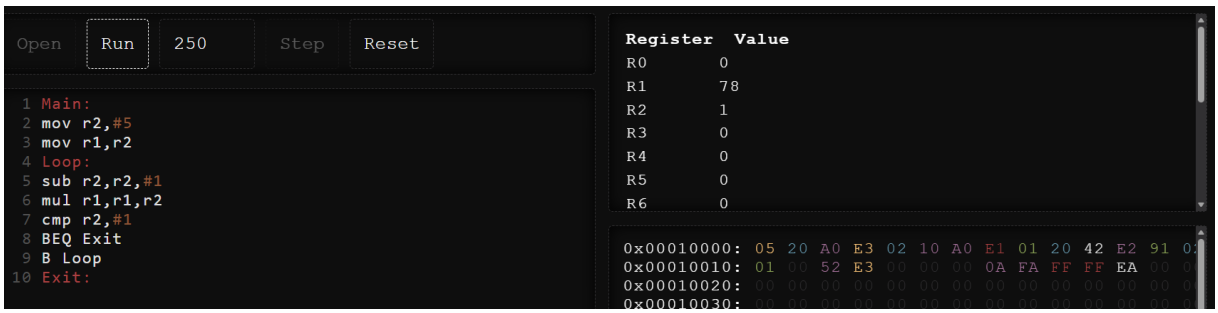
Template Week 4 – Software

Student number: 591658

Assignment 4.1: ARM assembly

Screenshot of working assembly code of factorial calculation:

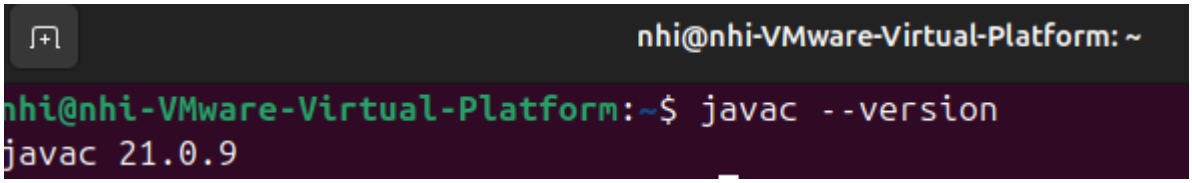
Factorial of 5



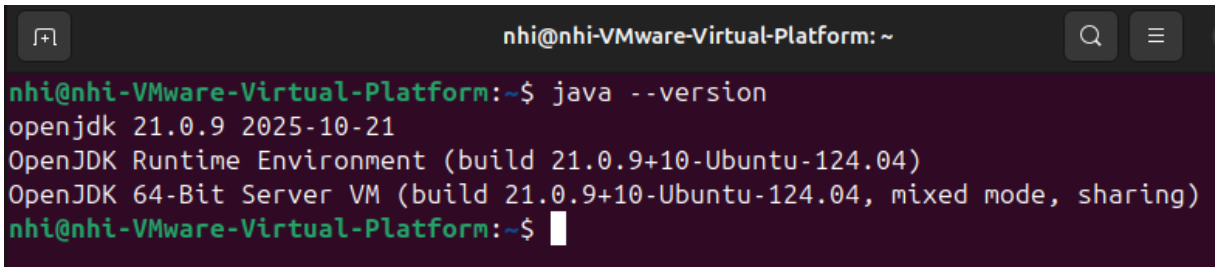
Assignment 4.2: Programming languages

Take screenshots that the following commands work:

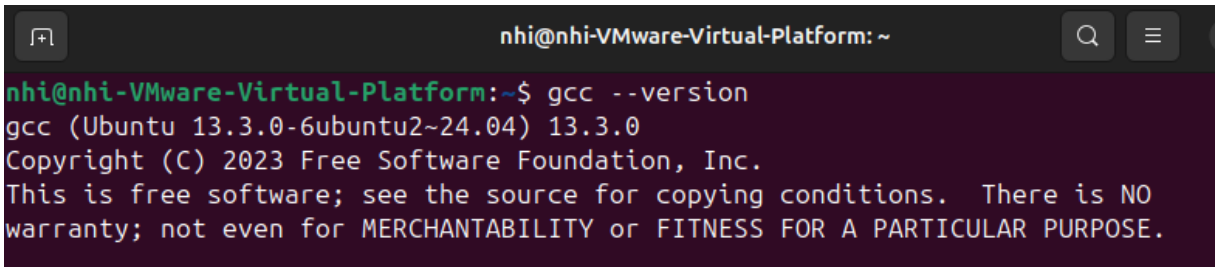
javac –version



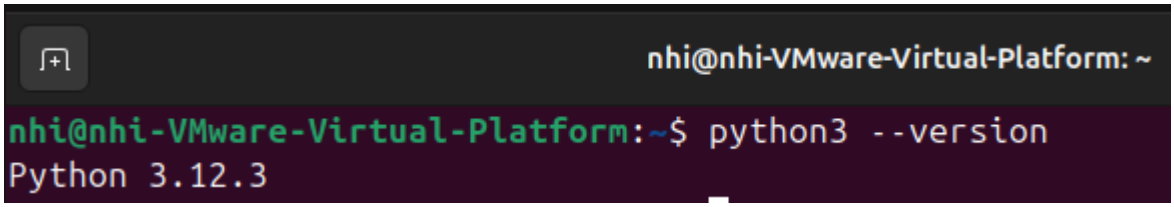
java –version



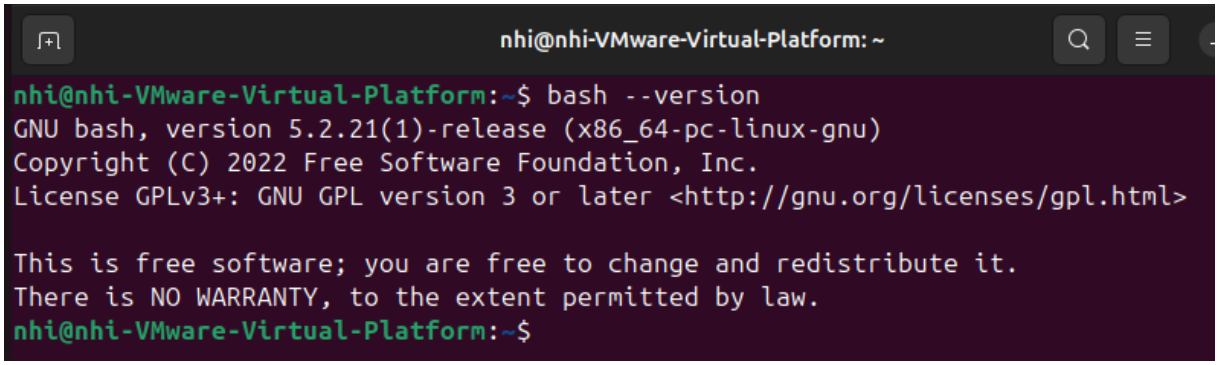
gcc –version



python3 –version



bash –version



Assignment 4.3: Compile

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

fib.c

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

fib.sh

Which source code files are compiled to byte code?

Fibonacci.java

Which source code files are interpreted by an interpreter?

fib.py

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

fib.c

How do I run a Java program?

Install java and javac compiler

Use javac compiler to compile Java file into a bytecode file (.class file) with the same name in the same directory

Command: javac Fibonacci.java

Run the bytecode file by command: java Fibonacci

How do I run a Python program?

Using python interpreter python3.

Command: python3 fib.py

How do I run a C program?

Use C compiler gcc to compile the file into an executable file.

Command: gcc fib.c -o fib

Run the executable file by command: ./fib

How do I run a Bash script?

Make Bash script file executable by command: sudo chmod a+x fib.sh

Run the file by command: sudo ./fib.sh

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

To run java source file, a bytecode (.class) file will be created

To run c source code file, a compiled file will be created

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?
  C program file run fastest

  Running Fibonacci.java

```
nhi@nhi-VMware-Virtual-Platform:~/Downloads/code$ javac Fibonacci.java
nhi@nhi-VMware-Virtual-Platform:~/Downloads/code$ ls
fib.c  Fibonacci.class  Fibonacci.java  fib.py  fib.sh  runall.sh
nhi@nhi-VMware-Virtual-Platform:~/Downloads/code$ java Fibonacci
Fibonacci(18) = 2584
Execution time: 0.55 milliseconds
nhi@nhi-VMware-Virtual-Platform:~/Downloads/code$
```

