Concordia University

Lab 2: Working with memory variables and linker scripts

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 a foundational understanding of memory variables, linker scripts, and debugging in ARM assembly language. There are mainly two parts to this learning experience. Firstly, the student must learn how to manipulate memory variables and understand the role of linker scripts in memory allocation. Secondly, the student must write an ARM assembly language program to compute the vector dot product of two arrays stored in memory.

# Theory and Discussion:

## Here is a general procedure of the lab:

1. Write the Assembly Code

* Use a text editor such as nano to write the ARM assembly code for the program through the terminal . Save the file as dot\_from\_mem.s.

1. Assemble the Code

* Run the following command to convert the assembly code into an object file:
* arm-none-eabi-as -g dot \_from\_mem.s -o dot \_from\_mem.o -al= dot \_from\_mem.lst

1. Link the Code

* Use a linker script to specify the memory locations for your code and data. Run this command to link the object file into an executable:
* arm-none-eabi-ld dot\_from\_mem.o -o dot\_from\_mem.elf -T stm32f334r8\_ALL\_IN\_RAM.ld

1. Connect the Microcontroller

* Plug in the microcontroller board to the PC
* Run the OpenOCD monitor program:
* openocd -f board/st\_nucleo\_f3.cfg

1. Debugging with GDB

* Start GDB with the following command:
* arm-none-eabi-gdb add\_from\_mem.elf
* Connect GDB to the microcontroller
* Load your program.
* Set a breakpoint at the start of your program
* Run it, and then step through it line by line.
* Use gdb commands like:
* x/3xb &mick to examine memory and
* info register to display the registers state
* Stepi to go trough the program line by line
* Continue to run your program
* Quit when the program is done

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

**Memory Variables:** These variables are stored in specified memory regions defined in the linker script. It can be defined in the .data section.

**Linker Scripts:** These are ASCII text files that control how the program's memory map is created. They specify where .data and .text sections are placed in memory.

**Array Dot Product:** The lab focuses on calculating the vector dot product of two arrays in memory. This involves using ARM arithmetic instructions like mul for multiplication and add for addition.

# **Addressing Modes:** ARM supports several addressing modes, such as immediate addressing, register addressing, and base plus offset. These modes are crucial for effective memory manipulation.

**Basic ARM arithmetic instructions:** To perform calculations

* **Adding :** Z=X+Y
* add Z, X, Y
* **Multiplying :** Z=X\*Y
* mul Z, X, Y

# Conclusion:

In this lab, we gained practical experience in ARM assembly language programming, focusing particularly on memory management, basic linear algebra operations and debugging techniques. Conducted in a Linux environment, the lab enabled us to deepen our experience with development tools from the last lab, such as the GNU Debugger (gdb), for step-by-step program tracing and the ARM toolchain for assembly and linking. Through this process, we generated key outputs like object files and list files, essential tools for debugging and validation. Our hands-on work included writing an ARM assembly program to compute the vector dot product of two arrays, providing us with insights into arithmetic operations and memory addressing modes. We also delved into the use of linker scripts for specifying memory locations for our code and data, enhancing our understanding of low-level memory allocation.

# Appendix:

## **Here is my .lst file content:**

ARM GAS Dot\_product.s page 1

1 .syntax unified

2 .cpu cortex-m4

3 .thumb

4 0000 00040020 .word 0x20000400

5 0004 ED000080 .word 0x800000ed

6 0008 00000000 .space 0xe4

6 00000000

6 00000000

6 00000000

6 00000000

7

8 .data

9 0000 020304 mick: .byte 2,3,4

10 0003 050607 keith: .byte 5,6,7

11 0006 00 dot: .space 0x01

12

13 .text

14 start:

15 00ec 4FF00004 mov r4, #0

16 00f0 4FF00005 mov r5, #0

17

18 loop:

19 00f4 0648 ldr r0, =mick

20 00f6 415D ldrb r1, [r0, r5]

21 00f8 0648 ldr r0, =keith

22 00fa 425D ldrb r2, [r0, r5]

