Concordia University

Lab 1: Introduction to the software tool chain and STM32F334 Nucleo-64 Microcontroller

COEN 311

Lab Section: SN-X

Computer Organization and Software

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I certify that this submission is my original work and meets the Faculty’s Expectations of Originality

# Objective:

The main goal of the lab for the student is to get used to the basic Linux operations and gain experience programming a microcontroller. There are mainly two parts to this learning experience. Firstly, the student had to get familiar with the basic Linux operations, such as directory management and text editing using ‘nano’. Secondly, the student had to utilise the ARM tool chain for programming the STM32F334 Nucleo-64 microcontroller

# Theory and Discussion:

## Here is a general procedure of the lab:

1. **Preparing the Linux Environment**

* Log in to an AITS Linux PC.
* Load the COEN311 module: Run the command module load COEN311.

1. **Running the openocd Monitor Program**

* Connect the STM Nucleo-64 board to the PC via USB.
* Start openocd: Run the command “openocd -f board/st\_nucleo\_f3.cfg”.

1. **Assembling and Loading an ARM Assembly Language Program**

* Write the Assembly Code: Use a text editor to write your assembly code.
* Assemble the Code: Run the command “arm-none-eabi-as -g add.s -o add.o -al=add.lst”.
* Link the Object File: Execute “arm-none-eabi-ld add.o -o add.elf -Ttext=0x8000000”.

1. **Single Stepping through the Program with gdb**

* Start GDB: Run “arm-none-eabi-gdb add.elf”.
* Set a Breakpoint: Use the command “break start”.
* Run the Program: Execute “continue”.
* Single Step: Use the command “stepi” to move one instruction at a time.
* Inspect Registers: Run “info registers” to see the state of the CPU registers.

1. **Exiting the Programs**

* Quit GDB: Type the command “quit”.
* Exit openocd: Press "CTRL-C" in the terminal where openocd is running.

## Here is a summary of the concept needed to proceed:

**Microcontroller:** A microcontroller is a compact integrated circuit that serve as the brain of our machine. We are using one called the STM32F334 Nucleo-64 in the context of our lab.

**Linux:** Linux is an operating system that provides various utilities and commands for hardware interaction. We are using several development tool such as openocd, arm-none-eabi-as, arm-none-eabi-ld and arm-none-eabi-gdb to obtain the path to “COEN311”, verify it and run it.

**Assembly Language:** Arm Assembly Language is a low-level programming language that allows direct hardware control. We are using it to write a simple program to add two numbers.

**.syntax unified**

**.cpu cortex-m4**

**.thumb.**

**start:**

**mov r0, #4**

**mov r1, #5**

**add r2, r1, r0**

**stop:**

**b stop**

Here, the mov command is used to transfer data in the registers and add is used to perform the addition.

**GNU Debugger:** The GNU Debugger (GDB) is essential for identifying and fixing errors. We are using the following commands to navigate the program one instruction at the time.

(gdb) break start

(gdb) continue

(gdb) stepi

(gdb) info registers

Going through the code in such manner allows us to monitor the state of the registers.

# Conclusion:

In the Lab, we got hands-on experience programming a microcontroller, We also got to conduct the experiment in the Linux environment. That environment allowed us to run specialized tools, such as openocd for on-chip debugging and arm-none-eabi-as for ARM assembly. The output of the assembly process was an object file and a list file, both crucial for debugging and execution. Therefore, we successfully familiarized ourselves with both the theory and the basic practical skills needed for programming microcontrollers

# Appendix:

## Here is my terminal 1 content:

[bethe] [/home/p/p\_thibe] > module load COEN311

[bethe] [/home/p/p\_thibe] > ls -l

total 32

drwxr-x--- 2 p\_thibe p\_thibe 4096 Sep 20 14:58 Desktop

drwxr-x--- 2 p\_thibe p\_thibe 4096 Sep 20 14:58 Documents

drwxr-x--- 2 p\_thibe p\_thibe 4096 Sep 20 14:58 Downloads

drwxr-x--- 2 p\_thibe p\_thibe 4096 Sep 20 14:58 Music

drwxr-x--- 2 p\_thibe p\_thibe 4096 Sep 20 14:58 Pictures

drwxr-x--- 2 p\_thibe p\_thibe 4096 Sep 20 14:58 Public

drwxr-x--- 2 p\_thibe p\_thibe 4096 Sep 20 14:58 Templates

drwxr-x--- 2 p\_thibe p\_thibe 4096 Sep 20 14:58 Videos

[bethe] [/home/p/p\_thibe] > cd COEN311

COEN311: No such file or directory.

