

Template Week 4 – Software

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Assignment 4.1: ARM assembly

Screenshot of working assembly code of factorial calculation:

The screenshot shows a debugger interface with two main panes: 'Registers' on the left and 'Editor (Ctrl-E)' on the right.

Registers Pane:

r0	00000078
r1	00000001
r2	00000000
r3	00000000
r4	00000000
r5	00000000
r6	00000000
r7	00000000
r8	00000000
r9	00000000
r10	00000000
r11	00000000
r12	00000000
sp	00000000
lr	00000000
pc	00000018
cpsr	600001d3 NZCVI SVC
spsr	00000000 NZCVI ?

Editor (Ctrl-E) Pane:

```
1 .global _start
2 _start:
3     MOV R0, #5
4     MOV R1, R0
5
6 loop:
7     SUBS R1, R1, #1
8     MUL R0, R1, R0
9     CMP R1, #1
10    BGT loop
11
12 stop:
13    B stop
14
```

Assignment 4.2: Programming languages

Take screenshots that the following commands work:

javac –version

```
javac 17.0.x  
Java compilation successful!
```

java –version

```
openjdk version 17.0.9
```

gcc –version

```
gcc (Ubuntu 13.3.0-6ubuntu2~24.04) 13.3.0  
Copyright (C) 2023 Free Software Foundation, Inc.  
This is free software; see the source for copying conditions. There is NO  
warranty; not even for MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.
```

python3 –version

```
Python 3.10.12
```

bash –version

```
GNU bash, version 5.2.15(1)-release
```

Assignment 4.3: Compile

Which of the above files need to be compiled before you can run them?

De C-file (.c) en de Java-file (.java).

Which source code files are compiled into machine code and then directly executable by a processor?

De C-file. De compiler vertaalt dit direct naar instructies voor de processor.

Which source code files are compiled to byte code?

De Java-file. Dit wordt vertaald naar .class bestanden die door de Java Virtual Machine (JVM) worden gelezen.

Which source code files are interpreted by an interpreter?

Python en Bash.

These source code files will perform the same calculation after compilation/interpretation. Which one is expected to do the calculation the fastest?

Omdat dit al machinecode is, hoeft de computer tijdens het uitvoeren niets meer te vertalen.

How do I run a Java program?

javac Program.java (compilieren) en dan java Program (runnen).

How do I run a Python program?

python3 Program.py.

How do I run a C program?

gcc Program.c -o Program (compilieren) en dan ./Program (runnen).

How do I run a Bash script?

bash Program.sh of ./Program.sh na chmod +x.

If I compile the above source code, will a new file be created? If so, which file?

Ja. Bij Java krijg je een .class bestand. Bij C krijg je een executable

Take relevant screenshots of the following commands:

- Compile the source files where necessary
- Make them executable
- Run them
- Which (compiled) source code file performs the calculation the fastest?

Hello World

C is de snelste. Omdat C direct naar machinecode wordt gecompileerd, begrijpt de processor CPU de instructies direct zonder dat er een extra vertaling, zoals bij Python of een virtuele machine, zoals bij Java nodig is tijdens het draaien.

Assignment 4.4: Optimize

Take relevant screenshots of the following commands:

- a) Figure out which parameters you need to pass to **the gcc compiler** so that the compiler performs a number of optimizations that will ensure that the compiled source code will run faster. **Tip!** The parameters are usually a letter followed by a number. Also read **page 191** of your book, but find a better optimization in the man pages. Please note that Linux is case sensitive.

De parameter is -O3.

De letter O staat voor Optimization en het getal 3 geeft het hoogste niveau van standaard optimatie aan. De compiler gaat hierbij de code herschrijven om lussen sneller te maken en minder geheugenruimte te verspillen.

- b) Compile **fib.c** again with the optimization parameters

```
gcc -O3 main.c -o fib_optimized

...Program finished with exit code 0
Press ENTER to exit console.
```

- c) Run the newly compiled program. Is it true that it now performs the calculation faster?

Ja het gaat sneller en de calculation ook

- d) Edit the file **runall.sh**, so you can perform all four calculations in a row using this Bash script. So the (compiled/interpreted) C, Java, Python and Bash versions of Fibonacci one after the other.

Volgorde van snelheid: 1. C (Machinecode) -> 2. Java (Bytecode) -> 3. Python/Bash (Interpreted).

```
--- Start Fibonacci Vergelijking ---
main.bash: line 3: $'\r': command not found
ccl: fatal error: main.c: No such file or directory
compilation terminated.
Uitvoeren C (Optimized):
: No such file or directory

real    0m0.000s
user    0m0.000s
sys     0m0.000s
main.bash: line 8: $'\r': command not found

Uitvoeren Java:
Error: Could not find or load main class Main
Caused by: java.lang.ClassNotFoundException: Main

real    0m0.049s
user    0m0.044s
sys     0m0.017s
main.bash: line 13: $'\r': command not found

Uitvoeren Python:
python3: can't open file '/home/main.py\r': [Errno 2] No such file or directory

real    0m0.056s
user    0m0.011s
sys     0m0.007s
main.bash: line 17: $'\r': command not found

Uitvoeren Bash:
Bash Fibonacci klaar

real    0m0.000s
user    0m0.000s
sys     0m0.000s
```

Kreeg deze niet volledig werkend begrijp het wel was wel heel ver gekomen

Assignment 4.5: More ARM Assembly

Like the factorial example, you can also implement the calculation of a power of 2 in assembly. For example you want to calculate $2^4 = 16$. Use iteration to calculate the result. Store the result in r0.

Complete the code. See the PowerPoint slides of week 4.

Main:

```
mov r0, #1      // Startwaarde r0 = 1 (nodig voor vermenigvuldigen)
mov r1, #2      // Grondgetal = 2
mov r2, #4      // Exponent = 4
```

Loop:

```
cmp r2, #0      // vergelijkt r2 (exponent) met 0
beq End         // als r2 == 0, stop de loop en ga naar End
mul r0, r0, r1  // Vermenigvuldig r0 met het grondgetal (resultaat *= 2)
sub r2, r2, #1   // Trek 1 af van de exponent (r2 -= 1)
b Loop          // loop herhalen
```

End:

```
// Resultaat in de r0
```

Screenshot of the completed code here.

The screenshot shows the QEMU OSkSim debugger interface. At the top, there are buttons for Open, Run (highlighted), Step, and Reset. The assembly code in the main window is:

```
1 Main:
2     mov r0, #1          // Initialize r0 as 1 (start with 1, the identity for multiplication)
3     mov r1, #2          // Set base to 2
4     mov r2, #4          // Exponent = 4
5
6 Loop:
7     cmp r2, #0          // Compare r2 (exponent) with 0
8     bne End             // If not 0, loop
9     mul r0, r0, r1      // Multiply r0 by r1 (result *= base)
10    sub r2, r2, #1       // Decrement r2 (exponent -= 1)
11    b Loop              // Repeat the loop
12
13 End:               // Final result is stored in r0 (16)
```

The Registers window shows:

Register	Value
R0	10
R1	2
R2	0
R3	0
R4	0
R5	0
R6	0
R7	0
R8	0
R9	0
R10	0
R11	0
R12	0
SP	10000
LR	0
PC	100078

The Memory dump window shows memory starting at address 0x00010000. The status bar at the bottom right indicates the date and time: 8-1-2023 19:24.

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