23 00fc 01FB02F3 mul r3, r1, r2

24 0100 1C44 add r4, r4, r3

25 0102 05F10105 add r5, r5, #1

26 0106 032D cmp r5, #3

27 0108 F4DB blt loop

28

29 010a 0348 ldr r0, =dot

30 010c 0470 strb r4, [r0]

31

32 stop:

33 010e FEE70000 b stop

33 00000300

33 00000600

33 0000

## **Here is my .Id file content:**

MEMORY {

FLASH : ORIGIN = 0x8000000, LENGTH = 64K

SRAM : ORIGIN = 0x20000000, LENGTH = 16K

}

SECTIONS {

.text : {

\*(.text)

} >SRAM

.data : {

\*(.data)

} >SRAM

}

## **Here is my terminal 1 content:**

[bellow] [/home/p/p\_thibe] > ls

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

[bellow] [/home/p/p\_thibe/COEN311] > LS

LS: Command not found.

[bellow] [/home/p/p\_thibe/COEN311] > ls

code

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

[bellow] [/home/p/p\_thibe/COEN311/code] > ls

lab1 lab2

[bellow] [/home/p/p\_thibe/COEN311/code] > cd lab2

[bellow] [/home/p/p\_thibe/COEN311/code/lab2] > ls

[bellow] [/home/p/p\_thibe/COEN311/code/lab2] > openocd -fboard/st\_nucleo\_f3.cfg

openocd: Command not found.

[bellow] [/home/p/p\_thibe/COEN311/code/lab2] > openocd -f board/st\_nucleo\_f3.cfg

openocd: Command not found.

[bellow] [/home/p/p\_thibe/COEN311/code/lab2] > module load COEN311

[bellow] [/home/p/p\_thibe/COEN311/code/lab2] > 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: 3.250952

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

^[[AInfo : 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 : halted: PC: 0x200000ee

Info : halted: PC: 0x200000f0

Info : halted: PC: 0x200000f2

Info : halted: PC: 0x200000f4

Info : halted: PC: 0x200000f8

Info : halted: PC: 0x200000fa

Info : halted: PC: 0x200000fc

Info : dropped 'gdb' connection

Info : accepting 'gdb' connection on tcp/3333

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: 0x200000f0

Info : halted: PC: 0x200000f4

Info : halted: PC: 0x200000f6

Info : halted: PC: 0x200000f8

Info : halted: PC: 0x200000fa

Info : halted: PC: 0x200000fc

Info : halted: PC: 0x20000100

Info : halted: PC: 0x20000102

Info : halted: PC: 0x20000106

Info : halted: PC: 0x20000108

Info : halted: PC: 0x200000f4

Info : halted: PC: 0x200000f6

Info : halted: PC: 0x200000f8

Info : halted: PC: 0x200000fa

Info : halted: PC: 0x200000fc

Info : halted: PC: 0x20000100

Info : halted: PC: 0x20000102

Info : halted: PC: 0x20000106

Info : halted: PC: 0x20000108

Info : halted: PC: 0x200000f4

Info : halted: PC: 0x200000f6

Info : halted: PC: 0x200000f8

Info : halted: PC: 0x200000fa

Info : halted: PC: 0x200000fc

Info : halted: PC: 0x20000100

Info : halted: PC: 0x20000102

Info : halted: PC: 0x20000106

Info : halted: PC: 0x20000108

Info : halted: PC: 0x2000010a

Info : halted: PC: 0x2000010c

Info : halted: PC: 0x2000010e

Info : halted: PC: 0x2000010e

Info : halted: PC: 0x2000010e

Info : halted: PC: 0x2000010e

Info : dropped 'gdb' connection

^Cshutdown command invoked

[bellow] [/home/p/p\_thibe/COEN311/code/lab2] >

## **Here is my terminal 2 content:**

[bellow] [/home/p/p\_thibe] > ls

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

[bellow] [/home/p/p\_thibe/COEN311] > ls

code

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

[bellow] [/home/p/p\_thibe/COEN311/code] > ls

lab1 lab2

[bellow] [/home/p/p\_thibe/COEN311/code] > cd lab2

[bellow] [/home/p/p\_thibe/COEN311/code/lab2] > ls

add\_from\_mem.elf add\_from\_mem.lst add\_from\_mem.o add\_from\_mem.s Lab2.pdf stm32f334r8\_ALL\_IN\_RAM.ld

