IBM AA-STS forum American Associates of the STS *forum*

Quantum Computing: Where It is Differentiated, What Has Been Demonstrated, And When It Reaches "Maturity"

Thursday, April 4, 2024, at IBM Innovation Studio, 51 Astor Place, 4th FL. New York, NY 10003

Summary of The Workshop

The workshop "Quantum Computing: Where It Is Differentiated, What Has Been Demonstrated, and When It Reaches 'Maturity'" provided valuable insights into the current state and future potential of Quantum Computing. The panel discussions and table discussions highlighted the rapid advancements in the field, the need for cautious evaluation of claims, and the importance of fostering an open ecosystem that encourages experimentation and collaboration.

Quantum Computing has the potential to revolutionize disparate fields including pharmaceuticals, materials science, finance, and encryption. However, challenges such as scaling, accessibility, and the development of user-friendly programming tools must be addressed to fully harness its capabilities. The workshop emphasized the significance of international cooperation, public outreach, and the inclusion of underrepresented communities in the development and application of Quantum Computing.

As the technology continues to evolve, it is crucial to drive research advances into practical applications to validate their positive impacts, but to similarly address potential negative impacts such as economic disparity and the risk of malicious use. The workshop served as a platform for experts and stakeholders to exchange ideas, identify opportunities, and collaborate towards a future where Quantum Computing can contribute to solving complex problems and drive scientific and societal progress.

Opening Remarks:

- Dr. Bernard Meyerson, IBM Fellow and Chief Innovation Officer Emeritus, provided a brief introduction.
- Mr. Sadayuki Tsuchiya, Executive Director of STS forum, celebrated the potential of US-Japan collaboration in Quantum Computing.

Panel Discussion by Experts:

Dr. Gretchen Campbell (National Quantum Coordination Office):

- Emphasized the importance of public outreach, the potential of quantum sensing and networking, and the need to temper the hype surrounding Quantum Computing.
- Noted that Quantum Computing was previously a national priority in the US.
- Stressed the importance of cautiously evaluating claims about Quantum Computing's capabilities.
- Emphasized that the science underlying Quantum Computing needs much work—implying that there are some scientific challenges that need to be overcome to engineer a scalable infrastructure for Quantum Computing.

Dr. Oliver Dial (IBM Quantum):

- Highlighted the increasing accessibility of Quantum Computing, with technology now available in data centers for anyone to use.
- Emphasized the need for meaningful applications despite current limitations, such as expense and slow operation.
- Discussed the importance of accurate answers and having deep enough circuits to avoid circularity.
- Mentioned ongoing work on short depth circuits, simulations, and matching processor topology with the topology of the system to be simulated (for computation).
- Acknowledged the gap between Quantum Computing capabilities and error correction, but emphasized the potential for steady and continuous growth.

Dr. Iordanis Kerenidis (CNRS, QC Ware Corp, Paris Centre for Quantum Computing):

- Emphasized the potential of Quantum Computing to solve previously intractable problems rather than simply doing things faster.
- Discussed the current crisis in computer science departments and the need for precise instructions in problem-solving.
- Highlighted the potential applications of Quantum Computing in web flow, biological advancements, financial markets, cause and effect, and quantum mathematics.
- Stressed the importance of searching for unsolved problems that Quantum Computing can address.
- Highlighted the important role that “transpilers” will play in making Quantum Computing more accessible to programmers with decades of expertise in programming traditional/binary computers.
- Noted that quantum math would emerge as a key theoretical prior for advancements in Quantum Computing technology.

Key points from the panel discussion:

Q: How can we harness scaled-up Quantum Computing, and how applicable will its utility be?
A: Quantum Computing is advancing rapidly, but claims about its capabilities should be cautiously evaluated. Enormous scaling problems are expected when applying Quantum Computing to use cases. However, the promise lies in the fact that computational hardness of certain classes of traditional computing problems (such as simulation of physical systems) can be surmounted with Quantum Computing.

