CMPT 334 **Spring 2021**

Assignment 1

Due: Wednesday February 17, 2021 – 8:00 AM

Submit a single pdf/word file in Moodle.

Provide short answers for the following question (100 points):

Q1. What is the difference between computer architecture and computer organization?

Computer architecture refers to those attributes of a system visible to a programmer or, put another way, those attributes that have a direct impact on the logical execution of a program. **Computer organization** refers to the operational units and their interconnections that realize the architectural specifications. Examples of architectural attributes include the instruction set, the number of bits used to represent various data types (e.g., numbers, characters), I/O mechanisms, and techniques for addressing memory. Organizational attributes include those hardware details transparent to the programmer, such as control signals; interfaces between the computer and peripherals; and the memory technology used.

Q2. What are the main structural components of a computer?

Central processing unit (CPU): Controls the operation of the computer and performs its data processing functions; often simply referred to as processor.

Main memory: Stores data.

I/O: Moves data between the computer and its external environment.

System interconnection: Some mechanism that provides for communication among CPU, main memory, and I/O. A common example of system interconnection is by means of a system bus, consisting of a number of conducting wires to which all the other components attach.

Q3. List the structure components of a single processor.

Control unit: Controls the operation of the CPU and hence the computer.

Arithmetic and logic unit (ALU): Performs the computer's data processing functions.

Registers: Provides storage internal to the CPU.

CPU interconnection: Some mechanism that provides for communication among the control unit, ALU, and registers.

Q4. Describe what is an Instruction Set Architecture (ISA). Give examples of different ISAs.

It is an abstract model that specifies the capability of a processor. It provides a set of instructions that are independent on the hardware underneath. An implementation of an ISA must be independent of the underneath dataflow, logic design and physical components organization. Examples of different ISAs include MIPS, x86, x64, IA64, SPARC, and PowerPC.

Q5. Describe what is a Von Neumann Architecture.

A computer architecture described by John von Neumann which includes three main components CPU, memory and IO. It is based on the stored program paradigm which states that the main memory can hold both data and instructions.

Q6. Describe the process that the CPU must undertake to read a value from memory in terms of the main registers being used (e.g., MAR, MBR, etc.) and system bus connections (e.g., data, address and control buses).

To read a value from memory, the CPU puts the address of the value it wants into the MAR. The CPU then asserts the Read control line to memory and places the address on the address bus. Memory places the contents of the memory location passed on the data bus. This data is then transferred to the MBR. To write a value to memory, the CPU puts the address of the value it wants to write into the MAR. The CPU also places the data it wants to write into the MBR. The CPU then asserts the Write control line to memory and places the address on the address bus and the data on the data bus. Memory transfers the data on the data bus into the corresponding memory location.

Q7. What are the techniques to increase the speed of processors?

Pipelining: The execution of an instruction involves multiple stages of operation, including fetching the instruction, decoding the opcode, fetching operands, performing a calculation, and so on.

Branch prediction: The processor looks ahead in the instruction code fetched from memory and predicts which branches, or groups of instructions, are likely to be processed next.

Superscalar execution: This is the ability to issue more than one instruction in every processor clock cycle.

Data flow analysis: The processor analyzes which instructions are dependent on each other's results, or data, to create an optimized schedule of instructions.

Speculative execution: Using branch prediction and data flow analysis, some processors speculatively execute instructions ahead of their actual appearance in the program execution, holding the results in temporary locations.

Q8. Processor A is 3.2 GHz while processor B is 3.0 GHz. Which processor will execute programs faster? If it can not be determined, explain why.

It can not be determined. CPU with a higher clock might be outperformed CPU with a lower clock speed, as its architecture deals with instructions more efficiently. A better performance measurement can be used like Clock cycles per instruction (CPI).

Q9. If a program has 60 percent of its code enhanced to run 2.3 times faster, what is the overall system speedup?

$$\text{Speedup} = \frac{1}{(1-f)+\frac{f}{SU_f}} = \frac{1}{0.4+\frac{0.6}{2.3}} = 1.5131579$$

Q10. Briefly explain, why do we need to have a balance of performance among the computer's different structural components?

Performance balance is the adjustment/tuning of the organization and architecture to compensate for the mismatch among the capabilities of the various components. Each component can have substantial effect on the computer performance. For example, having too fast CPU but slow main memory communication will cause a bottleneck and hinder the performance of the entire computer.