[bellow] [/home/p/p\_thibe/COEN311/code/lab2] > ls -l

total 96

-rwxrwx--- 1 p\_thibe p\_thibe 67044 Oct 4 15:51 add\_from\_mem.elf

-rw-rw---- 1 p\_thibe p\_thibe 1448 Oct 4 15:46 add\_from\_mem.lst

-rw-rw---- 1 p\_thibe p\_thibe 1864 Oct 4 15:46 add\_from\_mem.o

-rw-rw---- 1 p\_thibe p\_thibe 726 Oct 4 15:40 add\_from\_mem.s

-rw-rw---- 1 p\_thibe p\_thibe 64468 Oct 4 15:13 Lab2.pdf

-rw-rw---- 1 p\_thibe p\_thibe 170 Oct 4 15:49 stm32f334r8\_ALL\_IN\_RAM.ld

[bellow] [/home/p/p\_thibe/COEN311/code/lab2] > ls

add\_from\_mem.elf add\_from\_mem.o Lab2.pdf stm32f334r8\_ALL\_IN\_RAM.ld

add\_from\_mem.lst add\_from\_mem.s Question

[bellow] [/home/p/p\_thibe/COEN311/code/lab2] > Question]

Question]: Command not found.

[bellow] [/home/p/p\_thibe/COEN311/code/lab2] > cd Question

[bellow] [/home/p/p\_thibe/COEN311/code/lab2/Question] > cd /home/p/p\_thibe/COEN311/code/lab2

[bellow] [/home/p/p\_thibe/COEN311/code/lab2] > nano Terminal\_2

[bellow] [/home/p/p\_thibe/COEN311/code/lab2] > nano Dot\_product.s

[bellow] [/home/p/p\_thibe/COEN311/code/lab2] > cp /home/p/p\_thibe/COEN311/code/lab2/Dot\_product.s /home/p/p\_thibe/COEN311/code/lab2/Question

[bellow] [/home/p/p\_thibe/COEN311/code/lab2] > cd Question

[bellow] [/home/p/p\_thibe/COEN311/code/lab2/Question] > module load COEN311

[bellow] [/home/p/p\_thibe/COEN311/code/lab2/Question] > arm-none-eabi-as -g Dot\_product.s -o Dot\_product.o -al=Dot\_product.lst

[bellow] [/home/p/p\_thibe/COEN311/code/lab2/Question] > cd ..

[bellow] [/home/p/p\_thibe/COEN311/code/lab2] > ls -l

total 120

-rwxrwx--- 1 p\_thibe p\_thibe 67044 Oct 4 15:51 add\_from\_mem.elf

-rw-rw---- 1 p\_thibe p\_thibe 1448 Oct 4 15:46 add\_from\_mem.lst

-rw-rw---- 1 p\_thibe p\_thibe 1864 Oct 4 15:46 add\_from\_mem.o

-rw-rw---- 1 p\_thibe p\_thibe 726 Oct 4 15:40 add\_from\_mem.s

-rw-rw---- 1 p\_thibe p\_thibe 401 Oct 4 16:30 Dot\_product.s

-rw-rw---- 1 p\_thibe p\_thibe 64468 Oct 4 15:13 Lab2.pdf

drwxr-xr-x 2 p\_thibe p\_thibe 4096 Oct 4 16:38 Question

-rw-rw---- 1 p\_thibe p\_thibe 170 Oct 4 15:49 stm32f334r8\_ALL\_IN\_RAM.ld

-rw-rw---- 1 p\_thibe p\_thibe 13763 Oct 4 16:09 Terminal\_2

[bellow] [/home/p/p\_thibe/COEN311/code/lab2] > cp stm32f334r8\_ALL\_IN\_RAM.ld /home/p/p\_thibe/COEN311/code/lab2/Question

