

EE 3220 – Embedded System Design - 2020

Quiz 1

Submission method – online submission via Canvas

Name: Solution
Student ID: _____

Date: _____
Mark: _____

1) Describe the term “instruction set”. Explain how use of instruction set differs for low-level programming. (10%)

- Instruction set clear explanation – 5 marks
- Explain how different instruction set will differ for low-level programming – 5 marks

Sample solution: Instruction set architecture is a part of a computer that pertains to programming which is mainly machine code which supported data types, registers etc. It is for the communication between software and hardware.

Student can elaborate the meaning of instruction set. Instruction set is a group of commands for CPU executing the instruction.

2) Describe an embedded system in less than 100 words, and what are the differences between a microprocessor and a microcontroller? (10%)

- Embedded system description – 5 marks
Describing different parts and functionality inside it.
e.g., printer, mobile phone, microwave, steamer, watch, etc.

The Gasoline Automobile Engine Control Unit is an embedded system. it consists the function of fuel injection, air intake setting, spark time, knock control etc, to controlling the engine of a car. It is using high-performance microcontroller to enhance the reliability and safety of the control unit. It has lots of inputs and outputs like the sensors and actuators. it also have some constraints like the size and the reliability in harsh environment.

- Difference between uP and uC – 5 marks

For microcontroller, it has peripherals for concurrent embedded interfacing and control of analog, timing, non-logic level signals etc. the microprocessor mainly refers to CPU with memories and it use an External bus to interface. But microcontroller consists of CPU, I/O, memory and integrated to one chip and use an internal controlling bus.

3) Describe the assembler directives used in our course so far and explain their meanings. (10%)

- Each directive (2 marks)
- Each explanation (2 marks)

4) What is the difference between ARM compiler 5 and 6? In addition, please also elaborate the difference between ARMv8-A and ARMv7. What is the architecture that Cortex-M4 is using? (10%)

- ARM 5 vs 6 – 4 marks
- ARMv8-A vs v7 – 4 marks
- Cortex-M4 architecture – 2 marks

ARM Compiler 5 uses the compiler ARMCC while ARM Compiler 6 uses the compiler ARMCLANG

Cortex-M4 is ARMv7 architecture.

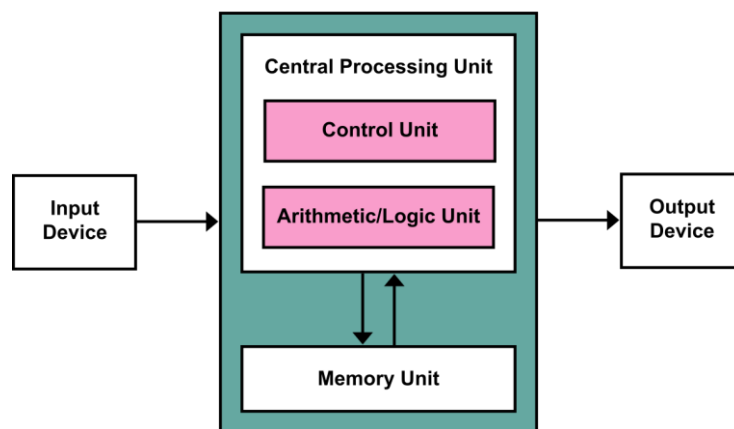
5) We take Cortex-M4 as an example. How many pipeline stages are there? Please illustrate the movement of an instruction, such as MOVE / ADD in these pipelines. (10%)

- Explained 3 pipeline stages (4 marks)
- Explain the movement with ARM instructions (6 marks)

Explain the three pipeline stages, Fetch, Decode, Execution stages.

Cortex-M4 processors use a 32-bit architecture, while most of the instructions are 16-bit, so usually, a maximum of 2 instructions could be fetched at a time, allowing extra bandwidth on the memory interface for a better performance as well as energy efficiency.

6) What are the advantages and disadvantages of Von Neumann architecture and Harvard architecture? (10%)



- Explain the advantage and disadvantage for Von Neumann (5 marks)
- Explain the advantage and disadvantage for Harvard (5 marks)

For Von Neumann architecture:

Simplicity, data and instruction share same bus

The execution time of instruction is slower than Harvard architecture

For Harvard architecture:

Execution time of instruction is lower than Von Neumann architecture

More complex hardware design since it takes separate data bus for instruction and data

ARM Cortex-M4 belongs to the Harvard architecture.

7. Cortex-M0+ is the most energy-efficient processor in the Cortex-M family. Suppose a Cortex-M0+ processor takes 100 uA in the active mode, and 48 uA in the sleep mode. If the application puts the processor 50% of the time in active mode and 50% in sleep mode, and the two button cell batteries power the processor, with a total capacity of 600 mAh. How long can the batteries last? (Thumb of rule: Battery life = Battery Capacity in mA per hour / Load Current in mA * 0.7). (5%)

- Correct value (5 marks) partial mark is given if result is incorrect, but the steps are correct.
- battery life = (600 mAh) / 0.074 mA * 0.7 = 5675.68 hours

8. Translate the following C statements into an assembly program, you can use any general purpose registers, and ARM instructions: (10%)

`x = 0x100; y = 0x200;`

`z = x * y - 3;`

- Correct translation to ARM instruction (5 marks)
- Correct use of registers (5 marks)

