September 2020 • e-ISSN: 1857-8187 • p-ISSN: 1857-8179

https://doi.org/10.5281/zenodo.4289381

Review Article

THE IMPORTANCE OF QUANTUM AND DNA COMPUTERS IN THE AGE OF DATA SCIENCE

Computer Science

Keywords: Quantum, DNA Computers, data science, data management.

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Abstract

The IT landscape is continuously changing based on the needs of large enterprises and also the needs of individuals who use technology for their personal undertakings. The change derives from the fact that people want to do things faster and in a more reliable way, so they can achieve better results more rapidly, thus IT developers, be it on the software or hardware field, are always in search for developing and providing better tools. Data Science is probably the most important development in the field of Data Analytics, which in return, is the most important aspect of a successful enterprise. To make things more qualitatively, we are entering a new age of computer hardware such as Quantum and DNA computers. Our paper will deal particularly with the importance of these developments in this age of IT, by bringing forward examples of how these technologies can help in the betterment of data management.

Introduction

Sooner or later we all have to deal with data. It is an essential part of how we work and manage our everyday life, businesses, etc. field experts are constantly working in the direction to provide a secure and fast data management for achieving success. Data Science is the way to go when considering all of this, and Quantum and DNA computers are the keys to achieve what we strive. These kinds of computers, although not quite that new in terminology, new in the way they are applied, are changing the data management landscape rapidly and hopefully with a high level of success and accuracy.

What is a Quantum Computer?

Nowadays quantum computers are in a phase of theoretical level, meaning that we are still far away to apply them in everyday use. Still, this new technology can greatly improve how we compute and analyze data. It is important to notice that these kinds of computations provide a different way to process information, thus we need to distinguish between what we just referred to Quantum Computing and what we know as traditional or classical ways of information processing (McMahon, 2008).

As we all know, from the terminological standpoint the most basic form of information is called a bit, which in a way it represents a question with yes and no answers, which of course is displayed through binary numbers that can be 0 or 1. A bit can contain each of these values. If we were to explain all of this from a physical point of view we can take for example an electric circuit which if it is at ground or it doesn't have any power in volts, the same can be expressed with 0, whereas if the circuit can have a value of say 10 volts, the same can be expressed with 1. In our case, anyway, we are dealing with mathematical issues and there is no need to get into the physical side of things (McMahon, 2008).

Probably the most important aspect of Quantum Computers is the fact that they deal extensively with randomness. To illustrate things in a better way we can take for example a flow of electrons in both horizontal and vertical direction and we record all of that flow and at the same time we measure it with proper devices and we may get values such as Ns and Ms. The spin of the electrons will certainly result in randomness such as NNMNNNMM, in other words, there won't be a specific pattern for the streaming of the electrons. This is the thing with which Quantum Computers will have to deal(Bernhardt, 2019).

Another good example is tossing a coin in the air and expect on which side it will fall because of the randomness of its movement; it can fall on any side each time we throw it. Still, here we encounter a difference in how each example expresses randomness.

Let us return to the coin again. Throwing or tossing a coin can certainly be described through classical mechanics by using calculus models. It all has to do with measuring the initial conditions before the coin was tossed such as how high above the ground is our hand, how much does the coin weights, the position of the coin in our hand(Bernhardt, 2019). By measuring all these aspects the values will help us determine which side the coin will fall. In other words, we are not dealing with true randomness in this case. What we call randomness in this example is the fact that every time the coin will be tossed the conditions will be different, although many times only slightly, still, they are variations that affect which side the coin will fall. We can easily say that in classical mechanics there is no true randomness but only dependency on any starting condition that directly impacts the expected result. With Quantum Computers we are concerned with true randomness(Bernhardt, 2019).

What about DNA Computer?

