3 Java/Python vs. C – Some Examples

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The First C Program

The most famous program of the world in C

```c
#include <stdio.h>

int main(int argc, char **argv) {
    /* greet user */
    printf("Hello World!\n");
    return 0;
}
```

Compilation and execution (on a UNIX system)

```
~> gcc -o hello hello.c
~> ./hello
Hello World!
~>
```

Not that complicated at all :-(
The First C Program

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int main(int argc, char **argv) {
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Compilation and execution (on a UNIX system)

```bash
~> gcc -o hello hello.c
~> ./hello
Hello World!
~>
```

Not that complicated at all :-)

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# The First C Program – a Comparison to Java

## The most famous program of the world in C

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#include <stdio.h>

int main(int argc, char **argv) {
    /* greet user */
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    return 0;
}
```

## The most famous program of the world in Java

```java
import java.lang.System;
class Hello {
    public static void main(String[] args) {
        /* greet user */
        System.out.println("Hello World!");
        return;
    }
}
```
The most famous program of the world in **C**

```c
#include <stdio.h>

int main(int argc, char **argv) {
    /* greet user */
    printf("Hello World!\n");
    return 0;
}
```

**C**: A C program starts with `main()`, a **global function** of type `int`, which is defined in exactly one **file**.

The most famous program of the world in **Java**

```java
import java.lang.System;
class Hello {
    public static void main(String[] args) {
        /* greet user */
        System.out.println("Hello World!");
        return;
    }
}
```

**Java**: Each Java program starts with the function `main()`, a **static method** of type `void`, which is defined in exactly one **class**.
The First C Program – a Comparison to Java

The most famous program of the world in **C**

```c
#include <stdio.h>

int main(int argc, char **argv) {
    /* greet user */
    printf("Hello World!\n");
    return 0;
}
```

The most famous program of the world in **Java**

```java
import java.lang.System;
class Hello {
    public static void main(String[] args) {
        /* greet user */
        System.out.println("Hello World!");
        return;
    }
}
```

**C**: <no counterpart>

**Java**: Each Java program consists of at least one `class`. 
The First C Program – a Comparison to Java

The most famous program of the world in **C**

```c
#include <stdio.h>

int main(int argc, char **argv) {
  /* greet user */
  printf("Hello World!\n");
  return 0;
}
```

- **C**: The output of the string takes place due to the function `printf()`. (\n \(\sim\) new line)

The most famous program of the world in **Java**

```java
import java.lang.System;
class Hello {
  public static void main(String[] args) {
    /* greet user */
    System.out.println("Hello World!");
    return;
  }
}
```

- **Java**: The output of one string takes place in the method `println()` from the class `out`, which is from the package `System`. 
The First C Program – a Comparison to Java

The most famous program of the world in **C**

```c
#include <stdio.h>

int main(int argc, char **argv) {
    /* greet user */
    printf("Hello World!\n");
    return 0;
}
```

**C**: To use the function `printf()`, the **library** `stdio.h` gets included by the **preprocessor instruction** `#include`.

The most famous program of the world in **Java**

```java
import java.lang.System;

class Hello {
    public static void main(String[] args) {
        /* greet user */
        System.out.println("Hello World!");
        return;
    }
}
```

**Java**: To use the **class** `out`, the **package** `System` gets included by the `import` instruction.
The First C Program – a Comparison to Java

The most famous program of the world in C

```c
#include <stdio.h>

int main(int argc, char **argv) {
    /* greet user */
    printf("Hello World!\n");
    return 0;
}
```

C: Return to the operating system with return value. 0 in this case indicates that no error has happened.

The most famous program of the world in Java

```java
import java.lang.System;

class Hello {
    public static void main(String[] args) {
        /* greet user */
        System.out.println("Hello World!");
        return;
    }
}
```

Java: Return to the operating system.
C version gets explained line by line
Return to the operating system with return value. 0 in this case indicates that no error has happened.

Java-version gets explained line by line
Return to the operating system.
The First C Program for a µController

Preliminary information:

- **DDRx**: data direction register
- **PINx**: port input register
- **PORTx**: port output register (of size 8 bit each)
The First C Program for a μController

Background information:

- LED is not lit:
  - DDRD bit 6: '1' (output)
  - PORTD bit 6: '1' (5V)

- LED lights up:
  - DDRD bit 6: '1' (output)
  - PORTD bit 6: '0' (0V)
The First C Program for a \( \mu \)Controller

“Hello world” for AVR ATmega (SPiCboard)

```c
#include <avr/io.h>

void main(void) {
    /* initialize hardware: LED on port D pin 6, active low */
    DDRD |= (1<<6); /* PD6 is used as output */
    PORTD |= (1<<6); /* PD6: high --> LED is off */

