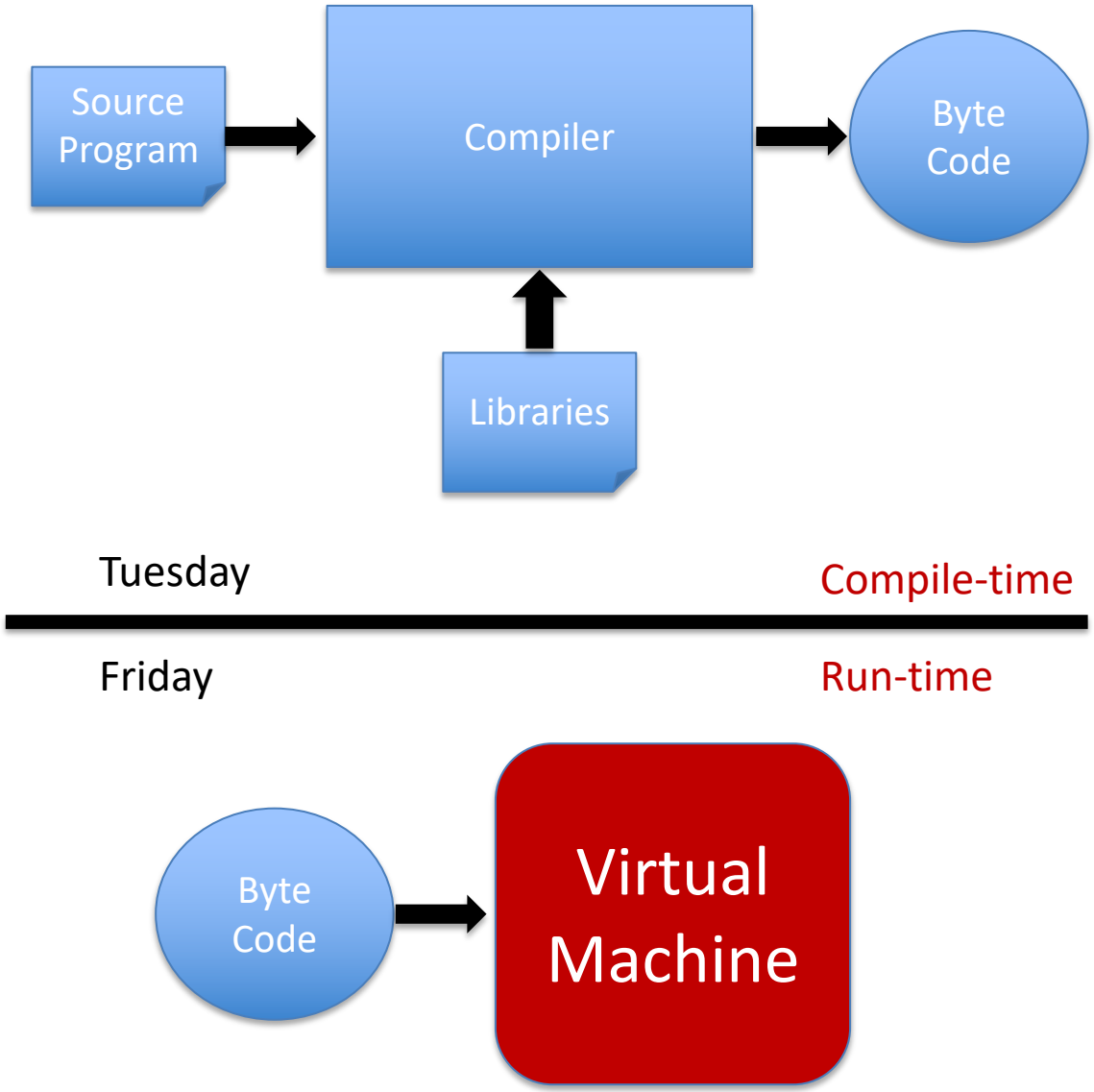
```
> javac Fact.java
> javap -c Fact
Compiled from "Fact.java"
public class Fact {
  public Fact();
    Code:
       0: aload_0
       1: invokespecial #1
       4: return

  static int fact(int);
    Code:
       0: iload_0
       1: ifne          6
       4: iconst_1
       5: ireturn
       6: iload_0
       7: iload_0
       8: iconst_1
       9: isub
      10: invokestatic  #2
      13: imul
      14: ireturn
}
```

Compiler + Virtual Machine

A compiler and VM are sometimes combined into one program, often called an interpreter or REPL. Python uses this model.



- In some language implementations, the compiler & VM are separate.
- The byte-code can be run on the VM any time after compilation.