[bethe] [/home/p/p\_thibe] > which download

download: Command not found.

[bethe] [/home/p/p\_thibe] > which openocd

/encs/pkg/openocd-0.11.0/root/bin/openocd

[bethe] [/home/p/p\_thibe] > module load COEN311

[bethe] [/home/p/p\_thibe] > which openocd

/encs/pkg/openocd-0.11.0/root/bin/openocd

[bethe] [/home/p/p\_thibe] > which arm-none-eabi-as

/encs/pkg/gcc-arm-11.2.2022.02/root/bin/arm-none-eabi-as

[bethe] [/home/p/p\_thibe] > which arm-none-eabi-ld

/encs/pkg/gcc-arm-11.2.2022.02/root/bin/arm-none-eabi-ld

[bethe] [/home/p/p\_thibe] > which arm-none-eabi-gdb

/encs/pkg/gcc-arm-11.2.2022.02/root/bin/arm-none-eabi-gdb

[bethe] [/home/p/p\_thibe] > man which

[bethe] [/home/p/p\_thibe] > lsusb

Bus 002 Device 002: ID 2109:0817 VIA Labs, Inc.

Bus 002 Device 001: ID 1d6b:0003 Linux Foundation 3.0 root hub

Bus 001 Device 006: ID 0483:374b STMicroelectronics ST-LINK/V2.1

Bus 001 Device 004: ID 17ef:608d Lenovo Optical Mouse

Bus 001 Device 003: ID 17ef:6099 Lenovo

Bus 001 Device 005: ID 2109:8886 VIA Labs, Inc.

Bus 001 Device 002: ID 2109:2817 VIA Labs, Inc.

Bus 001 Device 001: ID 1d6b:0002 Linux Foundation 2.0 root hub

[bethe] [/home/p/p\_thibe] > openocd -f board/st\_nucleo\_f3.cfg

Open On-Chip Debugger 0.11.0

Licensed under GNU GPL v2

For bug reports, read

http://openocd.org/doc/doxygen/bugs.html

Info : The selected transport took over low-level target control. The results might differ compared to plain JTAG/SWD

srst\_only separate srst\_nogate srst\_open\_drain connect\_deassert\_srst

Info : Listening on port 6666 for tcl connections

Info : Listening on port 4444 for telnet connections

Info : clock speed 1000 kHz

Info : STLINK V2J33M25 (API v2) VID:PID 0483:374B

Info : Target voltage: 3.263810

Info : stm32f3x.cpu: hardware has 6 breakpoints, 4 watchpoints

Info : starting gdb server for stm32f3x.cpu on 3333

Info : Listening on port 3333 for gdb connections

na

^[[A^[[A^[[BaInfo : accepting 'gdb' connection on tcp/3333

target halted due to debug-request, current mode: Handler HardFault

xPSR: 0x00000003 pc: 00000000 msp: 0x200003e0

Info : device id = 0x10016438

Info : flash size = 64kbytes

Info : Unable to match requested speed 1000 kHz, using 950 kHz

Info : Unable to match requested speed 1000 kHz, using 950 kHz

target halted due to debug-request, current mode: Thread

xPSR: 0x01000000 pc: 0x800000ec msp: 0x20000400

Info : Unable to match requested speed 1000 kHz, using 950 kHz

Info : Unable to match requested speed 1000 kHz, using 950 kHz

target halted due to debug-request, current mode: Thread

xPSR: 0x01000000 pc: 0x800000ec msp: 0x20000400

Info : Unable to match requested speed 8000 kHz, using 4000 kHz

Info : Unable to match requested speed 8000 kHz, using 4000 kHz

Info : Unable to match requested speed 1000 kHz, using 950 kHz

Info : Unable to match requested speed 1000 kHz, using 950 kHz

target halted due to debug-request, current mode: Thread

xPSR: 0x01000000 pc: 0x800000ec msp: 0x20000400

Info : halted: PC: 0x080000f0

Info : halted: PC: 0x080000f4

Info : halted: PC: 0x080000f8

Info : dropped 'gdb' connection

## Here is my terminal 2 content:

[bethe] [/home/p/p\_thibe] > ls- l

ls-: Command not found.