[bellow] [/home/p/p\_thibe/COEN311/code/lab2] > arm-none-eabi-ld Dot\_product.o -o Dot\_product.elf -T stm32f334r8\_ALL\_IN\_RAM.ld

arm-none-eabi-ld: cannot find Dot\_product.o: No such file or directory

[bellow] [/home/p/p\_thibe/COEN311/code/lab2] > module load COEN311 [bellow] [/home/p/p\_thibe/COEN311/code/lab2] > ls

add\_from\_mem.elf add\_from\_mem.o Dot\_product.s Question Terminal\_2

add\_from\_mem.lst add\_from\_mem.s Lab2.pdf stm32f334r8\_ALL\_IN\_RAM.ld

[bellow] [/home/p/p\_thibe/COEN311/code/lab2] > cd Question

[bellow] [/home/p/p\_thibe/COEN311/code/lab2/Question] > arm-none-eabi-ld Dot\_product.o -o Dot\_product.elf -T stm32f334r8\_ALL\_IN\_RAM.ld

[bellow] [/home/p/p\_thibe/COEN311/code/lab2/Question] > arm-none-eabi-gdb Dot\_product.elf

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

Copyright (C) 2022 Free Software Foundation, Inc.

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 Dot\_product.elf...

(gdb) target extended-remote localhost:3333

Remote debugging using localhost:3333

loop () at Dot\_product.s:23

23 mul r3, r1, r2

(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 0x11c lma 0x20000000

Loading section .data, size 0x7 lma 0x2000011c

Start address 0x20000000, load size 291

Transfer rate: 40 KB/sec, 145 bytes/write.

(gdb) break start

Breakpoint 1 at 0x200000ec: file Dot\_product.s, line 15.

(gdb) continue

Continuing.

Breakpoint 1, start () at Dot\_product.s:15

15 mov r4, #0

(gdb) info register

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 0x200000ec 0x200000ec <start>

xPSR 0x41000000 1090519040

fpscr 0x0 0

msp 0x20000400 0x20000400

psp 0x0 0x0

primask 0x0 0

basepri 0x0 0

faultmask 0x0 0

control 0x0 0

(gdb) x/1xb &result

No symbol "result" in current context.

(gdb) stepi

halted: PC: 0x200000f0

16 mov r5, #0

(gdb) info register

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 0x200000f0 0x200000f0 <start+4>

xPSR 0x41000000 1090519040

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: 0x200000f4

loop () at Dot\_product.s:19

19 ldr r0, =mick

(gdb) info register

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 0x200000f4 0x200000f4 <loop>

xPSR 0x41000000 1090519040

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: 0x200000f6

20 ldrb r1, [r0, r5]

(gdb) info register

r0 0x2000011c 536871196

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 0x200000f6 0x200000f6 <loop+2>

xPSR 0x41000000 1090519040

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: 0x200000f8

21 ldr r0, =keith

(gdb) info register

r0 0x2000011c 536871196

r1 0x2 2

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 0x200000f8 0x200000f8 <loop+4>

xPSR 0x41000000 1090519040

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: 0x200000fa

22 ldrb r2, [r0, r5]

(gdb) info register

r0 0x2000011f 536871199

r1 0x2 2

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 0x200000fa 0x200000fa <loop+6>

xPSR 0x41000000 1090519040

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: 0x200000fc

23 mul r3, r1, r2

(gdb) info register

r0 0x2000011f 536871199

r1 0x2 2

r2 0x5 5

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 0x200000fc 0x200000fc <loop+8>

xPSR 0x41000000 1090519040

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: 0x20000100

24 add r4, r4, r3

(gdb) info register

r0 0x2000011f 536871199

r1 0x2 2

r2 0x5 5

r3 0xa 10

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 0x20000100 0x20000100 <loop+12>

xPSR 0x41000000 1090519040

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: 0x20000102

25 add r5, r5, #1

(gdb) info register

r0 0x2000011f 536871199

r1 0x2 2

r2 0x5 5

r3 0xa 10

r4 0xa 10

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 0x20000102 0x20000102 <loop+14>