Advantages of the Phase Separation

- The compiler can find and report many (but not all) errors before the program is running;
- The compiler can sort out the type information at compile time so this work isn't required at run-time, this leads to more performant code.
- NB: compile-time information about a program is often said to be *static*

Python is dynamically-typed – the types of operands must be determined as the program is running

No type information

```
def fact(n):
    if n == 0:
        return 1
    else:
        return n * fact(n - 1)
```

What kind of multiply?

```
>>> dis.dis(fact)
  2           0 LOAD_FAST                0 (n)
              3 LOAD_CONST               1 (0)
              6 COMPARE_OP               2 (==)
              9 POP_JUMP_IF_FALSE       16

  3          12 LOAD_CONST               2 (1)
             15 RETURN_VALUE

  5     >>   16 LOAD_FAST                0 (n)
             19 LOAD_GLOBAL              0 (fact)
             22 LOAD_FAST                0 (n)
             25 LOAD_CONST               2 (1)
             28 BINARY_SUBTRACT
             29 CALL_FUNCTION            1
             32 BINARY_MULTIPLY
             33 RETURN_VALUE
             34 LOAD_CONST               0 (None)
             37 RETURN_VALUE
```

```
>>> dis.dis(fact)
  2           0 LOAD_FAST                0 (n)
              3 LOAD_CONST               1 (0)
              6 COMPARE_OP               2 (==)
              9 POP_JUMP_IF_FALSE       16

  3          12 LOAD_CONST               2 (1)
             15 RETURN_VALUE

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             32 BINARY_MULTIPLY
             33 RETURN_VALUE
             34 LOAD_CONST               0 (None)
             37 RETURN_VALUE
```

In order for BINARY_MULTIPLY to choose between integer multiply and floating point multiply, the operands (i.e., numbers) must be accompanied by type information at run-time. This is costly.

Java and Ocaml are statically typed – type information is known at compile time.

```
public class Fact {

  static int fact(int n) {
    if (n == 0)
      return 1;
    else
      return n * fact(n - 1);
  }
}
```

Inferred to be an integer multiply on Tuesday.

```
> javac Fact.java
> javap -c Fact
Compiled from "Fact.java"
public class Fact {
  public Fact();
    Code:
       0: aload_0
       1: invokespecial #1
       4: return

  static int fact(int);
    Code:
       0: iload_0
       1: ifne          6
       4: iconst_1
       5: ireturn
       6: iload_0
       7: iload_0
       8: iconst_1
       9: isub
      10: invokestatic  #2
      13: imul
      14: ireturn
}
```

No need for run-time type information

```java
static int fib(int n) {
  if (n < 2)
    return 1;
  else
    return fib(n - 1) + fib(n - 2);
}
```

Two wildly inefficient Fibonacci functions.

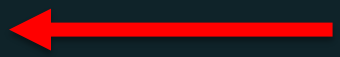
```python
def fib(n):
    if (n < 2):
        return 1
    else:
        return fib(n - 1) + fib(n - 2)
```

Run-times on VMs for fib(38)

```
> javac Fib.java
> time java Fib 38
fib(38) = 63245986

real    0m0.327s
user    0m0.322s
sys     0m0.035s
> time python fib.py 38
63245986

real    0m15.247s
user    0m14.767s
sys     0m0.125s
>
```