[bethe] [/home/p/p\_thibe] > module load COEN 311

ModuleCmd\_Load.c(208):ERROR:105: Unable to locate a modulefile for 'COEN'

ModuleCmd\_Load.c(208):ERROR:105: Unable to locate a modulefile for '311'

[bethe] [/home/p/p\_thibe] > module load COEN311

[bethe] [/home/p/p\_thibe] > mkdir COEN311

[bethe] [/home/p/p\_thibe] > cd COEN311

[bethe] [/home/p/p\_thibe/COEN311] > mkdir code

[bethe] [/home/p/p\_thibe/COEN311] > cd code

[bethe] [/home/p/p\_thibe/COEN311/code] > mkdir lab1

[bethe] [/home/p/p\_thibe/COEN311/code] > cd lab1

[bethe] [/home/p/p\_thibe/COEN311/code/lab1] > nano junk.txt

[bethe] [/home/p/p\_thibe/COEN311/code/lab1] > arm-none-eabi-as -g add.s -o add.o -al=add.lst

add.s: Assembler messages:

add.s:1: Error: unknown pseudo-op: `.synthax'

[bethe] [/home/p/p\_thibe/COEN311/code/lab1] > nano add.s

[bethe] [/home/p/p\_thibe/COEN311/code/lab1] > arm-none-eabi-as -g add.s -o add.o -al=add.lst

[bethe] [/home/p/p\_thibe/COEN311/code/lab1] > more add.lst

ARM GAS add.s page 1

1 .syntax unified

2 .cpu cortex-m4

3 .thumb

4

5 0000 00040020 .word 0x20000400

6 0004 ED000080 .word 0x800000ed

7 0008 00000000 .space 0xe4

7 00000000

7 00000000

7 00000000

7 00000000

8

9 start:

10 00ec 4FF00400 mov r0, #4

11 00f0 4FF00501 mov r1, #5

12 00f4 01EB0002 add r2, r1, r0

13

14 00f8 FEE7 stop: b stop

[bethe] [/home/p/p\_thibe/COEN311/code/lab1] > arm-none-eabi-ld add.o -o add.elf -Ttext=0x8000000

arm-none-eabi-ld: warning: cannot find entry symbol \_start; defaulting to 0000000008000000

[bethe] [/home/p/p\_thibe/COEN311/code/lab1] > ls -al

total 36

drwxrwx--- 2 p\_thibe p\_thibe 4096 Sep 20 15:40 .

drwxrwx--- 3 p\_thibe p\_thibe 4096 Sep 20 15:15 ..

-rwxrwx--- 1 p\_thibe p\_thibe 67176 Sep 20 15:40 add.elf

-rw-rw---- 1 p\_thibe p\_thibe 528 Sep 20 15:37 add.lst

-rw-rw---- 1 p\_thibe p\_thibe 1636 Sep 20 15:37 add.o

-rw-rw---- 1 p\_thibe p\_thibe 148 Sep 20 15:37 add.s

-rw-rw---- 1 p\_thibe p\_thibe 149 Sep 20 15:32 junk.txt

[bethe] [/home/p/p\_thibe/COEN311/code/lab1] > arm-none-eabi-gbd add.elf

arm-none-eabi-gbd: Command not found.

[bethe] [/home/p/p\_thibe/COEN311/code/lab1] > arm-none-eabi-gdb add.elf

GNU gdb (GNU Toolchain for the Arm Architecture 11.2-2022.02 (arm-11.14)) 11.2.90.20220202-git

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License GPLv3+: GNU GPL version 3 or later <http://gnu.org/licenses/gpl.html>

This is free software: you are free to change and redistribute it.

There is NO WARRANTY, to the extent permitted by law.

Type "show copying" and "show warranty" for details.

This GDB was configured as "--host=x86\_64-pc-linux-gnu --target=arm-none-eabi".

Type "show configuration" for configuration details.

For bug reporting instructions, please see:

<https://bugs.linaro.org/>.

Find the GDB manual and other documentation resources online at:

<http://www.gnu.org/software/gdb/documentation/>.

For help, type "help".

Type "apropos word" to search for commands related to "word"...

Reading symbols from add.elf...

(gdb) target extended-remote localhost:3333

Remote debugging using localhost:3333

0x00000000 in ?? ()

(gdb) monitor reset halt

Unable to match requested speed 1000 kHz, using 950 kHz

Unable to match requested speed 1000 kHz, using 950 kHz

target halted due to debug-request, current mode: Thread

xPSR: 0x01000000 pc: 0x800000ec msp: 0x20000400

(gdb) load

Loading section .text, size 0xfa lma 0x8000000

Start address 0x08000000, load size 250

Transfer rate: 726 bytes/sec, 250 bytes/write.