Q: Is an open, "wild west" approach to Quantum Computing research appropriate, or should there be more focus?
A: It's too early to pick and choose; an ecosystem allowing experimentation is crucial for identifying beneficial applications. Specialized hardware development, as seen in AI with GPUs, is not yet a focus in Quantum Computing. Panelists also raised the possibility of a “quantum winter” wherein lack of sufficient funding can negatively impact progress in Quantum Computing.

Q: Do short-term applications for Quantum Computing exist?
A: Yes, such as Shor's Algorithm, which would not have been possible on classical machines. The true advantages of Quantum Computing over classical computing must be considered.

Q: What role can Quantum Computing play in pharmaceutical research and precision medicine discovery?

A: Quantum simulations can be used to generate larger datasets and improve predictive models for identifying promising drug candidates. Integration with AI pipelines is possible, but laboratory validation will still be necessary.

Q: What is the current status of efforts to make Quantum Computing accessible and usable for coding?
A: Open-source initiatives like IBM's Qiskit exist to encourage the development of functions for unitary operations. These tools are still prototypes, but the goal is to create high-level, user-friendly systems in the future. Programming languages for Quantum Computing are at an early stage, and hardware limitations remain a challenge.

Key Messages from Table Discussions:

Table 1:

- Emphasized the need for treaties and international agreements on the use of Quantum Computing, possibly inspired by nuclear treaties.

- Discussed the importance of bringing Quantum Computing to underrepresented communities through initiatives like IBM's Quantum Summer School and engaging high school students with exciting educational materials.
- Raised concerns about the energy consumption of Quantum Computing, particularly the need for liquid helium for cooling, and the possibility of achieving room-temperature operation.

Table 2:

- Highlighted the need for more technically proficient individuals to pursue the hardware side of Quantum Computing, including electrical, mechanical, and physics disciplines.
- Discussed potential positive impacts such as advancements in pharmacology, optimization, and control, as well as negative impacts like malicious use for creating pathogens, untraceable communications, and improved deep fakes.
- Raised concerns about the future of encryption and the risk of identity theft as Quantum Computing becomes more accessible.

Table 3:

- Focused on the problems and solutions that may arise in Quantum Computing within the next 10+ years, considering 3-5 years too short for significant impact.
- Discussed the potential for democratization of the technology through open-source software and the need to balance research advances with practical applications.
- Identified advancements in biology, drug development, chemistry, agriculture, and data protection as potential benefits of Quantum Computing.

Table 4:

- Agreed that the impact of Quantum Computing is more likely to be seen in 5-10 years rather than 3-5 years.
- Discussed the necessity of changing encryption standards to mitigate the risk of bad actors storing and decrypting sensitive data.
- Identified drug design, materials science, encryption, biology, healthcare, financial predictive systems, and security as areas where Quantum Computing could add value.

Table 5:

- Emphasized the importance of democratizing access to Quantum Computing and making it a citizen technology.
- Recognized the potential for different model sensing technologies and the inherent problems in Quantum Computing that stem from the field of physics.
- Discussed the perception of inaccessibility as a potential negative impact and the need to address this issue.

Table 6:

- Prioritized the development of methods to protect against quantum attacks and the need for government involvement in mitigating risks.
- Identified finance, quantum chemistry, healthcare, and medicine as major application areas.
- Discussed the potential for economic disparity as a negative impact, with expensive technology widening the gap between countries with varying research resources.
- Emphasized the importance of clarifying expectations and the specialized nature of Quantum Computing, which will coexist with classical computation.

Table 7:

- Identified molecular modeling and clinical trial optimization as potential benefits of Quantum Computing.
- Discussed the meaning of "Quantum Advantage" and the possibility of it involving resource management rather than massive data collection.
- Suggested that Quantum Computing may become a backbone technology, integral to everyday functions but lacking public appeal despite its significance.

Closing Remarks:

- Mr. Mikio Mori, Ambassador, Consulate General of Japan in NY, highlighted the alignment between Quantum Innovation House of Japan and STS forum in contributing to society and deepening US-Japan collaboration.

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