    /* greet user */
    PORTD &= ~(1<<6); /* PD6: low --> LED is on */

    /* wait forever */
    while (1) {
    }
}
```
The First C Program for a μController

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    while (1) {
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}
```

Compilation and **flashing** (with SPiC-IDE) 

〜 Exercises
The First C Program for a μController

“Hello world” for AVR ATmega (SPiCboard)

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```

Compilation and flashing (with SPiC-IDE)

Execution (SPiCboard): (red LED lit)

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The First C Program for a \( \mu \text{Controller} \)

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    /* wait forever */
    while (1) {
    }
}
```

Compilation and **flashing** (with SPiC-IDE) ➝ **Exercises**

Execution (SPiCboard): 🟥 (red LED lit)

\( \mu \text{Controller} \) programming is “somewhat different”.

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The First C Program for a \( \mu \)Controller

“Hello world” for AVR ATmega (compare \( \rightarrow 3-1 \))

```c
#include <avr/io.h>

void main(void) {
    /* initialize hardware: LED on port D pin 6, active low */
    DDRD |= (1<<6); /* PD6 is used as output */
    PORTD |= (1<<6); /* PD6: high --> LED is off */

    /* greet user */
    PORTD &= ~(1<<6); /* PD6: low --> LED is on */

    /* wait forever */
    while (1) {
    }
}
```

The `main()`-function has **no return value** (type `void`). A \( \mu \)Controller program runs **indefinitely** \( \sim \) `main()` does not terminate.
The First C Program for a µController

“Hello world” for AVR ATmega (compare ➔ 3–1)

```c
#include <avr/io.h>

void main(void) {
  /* initialize hardware: LED on port D pin 6, active low */
  DDRD |= (1<<6); /* PD6 is used as output */
  PORTD |= (1<<6); /* PD6: high --> LED is off */

  /* greet user */
  PORTD &= ~(1<<6); /* PD6: low --> LED is on */

  /* wait forever */
  while (1) {
  }
}
```

There will be **no return** to an operating system (which one?). The endless loop assures that `main()` does not terminate.
The First C Program for a $\mu$Controller

“Hello world” for AVR ATmega (compare $\leftrightarrow$ 3–1)

```c
#include <avr/io.h>

void main(void) {
    /* initialize hardware: LED on port D pin 6, active low */
    DDRD |= (1<<6); /* PD6 is used as output */
    PORTD |= (1<<6); /* PD6: high --> LED is off */

    /* greet user */
    PORTD &= ~(1<<6); /* PD6: low --> LED is on */

    /* wait forever */
    while (1) {
        }
}
```

First, the **hardware** gets initialized (i.e., put in a pre-defined state). For this, **single bits** in certain **hardware registers** have to be changed.
The First C Program for a µController

“Hello world” for AVR ATmega (compare \[3–1\])

```c
#include <avr/io.h>

void main(void) {
    /* initialize hardware: LED on port D pin 6, active low */
    DDRD |= (1<<6);  /* PD6 is used as output */
    PORTD |= (1<<6); /* PD6: high --> LED is off */

    /* greet user */
    PORTD &= ~(1<<6); /* PD6: low --> LED is on */

    /* wait forever */
    while (1) {
    }
}
```

The interaction with the environment (in this case: switching on the LED) takes place by manipulating single bits in hardware registers.
The First C Program for a µController

“Hello world” for AVR ATmega (compare \(\leftrightarrow 3–1\))

```c
#include <avr/io.h>

void main(void) {
    /* initialize hardware: LED on port D pin 6, active low */
    DDRD |= (1<<6); /* PD6 is used as output */
    PORTD |= (1<<6); /* PD6: high --> LED is off */

    /* greet user */
    PORTD &= ~(1<<6); /* PD6: low --> LED is on */

    /* wait forever */
    while (1) {
        
    }
}
```

To access the hardware registers (DDRD, PORTD, provided as **global variables**), the library `avr/io.h` gets included with `#include`. 
user interaction (reading one character) with Linux:

```c
#include <stdio.h>

int main(int argc, char **argv) {
    printf("Press key: ");
    char key = getchar();
    printf("You pressed \%c\n", key);
    return 0;
}
```

The `getchar()`-function reads one character from the standard input (here: keyboard). The function "waits", if necessary, until a character is available.
user interaction (reading one character) with Linux:

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#include <stdio.h>

int main(int argc, char **argv) {
    printf("Press key: ");
    char key = getchar();
    printf("You pressed \%c\n", key);
    return 0;
}
```

The `getchar()`-function reads one character from the standard input (here: keyboard). The function “waits”, if necessary, until a character is available.
The Second C Program for a µController

Preliminary information:

- **Initialising:**
  - DDRD bit 2: ’0’
    - (input)
  - PORTD bit 2: ’1’
    - (pull-up switched on)

