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CSCI 240: Computer Organization and Assembly Language

Homework #1

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**Part A**

My computer is running a 64-bit version of the Windows 10 Home operating system. My processor is x64 based; it’s an AMD Ryzen 5 5600X 6-Core Processor running at 3.70 GHz. There is 16 GB of RAM installed. I have an NVIDIA GeForce RTX 3070 graphics card with 8GB of VRAM. For storage there is a 1 TB SSD.

**Part B**

Quantum computing is a new method of computing that takes advantage of the natural laws of quantum physics to enhance the process of computation. Devices utilizing this computational paradigm are called quantum computers. They are fundamentally different from “classical” computers.

Classical computers are composed of transistors. A transistor is a semiconductor (can behave as a conductor or an insulator) device capable of acting like an electronic switch; it can be “open” or “closed” (effectively representing a 0 or 1). Thus, all data in a classical computer is comprised of long sequences of binary digits or “bits.” A quantum computer, on the other hand, is fundamentally composed of quantum bits, a.k.a. “qubits.” One implementation of qubits uses two superconductors (materials capable of conducting electricity with no electrical resistance and thus requiring no input voltage to flow) that are separated by an insulator. This is called a Josephson junction. Then lasers (photon beams) are shot at these junctions in such a way that they either store, read, or write quantum information effectively simulating a qubit.

Quantum computing offers key advantages when compared to classical computing. In a classical computer, computational power increases linearly with the number of transistors. But for a quantum computer, computational power increases exponentially with the number of qubits. This is because of the nature of qubits. They have the property of superposition, that is, the property that they can be both a 0 and a 1 simultaneously. Many computational problems that were infeasible before (possible to solve but would take too long of a time) are now feasible with quantum computing. “In 2019, for example, Google claimed to carry out a calculation in about 200 seconds that would take a classical supercomputer around 10,000 years.” [7].

The quantum property of entanglement (called “spooky action at a distance” by Albert Einstein) is the phenomenon in which some property of two particles that may be separated by vast distances are directly correlated with one another. Thus, altering a qubit can have an immediate effect on another without regard to the speed of light (the cosmic “speed limit”)! This could revolutionize communication and allow for a “quantum internet.”

There are many applications that benefit from quantum computers’ ability to solve very complex computational problems in a short amount of time. Finding patterns in protein folding is important to the field of medicine and biological research. Useful conclusions about such patterns in the folding of proteins comprised of a large number of amino acids can be found in a reasonable amount of time only with quantum computing. Also, the nature of the problem of molecular manipulation is quantum so having a machine that is inherently quantum can facilitate atomic simulation. It is also useful for combing through and analyzing large amounts of data which could be useful for stock market analysis, weather forecasting, etc. The field of data science and artificial intelligence could be revolutionized with quantum computing. We could more securely encrypt the transfer of data by utilizing quantum uncertainty.

There are a few disadvantages of quantum computers, however. Present quantum computers are very large compared to a household computer. Also, to allow for superconducting, the quantum processor must be kept very cold at temperatures close to 0 Kelvin. There is also a substantially higher error rate in quantum data than there is with classical bits. Also, present RSA encryption could be broken by the enhanced computing speed of quantum computing because it relies on the problem of integer factorization being hard to solve; it is only hard for traditional computers though.

Overall, while there are some disadvantages of quantum computing, the possibilities of what it can do for humanity makes it revolutionary.

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**Part C**

A Fuzzy set is a generalized notion of the standard set that we typically consider. A normal set (or a “crisp” set in fuzzy set terminology) has members that are either definitively in the set or are definitively not in the set. Thus, membership is binary and thus obeys the properties of Boolean logic. As an example, we can ask the question, “Is Alice honest?” In a crisp set there are only two possible answers: Yes (1) or No (0). Alice is either in the set of honest people or she is not.