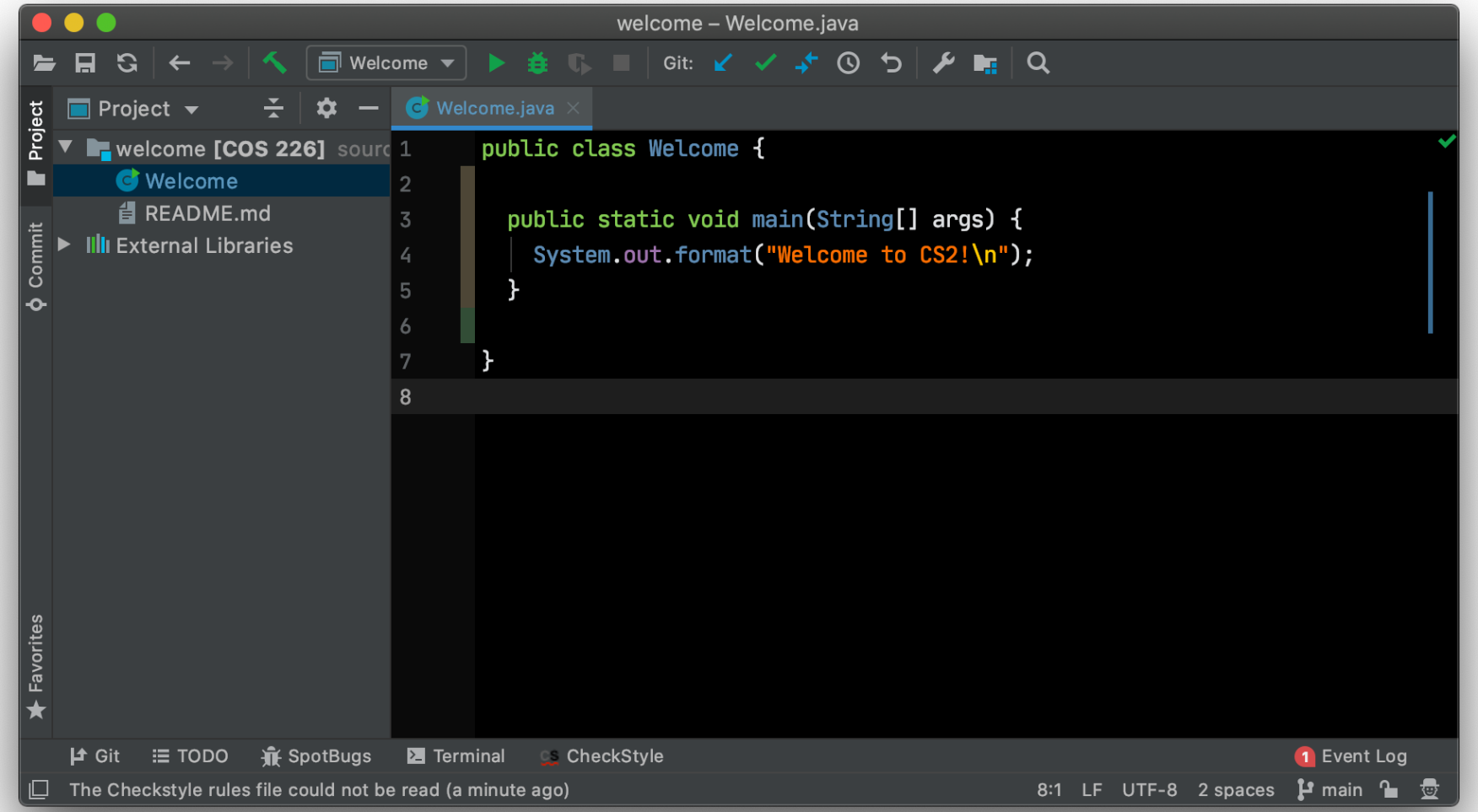


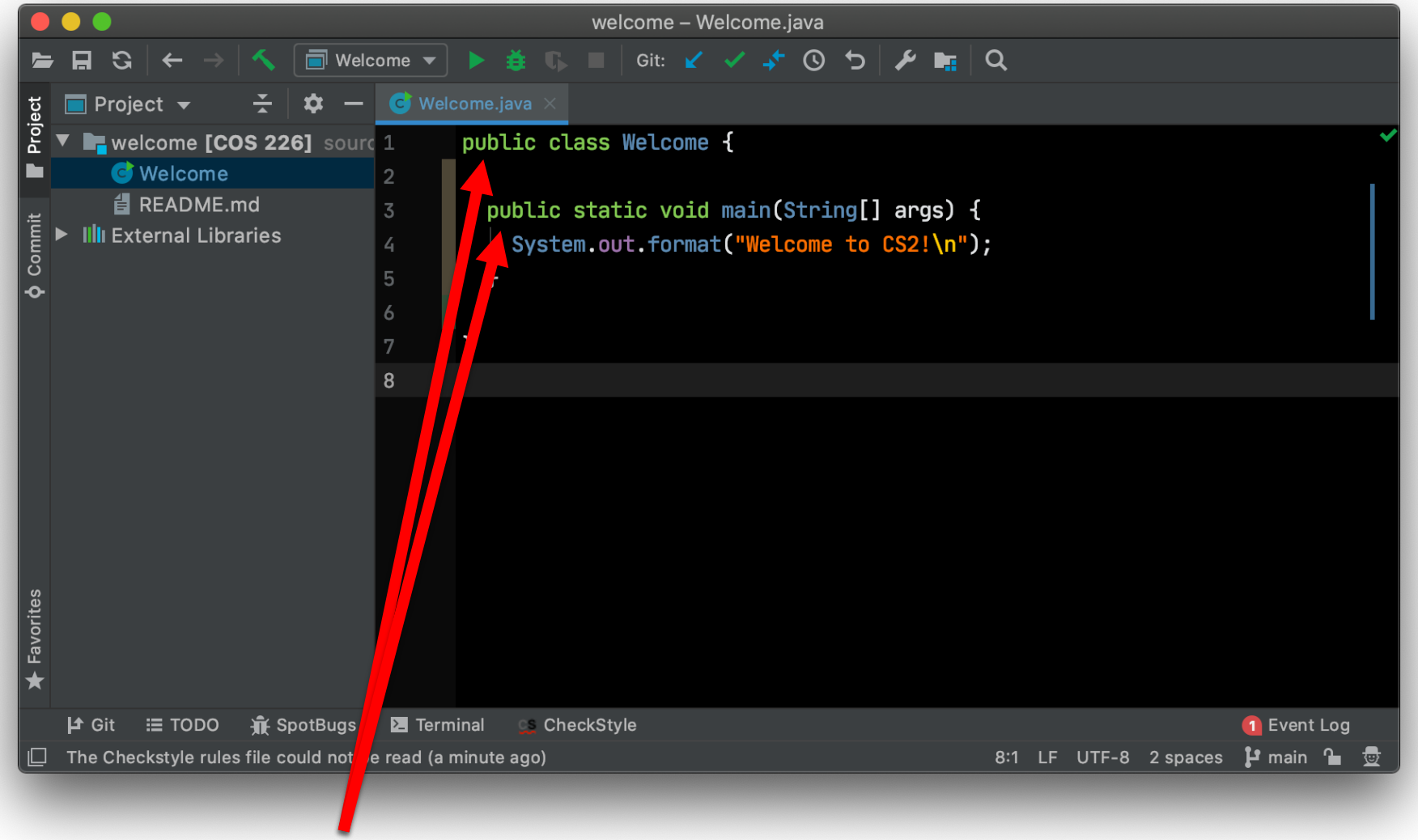
The Python time includes time for translation.

