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E-Periodical International

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In the Name of Allah, the Most Compassionate, the Ever-Merciful
Say: 'Travel through the earth and see (with a warned eye) what has been the
'(al-An'ām, 6 : 11)

Volume #01
Issue #02

Friday, May 27, 2022 - H/O Lahore - Pakistan| 35* Celsius 74 Humidity in Air - Wind 36 km/h | More than 5.0K
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Science

Quantum Computing

Understanding Quantum Computing, its potential and its applications

Written by Chan Naseeb

Quantum computing has disruptive potential. After steep advances in recent years, it is receiving significant government and business investments. As a tech-savvy businessperson, you might understand that quantum computers can harness the unusual properties of matter at the nanoscopic level to perform complex calculations beyond the realm of existing computers. But as claims regarding the power and pitfalls of Quantum computing mushroom, we need to discern myth from reality if we are to leverage quantum computing for business applications.

This blog will introduce you to Quantum Computing, followed by the business case for it. Finally, we touch base on its applications (a detailed blog on its applications will follow) and what to expect regarding advancements in this field.

Quantum Computing (QC) could be a way to revive the speed of progress for advancements in capabilities that computers have. Businesses are already experimenting with real QCs today to set themselves up for a competitive advantage in the future. QC represents a paradigm shift in which QCs will work in unison with traditional computers. They will not replace classical computers, but be a part of an expanded computing paradigm. This shift focuses on the fact that QCs are just meant to solve distinct problems unlike classical computers. In addition, quantum computers have the potential to solve some problems better, faster, and more efficiently than classical computers.

Several actors are working across academia, industry, and Government to get QCs into the mainstream.

Germany, for example, is spending 2 billion Euros to speed up Quantum developments in the country.

Since 2016, IBM has made quantum computers accessible to the public via a website [3] with a graphical interface that comes in handy for scientists worldwide to run their experiments using such portals. Scientists are exploring approaches to chemistry, optimization, and machine learning-related problems, figuring out what sorts of questions they can ask and how they'll frame those questions once the technology is further along.

Biological systems are extraordinarily complex. That's why it's very challenging and time-consuming to model and simulate them. Conventional computers see it difficult, if not impossible, to predict biological fragments and biochemical interactions. Because of that, the early-stage biomedical investigation has to be done by working chemically and in labs, hoping for reproducible situations between experiments. It results in a long time being taken by the drug discovery and testing process, which is an essential area of biomedical innovation. Using quantum computers, simulating these biological systems is possible and easily doable even on currently available noisy quantum computers.

Computing Paradigms

Many industries and academic areas such as environmental studies, chemistry, machine learning, and financial services and banking, have begun to examine Quantum Computing today, making environmental predictions, optimizing energy grids, generating breakthroughs in carbon-capture technologies, and machine learning. Tech giants and startups are working diligently to evolve and improve on Quantum Computing, but its widespread adoption is not yet reality. As a result, it may take years, possibly even decades, and much more compute power before we see the true problem-solving capability of Quantum Computing.

Now seems the right moment for business executives to prepare for the coming Quantum Era. The systems are in place to experiment and expand this fundamentally new technology, and businesses that seek to be at the forefront of this transformational shift will seize competitive advantage.

Moore's Law and the Potential for QC

The significance of QC is both understated and broadly overhyped at the same time. It is not expected that QCs will replace conventional computers. However, it does offer a new computing paradigm. QCs can work in unison with current conventional computing infrastructure to solve complex problems previously considered impractical or impossible. For instance, the difficulty of factoring large numbers into their primes is the basis of modern cryptography. Given the size of numbers used in public and private key encryption schemes, a quantum computer would take only minutes compared to trillions of years on a conventional computer.

As we aim to solve more complicated problems, new technologies like QC become ever more relevant and impactful. Getting more power out of conventional computers for a fixed amount of space, time, and resources has become more challenging and we are getting towards the limit of Moore's Law. QC could be a way to revive the progress rate that we have grown used to on traditional computers.

Suppose we can successfully use quantum computing to solve the problems which can't be adequately solved today with classical computers. In that case, it could give us an exponential increase in computing power that we can't get through traditional chip designs. QC can solve NP-complete problems efficiently as it provides exponential speedups and quantum algorithms such as Shor's algorithm for factorization exploit the problems' structure in a way that is far beyond our present-day techniques.

For decades, computing power has grown continuously, following the trend of Moore's Law. Moore's Law is reaching its limits, as seen in [3], as the ability to pack more and more transistors into a smaller and smaller space is not infinite. At some point, we will reach atomic dimensions, and that's the end of that approach. While we haven't reached the end of our present computing power approach, Moore's Law is going into saturation.

Current and Future Impacts

1. Quantum computing can bring our knowledge of nature and chemistry to a granularity that has never been possible before because the computations are too hard with the traditional computers.

QC could be a way to revive the speed of progress for advancements in computational capabilities

QC can help us develop a better understanding of nature and chemistry to levels that were never possible before

Businesses are already experimenting with real QCs today to set themselves up for a future of competitive advantage

We could expect to see these innovations drive some greater evolutions for quantum computing during that journey.

If we look into the future for companies that seek to transform their businesses through improved customer experiences, I believe we will see that they will look to advances in quantum computing. These advances will potentially include things such as vehicle routing, robotic movement planning, and potentially portfolio optimization, among others. These improvements could become so common that nearly everyone on the planet will interact with some of these capabilities every day.

Quantum computing has seen unprecedented progress, in great part thanks to IBM and others. Partnerships like Splunk and Quantum Computing Inc Honeywell and Microsoft, and AWS and IonQ [6] are spurring the continuous growth in the field. For example, quantum computing has been at the forefront of pandemic efforts to manage the spread of the disease and develop therapeutics and possible vaccines [7, 8]. We will likely see more use cases develop in other industries as people realize the power that quantum computing can offer. QC can lead to easily querying, monitoring, analyzing, and acting on data at scale, from any source at any time. Overall, though, it still has some time before becoming widely adopted.

2. The impact of quantum computing will be immense over the next few years.

Quantum computing stands able to help business leaders make great advancements to target audiences by analyzing insights and maximizing their efforts. Smart technologies and automation will make companies better able to understand and process customers' data, but they won't replace marketing and communications teams. All who work on the user side of the enterprise, — digital marketers, communications teams, user experience designers — will have the opportunity to be more creative and strategic. While yesterday we were speaking about IoT, cloud computing, and data analytics, all of which still firmly hold their place in the technological landscape, today we're also looking at AI, next-gen networks (5G, 6G), and, of course, quantum computing.

Quantum Trends in 2021

It is observed that **four major quantum trends may accelerate** in the rest of 2021. These are as follow:

1. **The rapid pace of conversion from classical to quantum algorithms and evolution of new quantum algorithms**

Building repositories of quantum algorithms starting from such small tasks as Sorting to more complex tasks as Deep Learning will be the key focus areas of quantum researchers in the immediate future.

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