**Introduction Draft and Peer Review**

**Introduction**

If the mystical black box that is your personal computer can instantly perform every task which you assign to it, then why might companies like Google and International Business Machines Corporation [IBM] be spending so much money on building quantum computers? To answer this question, a little light needs to be shined on how that black box works. Many computer users probably reflect on pesky loading screens and know that computers do not perform tasks instantly. Instead, more computationally intensive tasks take more time. Stated another way, the more basic operations that your computer must perform to execute a task, the longer it will take. A basic operation could be adding two numbers together, retrieving or storing a value from the computers’ memory or comparing two values. The algorithms which a computer uses to perform that task directly correlate to how many operations will be done and how fast the task will be performed. These algorithms yield equations for how many operations will have to be done as the size of the input to the algorithm grows. These equations can take all forms, from an algorithm taking only a constant number of operations, to an algorithm growing proportionally to a factorial function. If you cannot imagine how quickly factorial functions can grow, just remember that 1 factorial equals 1 and 20 factorial equals over 240,000,000,000,000,000,000. Even if each operation only takes a fraction of a second, a large input for an inefficient algorithm can quickly become years’ worth of computing for the fastest of computers. This paper will cover the growth, in basic operations and therefore runtime, of types of algorithms named non-deterministic polynomial time [NP] algorithms and how these algorithms impact the total run time of a program. With that in mind, will quantum computers offer a viable solution to the problem of quickly growing run times for computers? If so, then there must be a fundamental difference that allows quantum computers to do something that a classical computer cannot. One such solution would be implementing an algorithm not possible for a classical computer that would reduce the growth rate of the run time. I argue that quantum computers can allow the implementation of faster algorithms which are not possible on a classical computer, but still face limitations which will not allow all problems to be solved in a practical amount of time, therefore, quantum computers will be able to solve a larger domain of problems than a classical computer in practice, but some problems, namely NP-complete problems, will remain out of reach for quantum computers.

Thesis is too similar to aaronson’s article.

1. Background
   1. Algorithms
      1. Define algorithm
      2. Describe the relationship between algorithms and programs
      3. Describe the relationship between input size and run time.
      4. Limitations of current algorithms. -*cite some csc textbooks I have for algorithm run time.*
      5. NP- complete problems. -*need to find a good source for NP problems still*
   2. Introduce what a quantum computer is, and how it differs from a classical computer.
      1. Introduce a “clock cycle” as the fundamental unit which drives computation in classical computers.
      2. A constant number of instructions can be executed per clock cycle. Therefore, even large inputs for polynomial time algorithms can take a long time to compute.
   3. Current limitations of classical computers.
      1. Transistor as the heart of computation.
      2. Size of transistors and relation to speed.
         1. Transistors are closer, therefore the time taken for computation is less, clock cycle rate can be increased.
2. Current limitations of quantum computers.
   1. Describe superposition, and why it has the potential to be faster. Using much of *commercial applications of quantum computing* for this section (Bova, Goldfarb, Melko, 2021). Also, *Digital fluency: Understanding the basics of artificial intelligence, blockchain technology, quantum computing, and their applications for digital transformation* will help me further understand the benefits of quantum computing (Lang, 2021).
   2. Drawbacks of quantum computing such as interference and reading data.
3. To solve exponential problems, a quantum computer’s power will have to be able to scale exponentially or execute an algorithm which is impossible for a classical computer. Furthermore, that algorithm must show P=NP for a quantum computer. This section is where I draw on background information from the previous sections of the paper and make my arguments. Although I don’t have much in these sections now, they will contain a large portion of the paper. I need more research to be able to fill out this part of the outline still.
   1. Regarding the former, I need to do more research here, but I believe quantum computers can scale exponentially as their size increases. This implies that the size of a quantum computer is essential to taking on larger inputs to exponential algorithms (Lang, 2021).
   2. Regarding the latter, quantum computers will not be able to solve NP-complete problems, therefore some problems will remain out of reach for quantum computers (Aaronson, 2008).
4. conclusion

Special Notes:

1. I need to address in the introduction that I will not be addressing the memory space requirements of computers for the sake of simplicity. This is an unfair assessment of computational speed overall because memory is essential to the speed of computation.
2. I also have much more research to do before my final submission. I feel most confident in the background information on the subject, but my claims need to be supported by more evidence. I may end up altering my argument based on my findings.
3. My goal with this paper is to reach a broad audience, so I will need a fair bit of background information. I imagine much of my time will be spent condensing background information in order to talk more about my arguments and research.

**References**

Aaronson S. (2008). The Limits of Quantum. *Scientific American 298*(3),62-69. <https://www.cs.virginia.edu/~robins/The_Limits_of_Quantum_Computers.pdf>

Scott Aaronson defines some of the limitations of quantum computers in his article “The Limits of Quantum”. Aaronson was an assistant professor of electrical engineering and computer science at MIT when he wrote this and therefore is a reliable source to be making these claims. This article is found in the Scientific American, a journalism company. Given the article is found in a magazine and there are huge simplifications, I would say this article is good for background information on quantum computing. It also gives me a claim to work with, by someone credible, that states quantum computers cannot solve NP-Complete problems, therefore they are more powerful than classical computers, but not able to solve entirely new types of problems.

Bova, F., Goldfarb A. & Melko R. G. (2021) Commercial applications of quantum computing. *EPJ Quantum Technology, 8*(2). <https://doi.org/10.1140/epjqt/s40507-021-00091-1>

Lang, V. (2021). *Digital fluency: Understanding the basics of artificial intelligence, blockchain technology, quantum computing, and their applications for digital transformation*. Apress. <https://doi-org.ezproxy.library.uvic.ca/10.1007/978-1-4842-6774-5>