	REPL	Byte-Code Compiler	Native-Code Compiler
Python	YES		NO
Java	NO	YES	NO
OCaml	YES	YES	YES

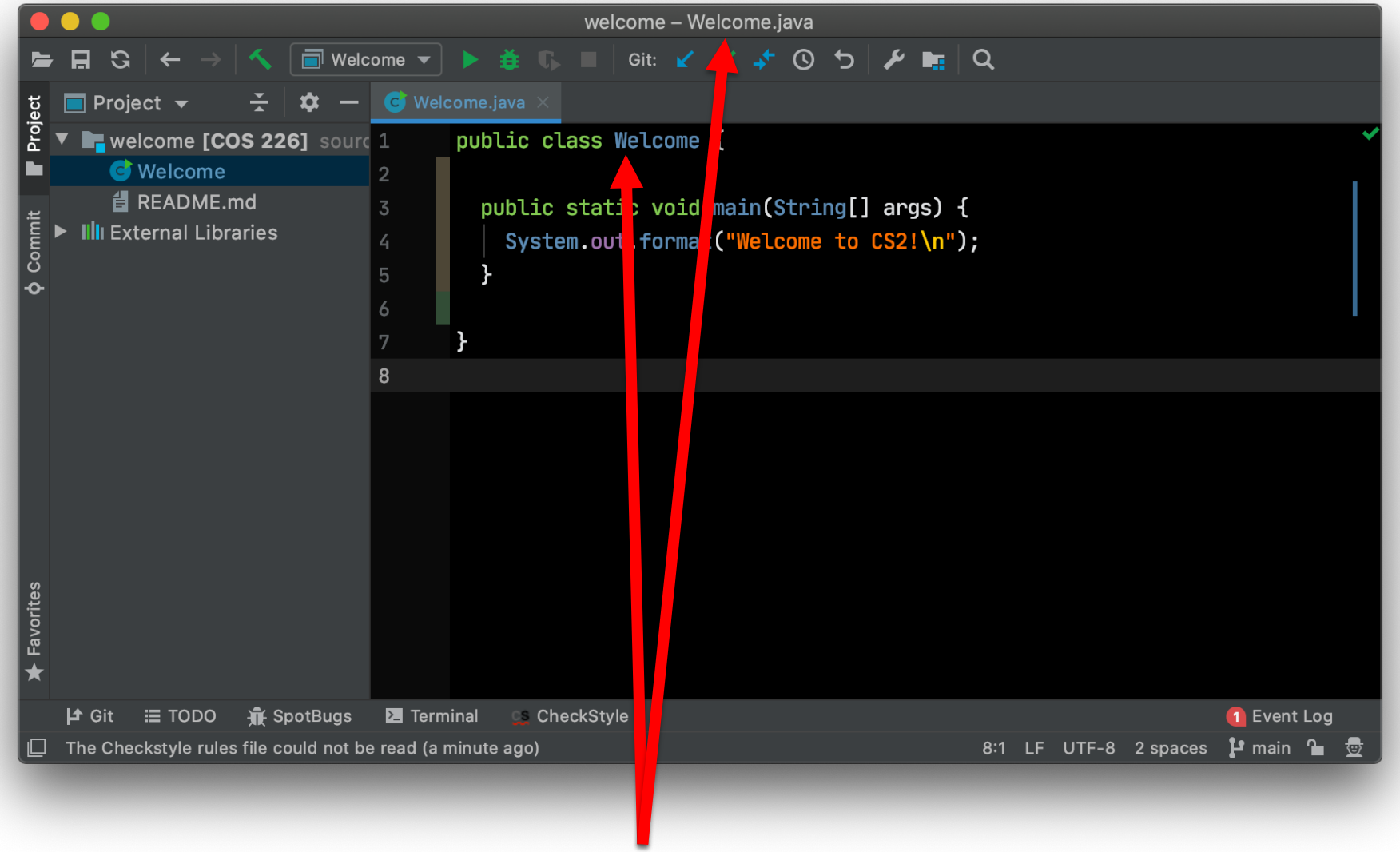
2. The basic structure of a Java program

- What Java programs look like.
- How they work.

