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Quantum What? A Boundary Object Lens for Understanding Quantum Computing

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TREO Paper

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Abstract

Quantum computing, a novel technology that promises to revolutionize computation, has become a topic of interest for multiple communities regarding the opportunities and challenges it might pose. Nevertheless, as it's still under development, it's hard to measure its potential impact on businesses and society. Making informed decisions to collaborate, understand, and develop this technology becomes challenging. This extended abstract explores the perceptions of how different communities understand quantum computing, following a case study approach adopting a boundary object perspective to make sense of the various communities' agreements, disagreements, and tensions. The data collection process is ongoing, and participation in the TREO Forum is expected to help enhance the richness and robustness of the research to make it a potentially publishable paper.

Keywords: Quantum Computing, Boundary Object, Emerging Technologies.

1 Introduction

Quantum computing is a novel technology leveraging the properties of quantum mechanics to perform computation (Hidary, 2019). It has been presented as a potential candidate to revolutionize how digital systems do computation, opening a new era for computing technologies and affecting the evolution of industries, organizations, and society (How and Cheah, 2023; Piattini et al., 2020). Nevertheless, as it is still in its early stages, there is no agreement on its potential impact, and views differ. Some groups share an optimistic view and consider it a technology with real future value, becoming a bridge to solving impossible problems (Hassija et al., 2020). Some other groups share a more pessimistic view and consider it a technology that could bring chaos to society and become a national security threat to governments and democracy (Raheman, 2022; Sharma et al., 2021). Others are more skeptical about the impact of this technology, as they consider we are still figuring out how to build these systems and must solve this problem first (Dyakonov, 2020). While pointing in opposite directions, these views are all meaningful as they consider the range of computing capabilities presented by quantum computing, particularly how each group understands that its unprecedented processing power could solve problems much faster than digital computers. While there has not been commercial proof of this quantum advantage in a real-life situation, Google's quantum computer showed the first approach to this in 2019 when they solved a computational problem in 200 seconds that would have taken a digital supercomputer a few days to solve (Gibney, 2019; Lichfield and Kakaes, 2019). The more optimistic seem to understand this capability as one that will allow a vital value creation–Novo Nordisk invested USD 200 million to develop a quantum computer (Ramskov, 2022). The more pessimistic seem to understand this capability as one that will hinder and destroy current value–the US called all its federal agencies to become quantum resistant by 2035 (Thornton, 2022). Finally, the more skeptical views align with the academic conversations regarding the physical challenges of building a quantum computer.

While aligned with views on quantum computing, these positions might also create tensions threatening the potential collaborations between the participants developing this technology. For example, there is tension between optimistic investors looking to capture the value of quantum computing like any other investment and skeptical researchers who need the investments but are less optimistic about reaching that value stage in the short term. While scarce research on quantum computing exists in IS, little has been done regarding how to manage these tensions. To address this situation, the main goal of this extended abstract is to start developing an answer to the following research question: ***How do the different approaches to understanding quantum computing create tension in the development of quantum computing technologies?***

2 Literature: Quantum Computing and Boundary Objects

Quantum computing is a novel technology that may have the potential to revolutionize how digital systems do computation, with the result that the computational power of systems could make a radical jump (Pérez-Castillo et al., 2021; Piattini et al., 2021). Simply put, quantum computers are technologies that operate following the rules of quantum physics instead of the traditional physics assumed by standard digital computers (Ashktorab et al., 2019). They need new machines to work in exceptional conditions (cryogenic temperatures, for example) and process information in a very different manner when compared to traditional computers, thanks to quantum physics properties (Kietzmann et al., 2021). Theoretically, these computers could solve problems beyond the capabilities of digital supercomputers, like developing person-specific drugs or even destroying current cryptographic systems (Hassija et al., 2020). From an academic perspective, research in quantum computing shows a growing number of publication outputs (Wang et al., 2021). Nevertheless, much of this research focuses on hardware development, though some work is also concerned with potential software applications. As an emerging topic, it has not been widely explored from an IS or a management perspective, making it hard for people outside of physics to understand this technology.