  Running fib.c

```
nhi@nhi-VMware-Virtual-Platform:~/Downloads/code$ gcc fib.c -o fib
nhi@nhi-VMware-Virtual-Platform:~/Downloads/code$ ls
fib  fib.c  Fibonacci.class  Fibonacci.java  fib.py  fib.sh  runall.sh
nhi@nhi-VMware-Virtual-Platform:~/Downloads/code$ ./fib
Fibonacci(18) = 2584
Execution time: 0.02 milliseconds
```

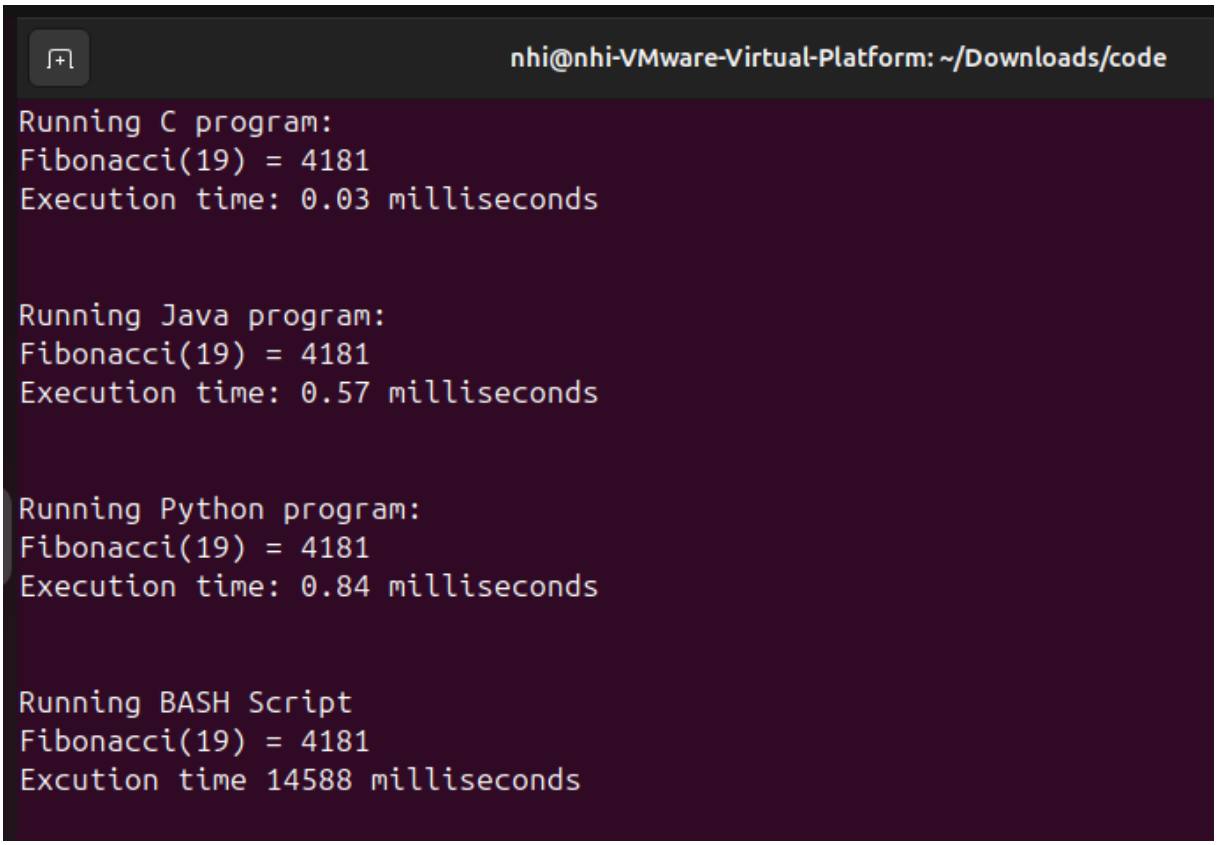
  Running fib.py

```
nhi@nhi-VMware-Virtual-Platform:~/Downloads/code$ ls
fib.c  Fibonacci.class  Fibonacci.java  fib.py  fib.sh  runall.sh
nhi@nhi-VMware-Virtual-Platform:~/Downloads/code$ python3 fib.py
Fibonacci(18) = 2584
Execution time: 0.60 milliseconds
nhi@nhi-VMware-Virtual-Platform:~/Downloads/code$
```