A DNA computer is a device that makes parallel computing by using various DNA molecules(Lewin, 2002). We know that all our complex organic system is based on a coding system which consists of four components of a DNA molecule. From a biological standpoint, one strand of DNA contains four bases: A, T, C, G. When these bases are joined with the deoxyribose they form a sequence(Boneh and Lipton, 1996). These strands can be separated by using different physics and chemistry processes. Each different DNA structure can be used by researchers to solve a different kind of problem(Lipton, 1995). It is important to mention that in DNA computing the majority of the DNA molecules are single and double-strand. Hairpin and plasmid are some of such strands. DNA computing models can do many operations such as insertion, deletion, adjoining, and cutting.

Every new technology is approved to improve any preexisting one or at times, totally substituting the previous technology. There are calculations, data sharing, and storage issues that cannot be easily solved if experts use the techniques which are in use today. This is where DNA computing lends its “helping hand”(Namasudra, Deka, 2019). There are many aspects for which DNA computers can offer vastly superior IT solutions compared to traditional devices. The main areas that this kind of computing can have a huge advantage, are as follows:

- *Speed*. This is measured with what we call MIPS, which stands for Million Instructions Per Second. Computers we consider traditional can around 100 million such instructions. On the other hand, combinations of strands in DNA computing have a computational power of more than 10^9, or more than 100 times faster compared to the fastest traditional computer.

- *Storage requirements are minimal*. If a conventional system used for storage needs 10^{12} cubic nanometers to store 1 bit, DNA computers can store memory space of around 1 bit per cubic nanometer.Just 1 gram of DNA can contain around 10^{21} DNA bases, which in return can contain 700TB of storage, meaning that in just a few grams we can store every single data for the entire world.

The power requirement is at a minimum. When DNA computers do their computing tasks, they need no power. This is a result of the fact that chemical bonds responsible for the construction of DNA do not need any kind of power source (Namasudra, Deka, 2019)**.** Another important aspect is the possibility to minimize the probability of mistakes when researchers use DNA computing, specifically when executing.

Researchers around the world have made many experiments to prove that by using a suitable encoding approach, DNA computing reliability can be vastly improved(Boneh et al., 1996). The goal of any researcher is to obtain the maximum coding set, something which they can achieve by using two different approaches. The first approach requires the usage of random arithmetic and is more common, whereas, the second one uses construct arithmetic, which in return is a better approach than the former for the fact that it will take less time when trying to find the right codes(Namasudra, Deka, 2019).

Data Science

To put it simply, Data Science means profound data analysis and interpretation. EachData analytics has its Epicycle of analysis encapsulating these 5 activities:

- To state and refine the question
- To explore the data
- To build formal statistical models
- To interpret the results
- To communicate those results

Each one of these steps requires a fast and accurate approach, something we believe Quantum and DNA computers can provide at the highest degree. (Peng, Matsui, 2015)

Importance of security

We are aware that security issues are of high importance in almost any field be it financing, military affairs, or any other business that requires confidentiality. These sensitive issues, in the scope of traditional systems, are mainly limited to their own domain os storage. New technologies provide a different kind of approach by making way for the users to store and access their data even outside their own scope. In each case what is important is to point to the fact that information security is crucial, especially if we consider the fact that although each new technology provides new ways of data management, on the other hand, it also gives new possibilities for hacker attacks. The attacks can be of any nature such as stealing or replacing data(Namasudra, Deka, 2019).

DNA computers offer a strong defense mechanism by introducing a new kind of data storage and mechanism to make it a lot harder or even impossible for cyber attackers to breach that data. These computers are especially crucial in the field of steganography and cryptography because they help achieve the highest possible level of unbreachable algorithms(Namasudra, Deka, 2019).

Conclusion

The world is stepping into the age of Artificial Intelligence and things are becoming more and more complicated, so we need the tools to manage this. Quantum and DNA computers representthe future of computing that will provide speed and quality so that Data experts will provide a more secure managing environment. But we should always keep in mind that all of these new technologies are just tools and that the most important aspect will always be how we, as humans, will use them for the better, because no matter how good a tool might be, if it is used by irresponsible people the future will be really grim.

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