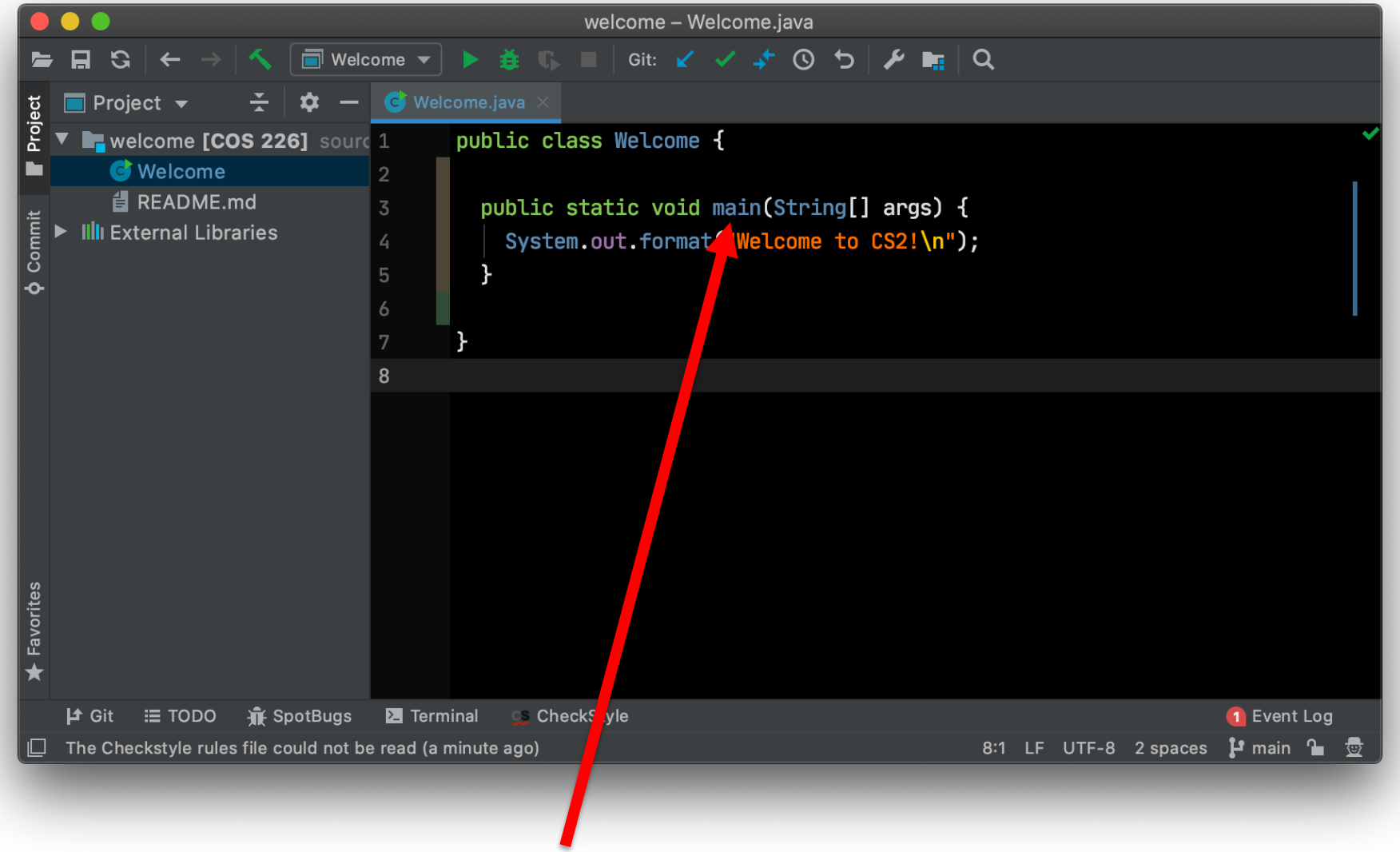

welcome – Welcome.java
Welcome
Git:
Project
Welcome.java
welcome [COS 226]
Welcome
README.md
External Libraries
public class Welcome {
public static void main(String[] args) {
System.out.format("Welcome to CS2!\n");
}
}
Project
Commit
Favorites
Git
TODO
SpotBugs
Terminal
CheckStyle
Event Log
The Checkstyle rules file could not be read (a minute ago)
8:1
LF
UTF-8
2 spaces
main