`mov r1, 0x100`

`mov r2, 0x200`

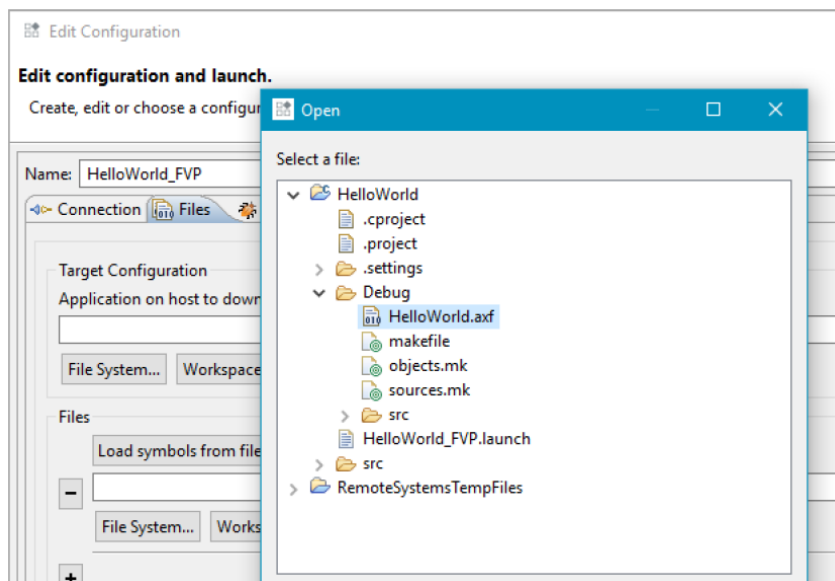
`mul r3, r1, r2`

`sub r3, r3, 3`

9. A MOV assembly instruction copies the value of the source register to the destination register. What is the value of the destination register r1 after the following instruction completes? Can you describe the memory allocation in a microprocessor system? (10%)

Memory Address	Assembly Instruction
...	...
0x08000166	MOV r1, pc
...	...

- Answer should be PC will be increased by 4, so r1 will be the memory address +4 (2 marks)
 - 0x0800016A
 - Explain the current memory types, data segment, code segment, stack, heap, and others (2-8 marks)
10. What is the difference between ARM32, Thumb, Thumb-2, and ARM64? In the tutorial session, why do we need to set the RO address, and select this axf file in the DS platform for the FVP? (10%)



Explain the key difference for the four types, 2 marks each
RO address – 1 mark
Explain why selecting the AXF file, 1 mark

ARM32 instruction is a 32-bits instruction while Thumb instruction is 16-bits.

Thumb-2 instruction is a Thumb instruction that have both 32 and 16 bits to improve the performance.

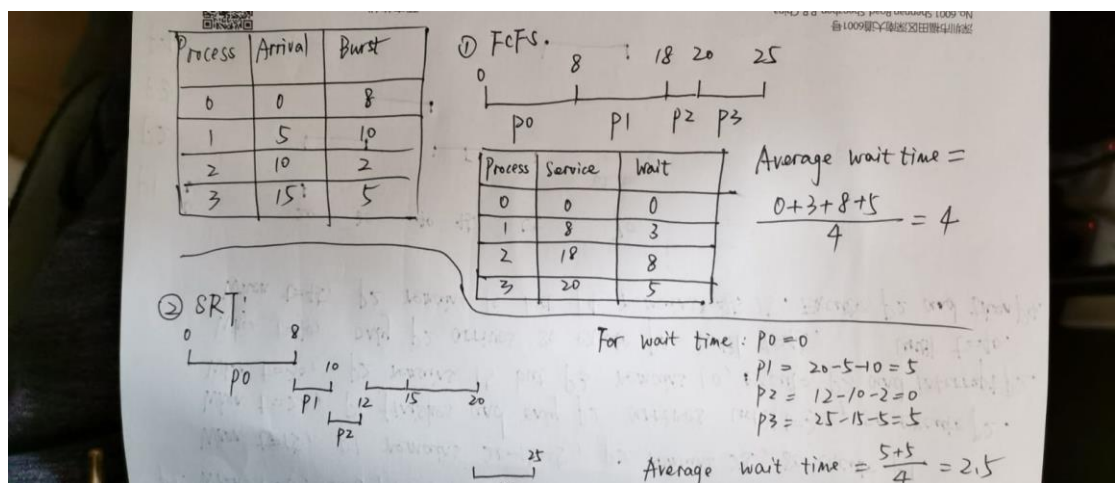
ARM64 is an ARM that enable 64-bits instruction while still compatible with 32-bits instruction from ARM32 we have to select this file address to make the debugger know that we want to debug the symbol from this file.

11. An embedded operating system uses both 1) FCFS and 2) SRT process scheduling algorithm. Please draw the two figures of all the process with burst time and wait time. (15%)

An embedded operating system uses both 1) First-come First-serve (FCFS) processing scheduling algorithm, and 2) the Shortest Remaining Time (SRT) process scheduling algorithm. Consider the arrival times and execution times for the following processes:

Process	Arrival Time	Burst Time
P0	0	8
P1	5	10
P2	10	2
P3	15	5

Please draw the two figures of all the process with burst time and wait time. What are the two average waiting time for the two scheduling algorithms? (15%)



- 5 marks for the correct two figures each.
- 5 marks for the two final correct average waiting time

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