In a fuzzy set however, an element’s membership may occur in gradations. An element can be “somewhat” or “kind of” in the fuzzy set. If we again ask the question, “Is Alice honest,” according to Fuzzy logic there may be more than two possible answers: Alice is always honest (1), Alice is usually honest (.7), Alice is usually dishonest (.3), and Alice is always dishonest (0). Alice can “sort of” belong to the set of honest people.

The field of fuzzy mathematics is concerned with fuzzy sets and logic and is applicable in several fields. As seen in the aforementioned example, use of adjectives like somewhat, usually, very, and sometimes convey a level of vagueness captured by fuzzy mathematics. Thus, linguistics, the study of language, is inherently a fuzzy topic. Bioinformatics, the study of biological data encompassing several fields of discipline, is by its very nature fuzzy. Medical information of a patient given by word of mouth from relatives is subjective. The degree to which a patient inflates or on the other hand understates their symptoms causes diagnosis to be very fuzzy.

Advantages of fuzzy sets include the applications already considered and anything in general that can occur on a range or spectrum rather than in a precise dichotomy. They allow for more generalized mathematics founded on fuzziness.

A disadvantage of fuzziness can be seen from the “weighting” of how honest Alice is using numbers between 0 and 1 inclusive to describe adjectives in the English language. The choosing of these weights is subjective and biased. Thus, even before precise mathematical analysis begins, imprecision is involved and thus any conclusion inferred by subsequent computation is intrinsically flawed or at least subjective.

Sources:

1. <https://en.wikipedia.org/wiki/Fuzzy_set>
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**Part D**

CISC stands for Complex Instruction Set Computer and RISC stands for Reduced Instruction Set Computer. They are both examples of Instruction Set Architectures (ISA) a.k.a. computer architectures. A computer architecture is the nature of the software/hardware interface that the programmer must be familiar with in order to effectively control the hardware to ultimately execute tasks. This includes the size in memory of the common data types, how software instructions are structured in memory, what an instruction can do, and the nature of the CPU and how it does its work.

A CISC is designed such that a single instruction is capable of doing multiple basic operations like arithmetic or loading/storing from/into main memory. An advantage of this is that there will be less instructions that the programmer has to code because each instruction can do more. The downside is that each instruction is more expensive; they can take several clock cycles to complete. Also, this leads to higher complexity in coding and variation in the length of instructions which can make processing slower.

Originally CISC was applied into the 1980s so that the complexity of software paralleled the growing complexity of new hardware. At that time memory was expensive so the efficient use of RAM that CISC allowed for was important.

A RISC is designed such that single instructions only seek to do basic tasks. This allows each instruction to be fast (once clock cycle per instruction) and to be of standardized length. These both lead to faster processing. Also, the number of types of instructions that the programmer must remember is less since each does a fundamental task. However, the tradeoff is that the code the programmer must write in order to execute a task would be longer since each instruction is not as powerful.

RISC is the more popular modern alternative to CISC because of the aforementioned advantages of simplicity. Simplicity in instructions means CPU design also becomes simpler, cheaper, and faster. As memory began to become cheaper, more importance was put on the simplicity of programming and the efficiency that that brings.

MIPS (Microprocessor without Interlocked Pipeline Stages) is classified as a RISC. It was developed by MIPS Computer Systems starting in the mid 1980s. It specifies that arithmetic operations only take place on 32 registers (very fast storage locations quickly accessed by the CPU). To perform a computation on data in main memory, data must be first loaded from memory into registers, operated upon, and then stored back from registers into memory. It chose to let the compiler find free registers for use for function calls rather than using hardware directly that would limit the number of calls that could be handled.

MIPS processors are power efficient and are fast. They contain more registers than ARM processors. They are faster than the commonly used x86 CISC processors in the ways mentioned above. The disadvantages when compared to other architectures are that ARM processors have a higher throughput and MIPS is much less adopted than x86.

MIPS is very useful for learning about computer architecture academically because of its great simplicity while still maintaining key functionality expected of an assembly programming instruction set architecture. It is also used in embedded systems, cars, datacenters, and wireless computer networking.

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