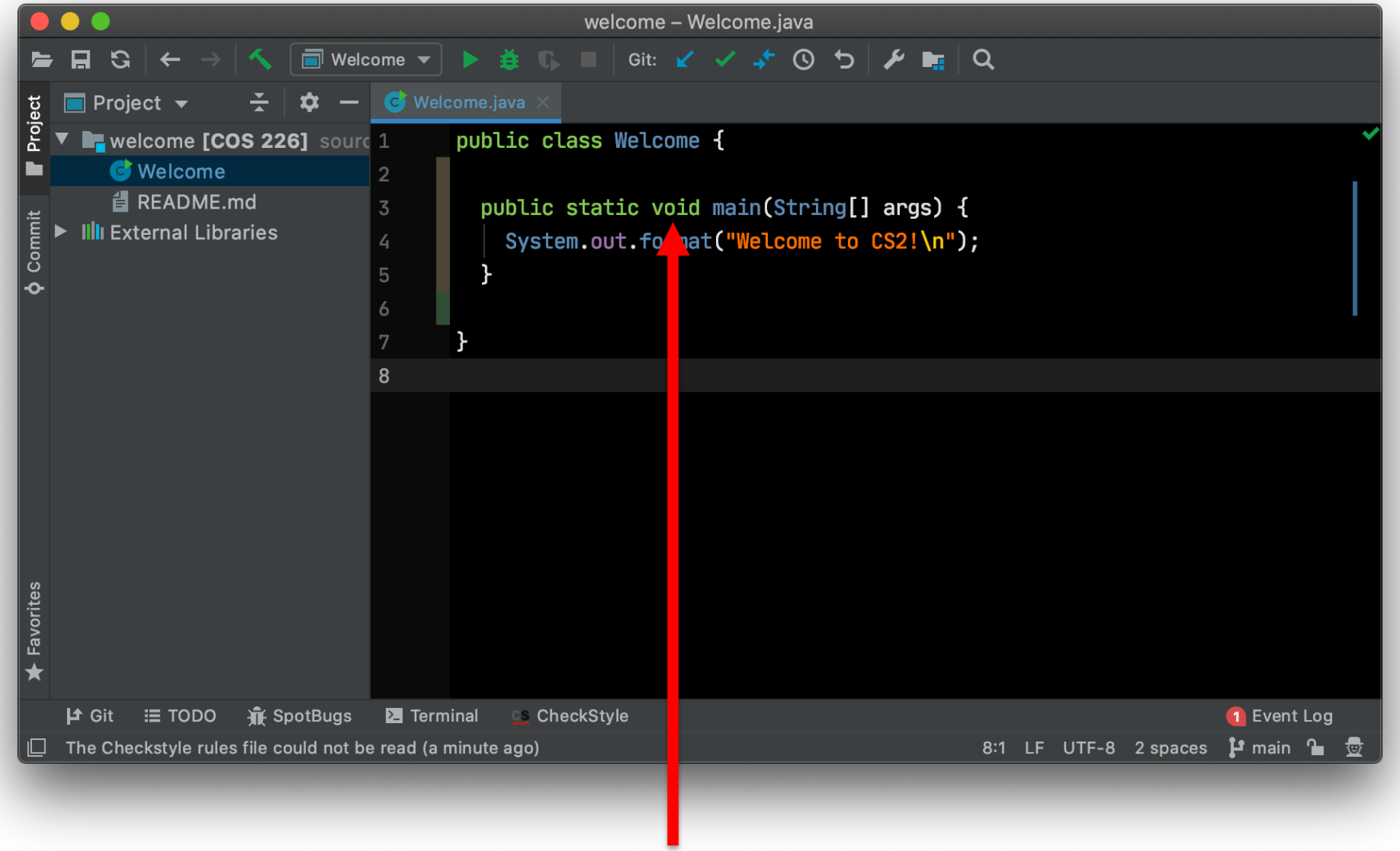
The keyword symbol public is a *visibility* attribute. The class Welcome and function main are visible anywhere. Another common visibility attribute for a declaration is private – the name is visible only within the class.