  Running fib.sh

```
nhi@nhi-VMware-Virtual-Platform:~/Downloads/code$ ls
fib.c  Fibonacci.java  fib.py  fib.sh  runall.sh
nhi@nhi-VMware-Virtual-Platform:~/Downloads/code$ sudo chmod a+x fib.sh
[sudo] password for nhi:
nhi@nhi-VMware-Virtual-Platform:~/Downloads/code$ ls
fib.c  Fibonacci.java  fib.py  fib.sh  runall.sh
nhi@nhi-VMware-Virtual-Platform:~/Downloads/code$ sudo ./fib.sh
Fibonacci(18) = 2584
Excution time 9195 milliseconds
```

  Running runall.sh to find out which source code file performs the calculation fastest. C file runs fastest.


nhi@nhi-VMware-Virtual-Platform: ~/Downloads/code
Running C program:
Fibonacci(19) = 4181
Execution time: 0.03 milliseconds
Running Java program:
Fibonacci(19) = 4181
Execution time: 0.57 milliseconds
Running Python program:
Fibonacci(19) = 4181
Execution time: 0.84 milliseconds
Running BASH Script
Fibonacci(19) = 4181
Excution time 14588 milliseconds

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.

-O1 Optimize.
-O2 Optimize even more.
-O3 Optimize yet more.

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

```
nhi@nhi-VMware-Virtual-Platform:~/Downloads/code$ gcc fib.c -O1 -o fib1
nhi@nhi-VMware-Virtual-Platform:~/Downloads/code$ gcc fib.c -O2 -o fib2
nhi@nhi-VMware-Virtual-Platform:~/Downloads/code$ ls
fib  fib1  fib2  fib.c  Fibonacci.class  Fibonacci.java  fib.py  fib.sh  runall.sh
```

c) Run the newly compiled program. Is it true that it now performs the calculation faster?
Yes, c file run faster after optimization.

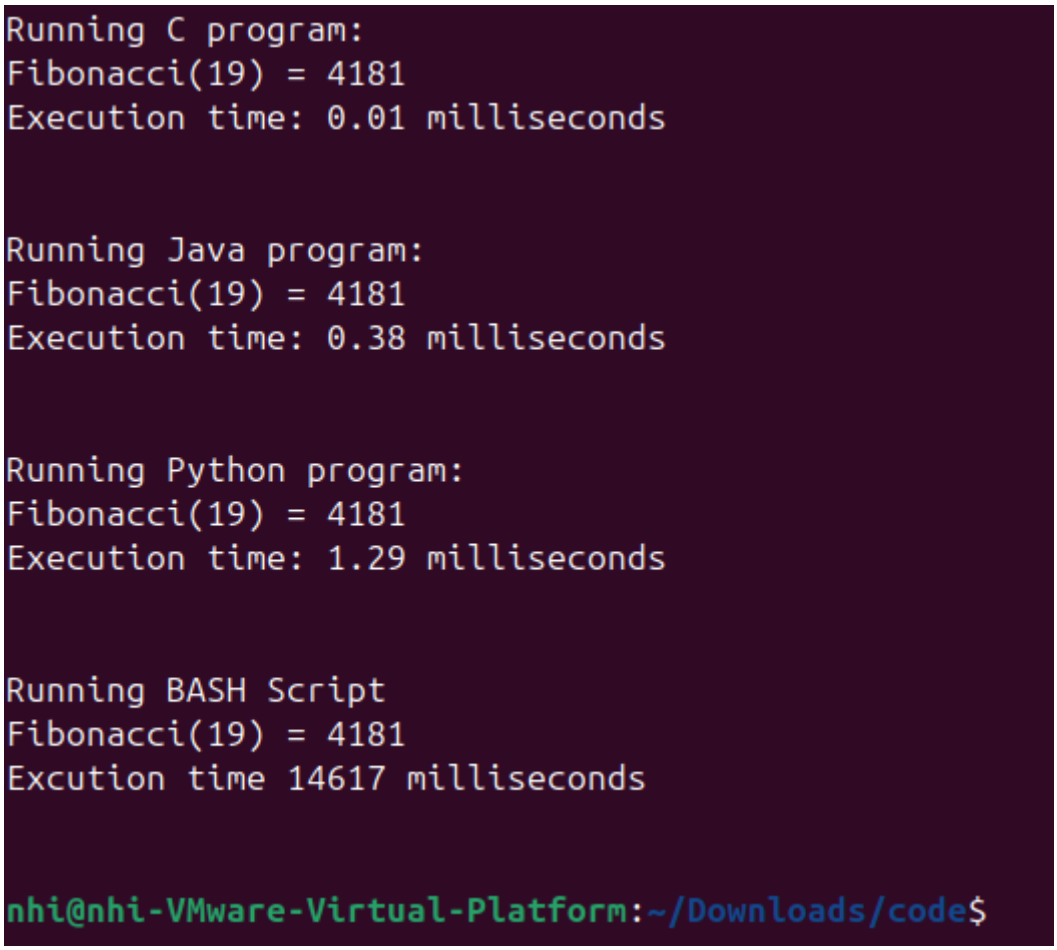
```
nhi@nhi-VMware-Virtual-Platform:~/Downloads/code$ gcc fib.c -O1 -o fib1
nhi@nhi-VMware-Virtual-Platform:~/Downloads/code$ gcc fib.c -O2 -o fib2
nhi@nhi-VMware-Virtual-Platform:~/Downloads/code$ ls
fib  fib1  fib2  fib.c  Fibonacci.class  Fibonacci.java  fib.py  fib.sh  runall.sh
nhi@nhi-VMware-Virtual-Platform:~/Downloads/code$ ./fib1
Fibonacci(18) = 2584
Execution time: 0.02 milliseconds
nhi@nhi-VMware-Virtual-Platform:~/Downloads/code$ ./fib2
Fibonacci(18) = 2584
Execution time: 0.01 milliseconds
```