- **Detection:**
  - PIND bit 2: ’1’
    => button not pressed
  - PIND bit 2: ’0’
    => button pressed
User interaction (waiting for a button to be pressed) on the SPiCboard:

```c
#include <avr/io.h>

void main(void) {
    /* initialize hardware: button on port D pin 2 */
    DDRD &= ~(1 << 2); /* PD2 is used as input */
    PORTD |= (1 << 2); /* activate pull-up: PD2: high */

    /* initialize hardware: LED on port D pin 6, active low */
    DDRD |= (1 << 6); /* PD6 is used as output */
    PORTD |= (1 << 6); /* PD6: high --> LED is off */

    /* wait until PD2 -> low (button is pressed) */
    while ((PIND >> 2) & 1) {
    }

    /* greet user */
    PORTD &= ~(1 << 6); /* PD6: low --> LED is on */

    /* wait forever */
    while (1) {
    }
}
```
User interaction (waiting for a button to be pressed) on the SPiCboard:

```c
#include <avr/io.h>

void main(void) {
    /* initialize hardware: button on port D pin 2 */
    DDRD &= ~(1 << 2); /* PD2 is used as input */
    PORTD |= (1 << 2); /* activate pull-up: PD2: high */

    /* initialize hardware: LED on port D pin 6, active low */
    DDRD |= (1 << 6); /* PD6 is used as output */
    PORTD |= (1 << 6); /* PD6: high --> LED is off */

    /* wait until PD2 -> low (button is pressed) */
    while ((PIND >> 2) & 1) {
        
        /* greet user */
        PORTD &= ~(1 << 6); /* PD6: low --> LED is on */

        /* wait forever */
        while (1) {
            
        }
    }
}
```

Just like the LED, the button is connected to a digital IO pin of the \( \mu \)Controller. We now configure pin 2 at port D as an input by deleting the corresponding bits in the register DDRD.
The Second C Program – Input with $\mu$Controller

User interaction (waiting for a button to be pressed) on the SPiCboard:

```c
#include <avr/io.h>

void main(void) {
    /* initialize hardware: button on port D pin 2 */
    DDRD &= ~(1 << 2); /* PD2 is used as input */
    PORTD |= (1 << 2); /* activate pull-up: PD2: high */

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    /* wait until PD2 -> low (button is pressed) */
    while ((PIND >> 2) & 1) {
    }

    /* greet user */
    PORTD &= ~(1 << 6); /* PD6: low --> LED is on */

    /* wait forever */
    while (1) {
    }
}
```

By setting bit 2 in the register PORTD as 1, the internal pull-up resistor (high resistance) gets activated. Which is connected to $V_{CC} \sim PD2 = high$. 
The Second C Program – Input with μController

User interaction (waiting for a button to be pressed) on the SPiCboard:

```c
#include <avr/io.h>

void main(void) {
    /* initialize hardware: button on port D pin 2 */
    DDRD &= ~(1 << 2); /* PD2 is used as input */
    PORTD |= (1 << 2); /* activate pull-up: PD2: high */

    /* initialize hardware: LED on port D pin 6, active low */
    DDRD |= (1 << 6); /* PD6 is used as output */
    PORTD |= (1 << 6); /* PD6: high --> LED is off */

    /* wait until PD2 -> low (button is pressed) */
    while ((PIND >> 2) & 1) {
    }

    /* greet user */
    PORTD &= ~(1 << 6); /* PD6: low --> LED is on */

    /* wait forever */
    while (1) {
    }
}
```

**Active waiting:** waits for a button to be pressed, i.e., while PD2 (bit 2 in the register PIND) is high. When the button gets pressed, PD2 is pulled to ground (~ bit 2 in the register PIND) is now low and the loop is exited.
User interaction with the SPiCboard gets explained line by line

**Active waiting:** waits for a button to be pressed, i.e., while PD2 (bit 2 in the register PIND) is *high*. When the button gets pressed, PD2 is pulled to ground \(\sim\) bit 2 in the register PIND is now *low* and the loop is exited.
As a Reference: User Interaction as a Java-Program

```java
import java.lang.System;
import javax.swing.*;
import java.awt.event.*;

public class Input implements ActionListener {
    private JFrame frame;

    public static void main(String[] args) {
        // create input, frame and button objects
        Input input = new Input();
        input.frame = new JFrame("Java Program");
        JButton button = new JButton("Press me");

        // add button to frame
        input.frame.add(button);
        input.frame.setSize(400, 400);
        input.frame.setVisible(true);

        // register input as listener of button events
        button.addActionListener(input);
    }

    public void actionPerformed(ActionEvent e) {
        System.out.println("Button pressed!");
        System.exit(0);
    }
}
```

