EE3220 Quiz 1 Solutions:

1. **Describe the term "instruction" and "instruction set architecture (ISA)". Accordingly to the knowledge you have learned in our course, explain what is required when we add a new instruction to a System-on-Chip. (10%)**

Ans: In computer science, an instruction is an order given to a computer processor by a computer program. An instruction set architecture (ISA), also called computer architecture, is an abstract model of a computer. For other content, you can describe in your own words with reasons.

2. **Describe the relationship between an embedded system and System-on-Chip in less than 200 words, and what are the differences between a microprocessor and an MCU? (10%)**

Ans: Please describe in your own words with the content on the course. For the differences between microprocessor and MCU, the followings are some examples:

Cost: Generally, microcontrollers (MCU) cost less than microprocessors. Microprocessors are typically manufactured for use with more expensive devices. They are also significantly more complex, as they are meant to perform a variety of computational tasks while microcontrollers usually perform a dedicated function. With a microcontroller, engineers write and compile the code intended for the specific application and upload it into the microcontroller, which internally houses all of the necessary computing features and components to execute the code.

Speed: When it comes to clock speed, there is a significant difference. This relates back to the idea that microcontrollers are meant to handle a specific task or application, while a microprocessor is meant for more complex, robust, and unpredictable computing tasks. That means using just the right amount of speed and power to get the job done – no more and no less. As a result, many microprocessors are clocking speeds of up to 4 GHz while microcontrollers can operate with much slower speeds of 200 MHz or less.

Power Consumption: One of the key advantages associated with microcontrollers is their low power consumption. A computer processor that performs a dedicated task requires less speed, and therefore less power, than a processor with robust computational capacity. Power consumption plays an important role in implementation design: a processor that consumes a lot of power may need to be plugged in or supported by an external power supply, whereas a processor that consumes limited power could be powered for a long time by just a small battery.

3. **What are the similarities and differences between Keil Studio and Mbed? In addition, please also elaborate on the difference between ARMv8-A and ARMv9. What is the architecture that Cortex-M4 is using? (10%)**

Ans: You can note some key differences of each question. For example: Keil and Mbed both can use C++ and complie the program. Mbed has online compiler and CLI and Keil has keil studio cloud. ARMv9 support scalable vector extension and SVE2 microprocessor instrctions but ARMv8-A does not. Cortex-M4 is using ARMv7-M.

4. **We take Microbit v1 as an example. Describe the process technology used, How many pipeline stages and interrupts are there? Please illustrate the movement of instruction, such as the 32-bit hardware integer multiply with**

32-bit result in these pipelines. (10%)

Ans: There are three pipeline stages, fetch-decode-execution. For the movement, you can explain in your own word from what you learned on the lecture.

5. **Take ARM Cortex-M M0 and M4 processors as an example, compare the advantages of Von Neumann architecture and the Harvard architecture for these two processors. (5%)**

Ans: For some of the features:

Von Neumann has the same memory for data and instructions while Harvard architecture has two separate memories. It saves the buses and increase the speed for Von Neumann but may have less memory.

6. **It is required to swap the data of two registers R1 and R2, which are part of the processor architecture. (10%)**

   - Write the code to do it using only PUSH and POP operations.
   - Write the code to do it by using register transfer instructions.
   - Compare the two methods and explain why one method is superior to the other in terms of time expended.