xPSR 0x41000000 1090519040

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: 0x20000106

26 cmp r5, #3

(gdb) info register

r0 0x2000011f 536871199

r1 0x2 2

r2 0x5 5

r3 0xa 10

r4 0xa 10

r5 0x1 1

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 0x20000106 0x20000106 <loop+18>

xPSR 0x41000000 1090519040

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: 0x20000108

27 blt loop

(gdb) info register

r0 0x2000011f 536871199

r1 0x2 2

r2 0x5 5

r3 0xa 10

r4 0xa 10

r5 0x1 1

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 0x20000108 0x20000108 <loop+20>

xPSR 0x81000000 -2130706432

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: 0x200000f4

19 ldr r0, =mick

(gdb) stepi

halted: PC: 0x200000f6

20 ldrb r1, [r0, r5]

(gdb) stepi

halted: PC: 0x200000f8

21 ldr r0, =keith

(gdb) stepi

halted: PC: 0x200000fa

22 ldrb r2, [r0, r5]

(gdb) stepi

halted: PC: 0x200000fc

23 mul r3, r1, r2

(gdb) stepi

halted: PC: 0x20000100

24 add r4, r4, r3

(gdb) stepi

halted: PC: 0x20000102

25 add r5, r5, #1

(gdb) stepi

halted: PC: 0x20000106

26 cmp r5, #3

(gdb) stepi

halted: PC: 0x20000108

27 blt loop

(gdb) info register

r0 0x2000011f 536871199

r1 0x3 3

r2 0x6 6

r3 0x12 18

r4 0x1c 28

r5 0x2 2

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 0x20000108 0x20000108 <loop+20>

xPSR 0x81000000 -2130706432

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: 0x200000f4

19 ldr r0, =mick

(gdb) stepi

halted: PC: 0x200000f6

20 ldrb r1, [r0, r5]

(gdb) stepi

halted: PC: 0x200000f8

21 ldr r0, =keith

(gdb) stepi

halted: PC: 0x200000fa

22 ldrb r2, [r0, r5]

(gdb) stepi

halted: PC: 0x200000fc

23 mul r3, r1, r2

(gdb) stepi

halted: PC: 0x20000100

24 add r4, r4, r3

(gdb) stepi

halted: PC: 0x20000102

25 add r5, r5, #1

(gdb) stepi

halted: PC: 0x20000106

26 cmp r5, #3

(gdb) stepi

halted: PC: 0x20000108

27 blt loop

(gdb) stepi

halted: PC: 0x2000010a

29 ldr r0, =dot

(gdb) info register

r0 0x2000011f 536871199

r1 0x4 4

r2 0x7 7

r3 0x1c 28

r4 0x38 56

r5 0x3 3

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 0x2000010a 0x2000010a <loop+22>

xPSR 0x61000000 1627389952

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: 0x2000010c

30 strb r4, [r0]

(gdb) info register

r0 0x20000122 536871202

r1 0x4 4

r2 0x7 7

r3 0x1c 28

r4 0x38 56

r5 0x3 3

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 0x2000010c 0x2000010c <loop+24>

xPSR 0x61000000 1627389952

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: 0x2000010e

stop () at Dot\_product.s:33

33 b stop

(gdb) stepi

halted: PC: 0x2000010e

33 b stop

(gdb) stepi

halted: PC: 0x2000010e

33 b stop

(gdb) stepi

halted: PC: 0x2000010e

33 b stop

(gdb) info register

r0 0x20000122 536871202

r1 0x4 4

r2 0x7 7

r3 0x1c 28

r4 0x38 56

r5 0x3 3

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 0x2000010e 0x2000010e <stop>

xPSR 0x61000000 1627389952

fpscr 0x0 0

msp 0x20000400 0x20000400

psp 0x0 0x0

primask 0x0 0

basepri 0x0 0

faultmask 0x0 0

control 0x0 0

(gdb) x/1xb &dot

0x20000122: 0x38

(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/lab2/Question/Dot\_product.elf, Remote target

[Inferior 1 (Remote target) detached]

[bellow] [/home/p/