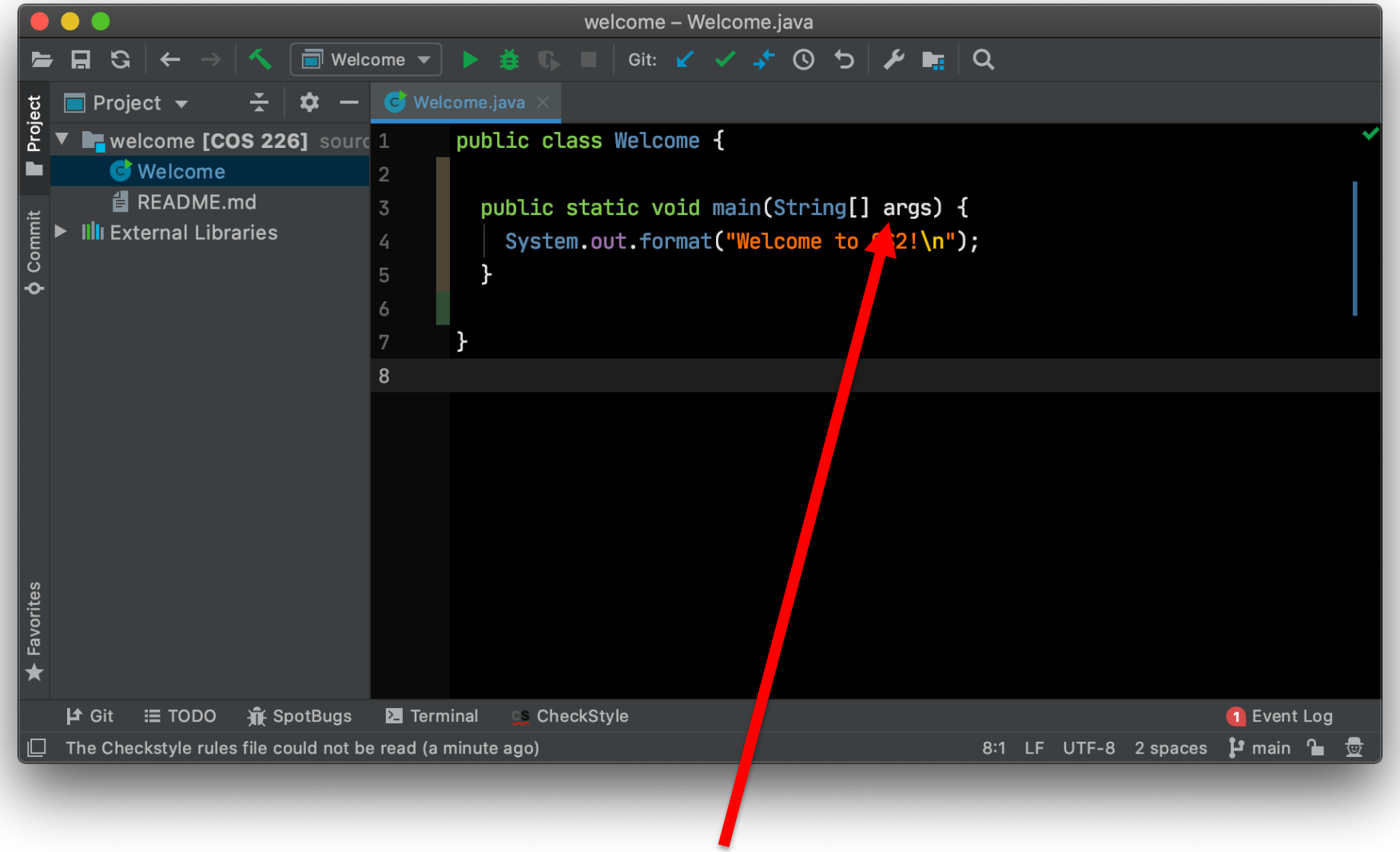
Class names begin with a capital letter. A file can have at most one public class. The name must match the file name.