(gdb) break start

Breakpoint 1 at 0x80000ec: file add.s, line 10.

Note: automatically using hardware breakpoints for read-only addresses.

(gdb) continue

Continuing.

Breakpoint 1, start () at add.s:10

10 mov r0, #4

(gdb) info registers

r0 0x0 0

r1 0x0 0

r2 0x0 0

r3 0x0 0

r4 0x0 0

r5 0x0 0

r6 0x0 0

r7 0x0 0

r8 0x0 0

r9 0x0 0

r10 0x0 0

r11 0x0 0

r12 0x0 0

sp 0x20000400 0x20000400

lr 0xffffffff -1

pc 0x80000ec 0x80000ec <start>

xPSR 0x41000003 1090519043

fpscr 0x0 0

msp 0x20000400 0x20000400

psp 0x0 0x0

primask 0x0 0

basepri 0x0 0

faultmask 0x0 0

control 0x0 0

(gdb) stepi

halted: PC: 0x080000f0

11 mov r1, #5

(gdb) info registers

r0 0x4 4

r1 0x0 0

r2 0x0 0

r3 0x0 0

r4 0x0 0

r5 0x0 0

r6 0x0 0

r7 0x0 0

r8 0x0 0

r9 0x0 0

r10 0x0 0

r11 0x0 0

r12 0x0 0

sp 0x20000400 0x20000400

lr 0xffffffff -1

pc 0x80000f0 0x80000f0 <start+4>

xPSR 0x41000003 1090519043

fpscr 0x0 0

msp 0x20000400 0x20000400

psp 0x0 0x0

primask 0x0 0

basepri 0x0 0

faultmask 0x0 0

control 0x0 0

(gdb) stepi

halted: PC: 0x080000f4

12 add r2, r1, r0

(gdb) info registers

r0 0x4 4

r1 0x5 5

r2 0x0 0

r3 0x0 0

r4 0x0 0

r5 0x0 0

r6 0x0 0

r7 0x0 0

r8 0x0 0

r9 0x0 0

r10 0x0 0

r11 0x0 0

r12 0x0 0

sp 0x20000400 0x20000400

lr 0xffffffff -1

pc 0x80000f4 0x80000f4 <start+8>

xPSR 0x41000003 1090519043

fpscr 0x0 0

msp 0x20000400 0x20000400

psp 0x0 0x0

primask 0x0 0

basepri 0x0 0

faultmask 0x0 0

control 0x0 0

(gdb) stepi

halted: PC: 0x080000f8

stop () at add.s:14

14 stop: b stop

(gdb) info registers

r0 0x4 4

r1 0x5 5

r2 0x9 9

r3 0x0 0

r4 0x0 0

r5 0x0 0

r6 0x0 0

r7 0x0 0

r8 0x0 0

r9 0x0 0

r10 0x0 0

r11 0x0 0

r12 0x0 0

sp 0x20000400 0x20000400

lr 0xffffffff -1

pc 0x80000f8 0x80000f8 <stop>

xPSR 0x41000003 1090519043

fpscr 0x0 0

msp 0x20000400 0x20000400

psp 0x0 0x0

primask 0x0 0

basepri 0x0 0

faultmask 0x0 0

control 0x0 0

(gdb) quit

A debugging session is active.

Inferior 1 [Remote target] will be detached.

Quit anyway? (y or n) y

Detaching from program: /nfs/home/p/p\_thibe/COEN311/code/lab1/add.elf, Remote target

[Inferior 1 (Remote target) detached]

[bethe] [/home/p/p\_thibe/COEN311/code/lab1] > ld -al

ld: unrecognized option '-al'

ld: use the --help option for usage information

[bethe] [/home/p/p\_thibe/COEN311/code/lab1] > ls -l

total 28

-rwxrwx--- 1 p\_thibe p\_thibe 67176 Sep 20 15:40 add.elf

-rw-rw---- 1 p\_thibe p\_thibe 528 Sep 20 15:37 add.lst

-rw-rw---- 1 p\_thibe p\_thibe 1636 Sep 20 15:37 add.o

-rw-rw---- 1 p\_thibe p\_thibe 148 Sep 20 15:37 add.s