Ans: The codes could be a little different. As an example:

```
PUSH {r1,r2}
POP{r2,r1}

MOV R0, R1
MOV R1, R2
MOV R2, R0
```

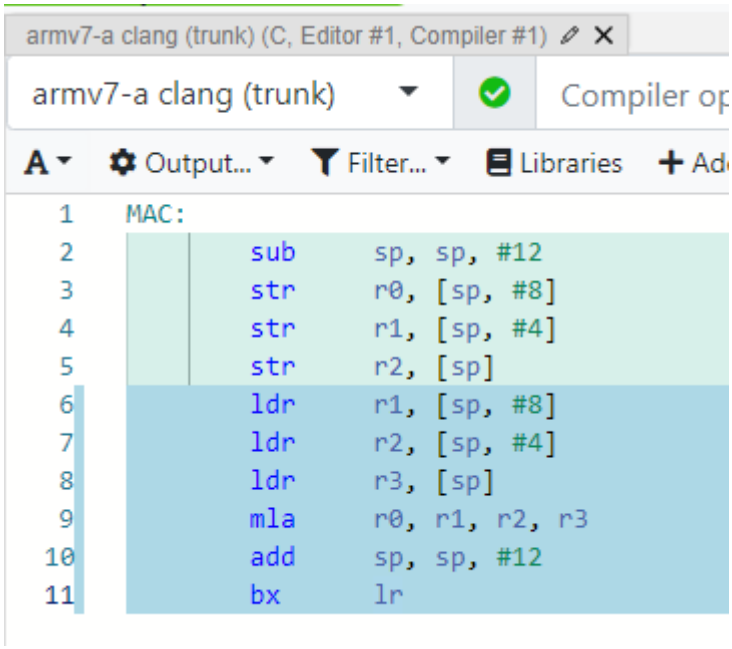
Using register transfer instruction method required a additional register to store the data in the process, but using only PUSH and POP method does not.

The register transfer instruction method only needs three instructions, but PUSH and POP method needs at least four, so it takes more time.

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

```
int MAC(int a, int b, int c) {
return ((a*b) + c);}
```

Ans: As an example:



The instructions are also shown in figure as ARMV7-a clang (trunk).

8. **Given an 8-bit ALU with outputs F7 to F0 and available Carries C8 and C7, show the logic circuit / Boolean function for generating the signals for the four status bits N, Z, V, C. (5%)**

Ans: You can show the logic in different ways. In Boolean Function, for one example,
Waiting for grade
N : F7 XOR 0
z: NOT(F7 AND F6 AND F5 AND F4 AND F3 AND F2 AND F1 AND F0)
V: C8
C: C7 OR C8

9. **Explain the functionality of different memory types, data segment, code segment, stack, heap. Use a C program to illustrate the idea. (10%)**

Ans: You can design a program with certain structure. As an example from students, you can refer to this as one kind of answer:
/ initialize C run-time environment, set up heap memory
int a; // RAM, value may change
int d = 1; // d is initialized data in RAM
const char b; // Flash ROM, constant value
void main(void){
int e; // stack, it is automatic variables stores on stack
char f[20]; // auto, stack
a = e + 1;
}
data segment: ||d|| 0x00000001
code segment: int d = 1;

10. **Explain the meaning of Registers->Core, Thread and Call Stack with the support from the figure below? Explain the concept of why "A procedure call has more overheads than a jump instruction". (10%)**

Ans: One kind of answer for reference:

The Registers-core are the visible registers. This would include registers r0-r15.

A thread is a line of commands, and represents a flow of control in a sequence. Each command is run one at a time in a thread. As such, breakpoints can be used to stop at a single command in a thread.

A call stack is the area of memory used to store the function return information. These would be the scratch registers such as r0 and r1.

A function needs to allocate some memory for where the function code starts as to be able to return to that point when it exits that instruction. As such it would use some cpu cycles to do so which increases its overhead. A jump instruction wouldn't need to do so

11. **A RISC Computer has a 32-bit instruction format with 1) Opcode: 8-bits, 2) 3 register fields, each of 4 bits, 3) A 4-bit field for "condition". The remaining bits are for information pertaining to the processor. Please show your calculations.**
    1) **What is the maximum number of operations possible?**
       2^8=256
    2) **How many combinations of three registers are possible?**
       2^4 *2^4 *2^4 =4096
    3) **How many conditions can be accommodated?**
       2^4 = 16
    4) **How many registers are possible?**
       2^4 = 16