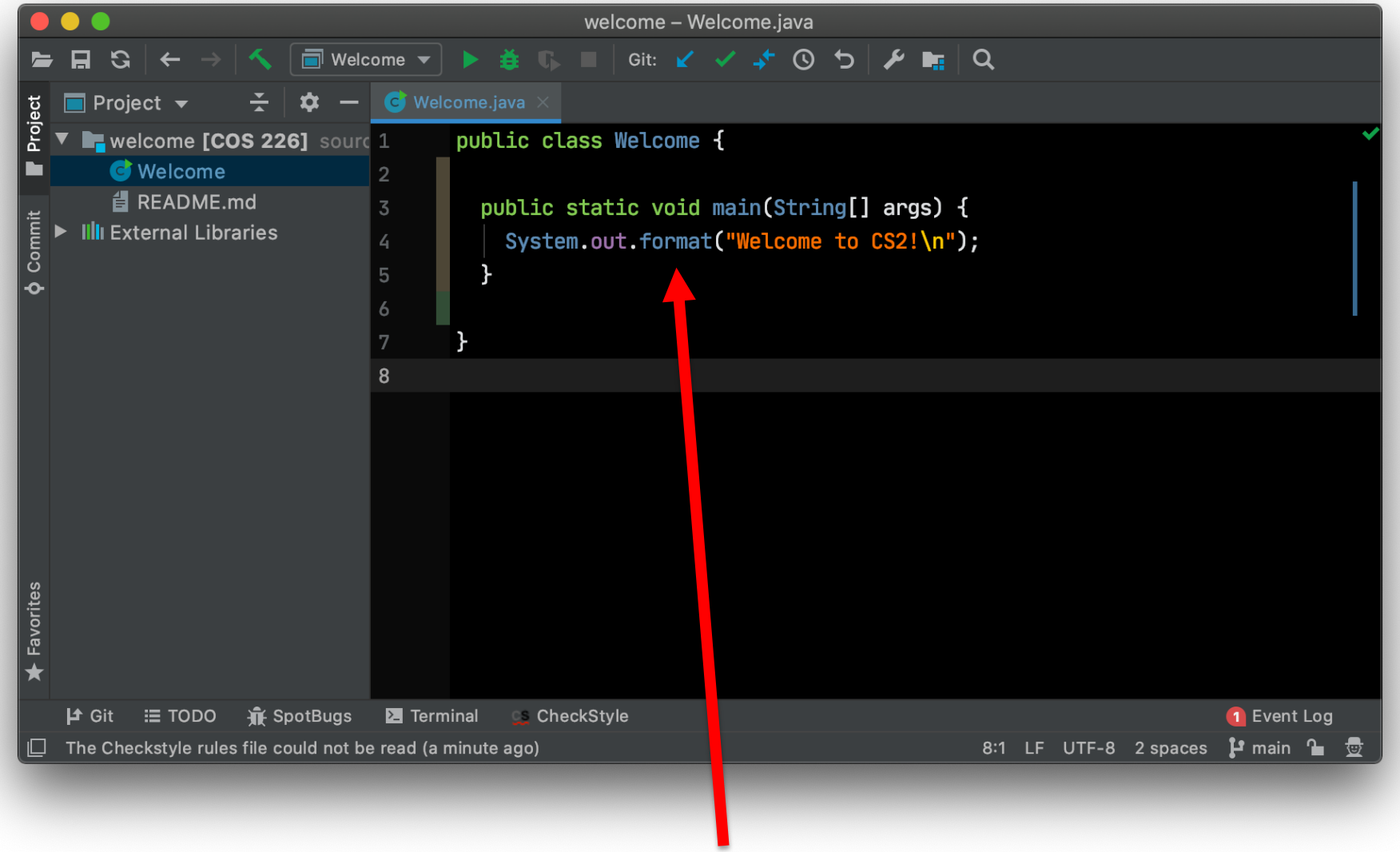
If you compile a Java source file containing a public class and want to execute the code in it, it must have a public and static function called main.



The symbol void is a *type*, in this position it is the *return type* of function main. Function main doesn't return a value.



The symbol args is a *formal parameter* of the function main. The programmer declares that it will hold a value of type array of Strings. These are the *command line arguments*.



The body of the function, enclosed in braces {}, simply calls the format function contained in the System.out class.

Example: Who is taking CS2?

s	School	Major	Grad Year
nas@bc	Morrissey College, A	computer science b.	2023
i@bc.e	Morrissey College, A	computer science b.	2024
ne@bc	Morrissey College, A	computer science b.	2024
c.edu	Morrissey College, A	computer science b.	2022
@bc.e	Morrissey College, A	philosophy	2022
@bc.e	Morrissey College, A	computer science b.	2024
y@bc.e	Morrissey College, A	computer science b.	2023
dia@bc	Morrissey College, A	mathematics bs	2022
an@bc	Carroll School of Ma	information systems	2023
is.5@b	Morrissey College, A	biology	2021
c.edu	Carroll School of Ma	undeclared	2023
@bc.e	Morrissey College, A	computer science b.	2024
bc.edu	Morrissey College, A	computer science b.	2024
za@bc.	Morrissey College, A	computer science b.	2024
.edu	Morrissey College, A	computer science b.	2024
.2@bc	Morrissey College, A	computer science b.	2024
@bc.ec	Morrissey College, A	computer science b.	2024
es@bc.	Morrissey College, A	computer science b.	2024

MCAS	CSBA	2024
MCAS	PHIL	2022
MCAS	CSBA	2024
MCAS	CSBA	2022
MCAS	CSBS	2024
MCAS	CSBA	2023
MCAS	MATH	2022
CSOM	ISYS	2023
MCAS	BIOL	2021
CSOM	UNDC	2023
MCAS	CSBA	2024
MCAS	CSBA	2024
MCAS	CSBS	2024
MCAS	CSBS	2024
MCAS	CSBS	2024
MCAS	CSBA	2024
MCAS	MATH	2024
MCAS	CSBS	2024
MCAG	BIOL	2026
MCAS	ECON	2023

Count Enrolled Students