Input as a “typical” Java program (object-oriented, graphic)
As a Reference: User Interaction as a Java-Program

```java
import java.lang.System;
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    public void actionPerformed(ActionEvent e) {
        System.out.println("Button pressed!");
        System.exit(0);
    }
}
```

Input as a “typical” Java program (object-oriented, graphic)

The class Input implements an interface to receive interaction events.
import java.lang.System;
import javax.swing.*;
import java.awt.event.*;

public class Input implements ActionListener {

    private JFrame frame;

    public static void main(String[] args) {
        // create input, frame and button objects
        Input input = new Input();
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        button.addActionListener(input);
    }

    public void actionPerformed(ActionEvent e) {
        System.out.println("Button pressed!");
        System.exit(0);
    }
}

Input as a “typical” Java program (object-oriented, graphic)

The program behaviour is implemented with the help of a multitude of objects (frame, button, input), which are created during initialization.
import java.lang.System;
import javax.swing.*;
import java.awt.event.*;

public class Input implements ActionListener {
    private JFrame frame;

    public static void main(String[] args) {
        // create input, frame and button objects
        Input input = new Input();
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    public void actionPerformed(ActionEvent e) {
        System.out.println("Button pressed!");
        System.exit(0);
    }
}

Input as a “typical” Java program (object-oriented, graphic)

The created button-object sends a message to the input-object.
As a Reference: User Interaction as a Java-Program

```java
import java.lang.System;
import javax.swing.*;
import java.awt.event.*;

public class Input implements ActionListener {
    private JFrame frame;

    public static void main(String[] args) {
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    public void actionPerformed(ActionEvent e) {
        System.out.println("Button pressed!");
        System.exit(0);
    }
}
```

Input as a “typical” Java program (object-oriented, graphic)

The button press gets signaled by an actionPerformed()-message (method call).
The program cannot be compared to its counterpart in C directly.
- It uses the (already known to you) **object-oriented paradigm**, which is typical for Java.
- This difference shall be emphasised here.

User interaction in Java explained line by line

The button press gets signaled by an `actionPerformed()`-message (method call).
A First Conclusion: From Java → C (Syntax)

- Java and C have similar **syntax**
  (Syntax: “What do valid programs of the language look like?”)

- C syntax was used as a reference for the development of Java
  → many language elements are similar or identical
  - blocks, loops, conditions, statements, literals
  - these elements will be looked at in detail in the following chapters

- Major elements from Java are **not** present in C
  - classes, packages, objects, exceptions, ...
A First Conclusion: From Java $\rightarrow$ C (Idiomatic)

There are major **idiomatic** differences
(Idiomatic: “What do programs of the language usually look like?”)

**Java: object-oriented paradigm**
- Central question: From which **things** is a problem made of?
- Segmentation of the problem in **classes** and **objects**
- Hierarchy by **inheritance** and **aggregation**
- Program flow by interaction between **objects**
- Re-usability through extensive **class libraries**

**C: imperative paradigm**
- Central question: From which **steps** is the problem made up?
- Segmentation of the problem in **functions** and **variables**
- Hierarchy by breakdown into **functions**
- Program flow through calls between **functions**
- Re-usability through **function libraries**
There are **philosophical** differences as well (Philosophy: “Basic ideas and concepts of a language”)

**Java**: Security and portability due to **abstracting from machine**
- Compilation for virtual machines (JVM)
- Extensive checks for programming errors during runtime
  - range overflow, division by 0, ...
- Problem-centric memory model
  - Only type-safe memory accesses, automatic garbage collection during runtime.

**C**: efficiency and lightweight due to **machine orientation**
- Compilation for concrete hardware architecture
- No checks for programming errors during runtime
  - some error are caught by the operating system – if present
- Memory model close to the machine
  - pointers provide direct memory access
  - coarse-grained access protection and automatic garbage collection (at processor level) by an OS – if present
A First Conclusion: \( \mu \)Controller-Programming

\[ C \mapsto \text{machine orientation} \mapsto \mu C \text{ programming} \]

The machine orientation of the language C especially shows when looking at \( \mu \)Controller programming!

- Only one program is running
  - On RESET the program is loaded directly from flash memory
  - Hardware has to be initialized by the program first
  - Shall never terminate (e.g., with the help of an infinite loop in `main()`)

- The solution is implemented close to the machine
  - Direct manipulation of single bits in hardware registers
  - Therefore detailed knowledge of electrical wiring is needed
  - No support of an operating system (like Linux)
  - Usually a low level of abstraction \( \mapsto \) error-prone... but fast
A First Conclusion: $\mu$Controller-Programming

$C \leftrightarrow$ machine orientation $\leftrightarrow$ $\mu$C programming

The machine orientation of the language C especially shows when looking at $\mu$Controller programming!

- Only one program is running
  - On RESET the program is loaded directly from flash memory
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Approach: Higher abstraction with problem-oriented libraries