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.
Make runall.sh executable with sudo chmod a+x

```
nhi@nhi-VMware-Virtual-Platform:~/Downloads/code$ ls -l runall.sh
-rw-rw-r-- 1 nhi nhi 249 Jun  9  2023 runall.sh
nhi@nhi-VMware-Virtual-Platform:~/Downloads/code$ sudo chmod a+x runall.sh
[sudo] password for nhi:
nhi@nhi-VMware-Virtual-Platform:~/Downloads/code$ ls -l runall.sh
-rwxrwxr-x 1 nhi nhi 249 Jun  9  2023 runall.sh
```

Run ./runall.sh

```
nhi@nhi-VMware-Virtual-Platform:~/Downloads/code$ ls
fib  fib.c  Fibonacci.class  Fibonacci.java  fib.py  fib.sh  runall.sh
nhi@nhi-VMware-Virtual-Platform:~/Downloads/code$ ./runall.sh
```



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.

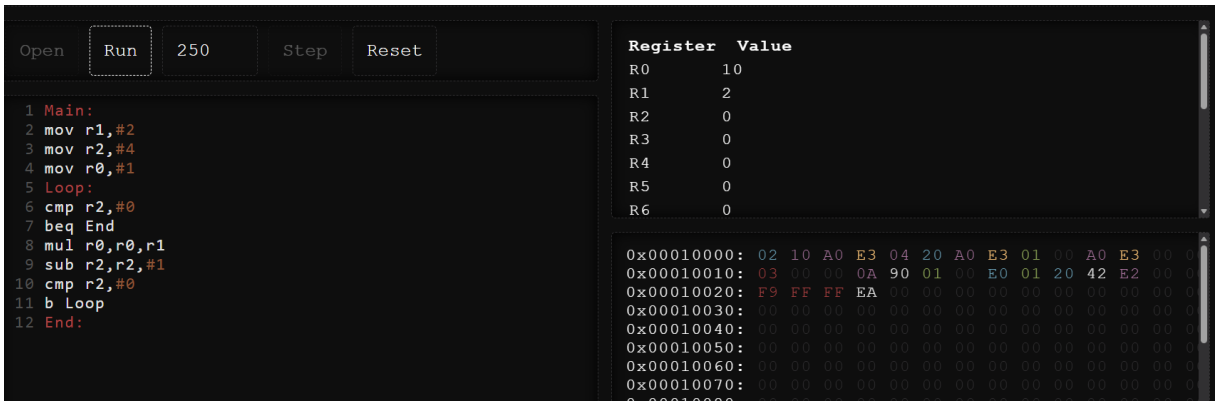
```
Main:
mov r1, #2
mov r2, #4

Loop:

End:
```

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

Screenshot of the completed code here.



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