Boundary objects, a term first introduced by (Star and Griesemer, 1989), refer to elements that can serve as a translation device regarding a shared topic between multiple communities. In other words, boundary objects can be seen as interfaces facilitating communication and collaboration across different social boundaries and various groups interested in the same topic. Still, these groups do not necessarily share the knowledge or views regarding the subject. Boundary objects can be multiple elements, not necessarily physical artifacts; they can also be documents, concepts, or any information that '*exists in the liminal spaces between adjacent communities of people*'(Huvila et al., 2017). Following this idea, boundary objects are a helpful lens for understanding quantum computing across the different communities involved in its development. As the strength of boundary objects lies in their capacity to maintain the identity and coherence of each community's perspective at the same time, it supports the mutual understanding and work across those differences; the use of this lens becomes in-handy to identify what elements can be used as a boundary object within the field of quantum computing development to facilitate the understanding and collaboration between the different groups involved.

3 Method

This study adopts a case study approach (Eisenhardt, 1989) using the boundary object perspective as a theoretical lens. This study focused on a European organization that is helping organizations in Europe become ready for quantum technologies. This organization has an extensive reach across Europe. It works with multiple stakeholders, including private and public companies, policymakers, and researchers from various domains (e.g., physics, chemistry, computing science, and management). The primary data collection technique was interviews with members from different stakeholders. Other data collection techniques have been field notes at meetings, conferences, and internal documents. While the data analysis has not started yet, the authors have defined that all interviews and field notes will be transcribed and coded following the principles defined by (Corbin and Strauss, 2015) for open, axial, and selective coding to identify emerging patterns in the data, and later explore and identify relevant findings.

4 Expected Contributions

As explained before, this study is still under data collection. As part of its development, we expect to use the TREO Forum as a space for discussion and an incubator to transform this research into a publishable paper. The expected contributions so far lay in two main areas: theoretical and practical. From a theoretical stance, there is scarce research on quantum computing in information systems. This research aims to expand the current knowledge regarding this technology to help the field develop its understanding when it becomes commercially available. From a practical point of view, this research aims to support the different communities involved in creating this technology and its policymaking to understand better, communicate, and collaborate to develop its understanding and progress further.

References

Corbin, J. and Strauss, A. (2015). *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory*, 4th Edition. Thousand Oaks: Sage Publications, Inc.

Dyakonov, M. I. (2020). *Will We Ever Have a Quantum Computer?,* 1st Edition. Cham: Springer Nature Switzerland.

Eisenhardt, K. M. (1989). Building Theories from Case Study Research. *Academy of Management Review*, 14 (4), 532-550.

Gibney, E. (2019). Hello quantum world! Google publishes landmark quantum supremacy claim. *Nature*, 574 (7779), 461-462.

Hassija, V., Chamola, V., Goyal, A., Kanhere, S. S., and Guizani, N. (2020). Forthcoming applications of quantum computing: peeking into the future. *IET Quantum Communication*, 1 (2), 35-41.

Hidary, J. D. (2019). *Quantum Computing: An Applied Approach*. Springer International Publishing.

How, M.L., and Cheah, S.M. (2023). Business Renaissance: Opportunities and Challenges at the Dawn of the Quantum Computing Era. *Businesses*, 3 (4), 585-605.

Huvila, I., Anderson, T. D., Jansen, E. H., McKenzie, P., and Worrall, A. (2017). Boundary objects in information science. *Journal of the Association for Information Science and Technology*, 68 (8), 1807-1822.

Lichfield, G., and Kakaes, K. (2019). *Quantum supremacy from Google? Not so fast, says IBM*. MIT Technology Review. https://tinyurl.com/bdz3utvv (visited on March 10, 2024).

Piattini, M., Peterssen, G., and Pérez-Castillo, R. (2020). Quantum Computing: A New Software Engineering Golden Age. *ACM SIGSOFT Software Engineering Notes*, 45 (3), 12-14.

Raheman, F. (2022). The Future of Cybersecurity in the Age of Quantum Computers. *Future Internet*, 14 (11), 335.

Ramskov, J. (2022). *Novo Nordisk Foundation donates DKK 1.5 billion for the development of the world's best quantum computer*. Ingeniøren. https://tinyurl.com/43ctj8s4 (visited March 10, 2024).

Sharma, M., Choudhary, V., Bhatia, R. S., Malik, S., Raina, A., and Khandelwal, H. (2021). "Leveraging the power of quantum computing for breaking RSA encryption." *Cyber-Physical Systems*, 7 (2), 73-92.

Star, S. L., and Griesemer, J. R. (1989). "Institutional Ecology, `Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39." *Social Studies of Science*, *19* (3), 387–420.

Thornton, D. (2022). *NSA releases 'post-quantum' guidance for national security system owners, operators and vendors*. Federal News Network. https://tinyurl.com/yuu7bc83 (visited on March 10, 2024).