Workshop Summary of the Second International Workshop on Quantum Data Science and Management (QDSM)

Valter Uotila
University of Helsinki
Helsinki, Finland
valter.uotila@helsinki.fi

Sven Groppe
Institute of Information Systems (IFIS), University of Lübeck
Lübeck, Germany
sven.groppe@uni-luebeck.de

Le Gruenwald
The University of Oklahoma
USA
ggruenwald@ou.edu

Jiaheng Lu
University of Helsinki
Helsinki, Finland
jiaheng.lu@helsinki.fi

Wolfgang Mauerer
Technical University of Applied Science Regensburg
Regensburg, Germany
wolfgang.mauerer@oth-regensburg.de

ABSTRACT

Continuing the workshop's success last year, the second international workshop on Quantum Data Science and Management (QDSM), co-located with VLDB 2024, is centered around addressing the possibilities of quantum computing for data science and data management. Quantum computing is a relatively new and emerging field that is believed to have huge computational potential in the future. In the QDSM workshop, we want to provide a venue for discussing and publishing novel results of applying quantum computing to hard data science and data management problems. This year these problems include storing relational tables on universal quantum computers, quantum graph neural network-based deep learning, circuit-based quantum data structures, executing graph algorithms on quantum computers, and studying the feasibility of hosting SQL query execution on quantum platforms. The workshop provides a platform for active discussion on these and related topics.

VLDB Workshop Reference Format:
Valter Uotila, Sven Groppe, Le Gruenwald, Jiaheng Lu, and Wolfgang Mauerer. Workshop Summary of the Second International Workshop on Quantum Data Science and Management (QDSM). VLDB 2024 Workshop: The Second International Workshop on Quantum Data Science and Management (QDSM'24).

1 INTRODUCTION

After years of research, quantum computing has seen remarkable advancements, with prototypes now accessible via cloud services like IBM Q, Google Quantum AI, Amazon Braket, and Xanadu Cloud. While large-scale, fault-tolerant quantum computers are not yet available, the technology's potential is undeniable.

Proceedings of the VLDB Endowment. ISSN 2150-8097.

For most database researchers, quantum computing and quantum machine learning are emerging fields. This workshop aims to unite academic and industry experts from various disciplines — database, AI, software, and physics — to discuss the challenges and applications of quantum computing and machine learning. We aim to foster collaboration between database researchers and quantum computing professionals and explore how quantum resources can enhance data science and management.

We believe that many intriguing possibilities lie at the intersection of quantum computing, data science, and data management, but there are few venues for publishing such cross-disciplinary work. The Quantum Data Science and Management workshop will not only present early research findings but also offer demonstrations of novel quantum computing techniques and provide attendees with hands-on experience that goes beyond basic examples available online. This will give researchers practical insights into using quantum computing for data science and management tasks.

2 TYPES OF PAPERS

The workshop solicits papers of the following categories.

Research Papers propose new approaches, theories, or techniques related to quantum data science and management, including new data structures, protocols, and algorithms. They should make substantial theoretical and empirical contributions to the research field.

System Papers describe new systems and whole frameworks for enabling quantum data science and management.

Experiments and Analysis Papers focus on the experimental evaluation of existing approaches, including data structures and algorithms for quantum data science and management, and bring new insights through the analysis of these experiments. Results of Experiments and Analysis Papers can be, for example, showing the benefits of well-known approaches in new settings and environments, opening new research problems by demonstrating unexpected behavior or phenomena or comparing a set of traditional approaches in an experimental survey.

Application Papers report practical experiences on quantum data science and management applications. Application Papers

might describe how to apply quantum technologies to specific application domains.

Vision Papers identify emerging new or future research issues and directions and describe new research visions for quantum data science and management. The new visions will potentially have significant impacts on society.

Demo Papers deal with innovative approaches and applications for quantum data science and management. These papers describe a showcase of the proposed approach/application. We are especially interested in demonstrations having a WOW effect.

3 TOPICS OF INTEREST

We are interested in all topics concerning quantum computing for data science and management, such as the following:

- Quantum computing, quantum algorithms, and quantum software tools for problems related to data science and management
- Quantum machine learning for data science, data management and database optimization
- Post-quantum cryptography and security for databases and data management
- Classical data science and management for quantum computing and quantum machine learning

4 REVIEW PROCESS

We have enforced a rigorous peer and single-anonymous review process with the option for authors of a double-anonymous review process. All manuscripts submitted to our workshop have been reviewed by at least three PC members. To verify the originality of submissions, we have used Plagiarism Detection Tools to check the content of the submitted manuscripts against previous publications.

The articles have been evaluated according to the following aspects:

- Relevance to the workshop
- Novelty and practical impact
- Technical soundness
- Appropriateness and adequacy of literature review, background discussion, and analysis of issues
- Presentation, including overall organization, English, and readability

5 RATIONALE ABOUT RECRUITING THE CHAIRS AND PROGRAM COMMITTEE WITH SPECIAL REGARD TO DIVERSITY CONSIDERATIONS

The PC chairs of the Quantum Data Science and Management workshop are coming from two continents, Europe and North America, which would attract an international community. One of the PC chairs is female (25%). The h-index of the PC chairs ranges between 20 and 40[1].

We have currently recruited 16 PC members and chairs who are experts in the topics of interest of our workshop. Our PC represents a good mixture of different experiences, not only in terms of research areas but also in terms of levels of research experience. While most PC members are from academia, one expert is also from industry (6%). Three of the PC members and chairs are women (19%). The chairs and PC members are listed in the Appendix.

[1] according to Google Scholar and Scopus

6 KEYNOTES

The workshop included two keynote talks.

The first keynote talk with the title *Advancing Quantum Algorithms for Real-World Impact* was by Kathrin Spendier (XPRIZE Foundation). She pointed out that quantum computing is progressing steadily, but current hardware and algorithms are not yet capable of solving societal problems beyond classical computers' reach. Few companies and researchers are focusing on translating quantum algorithms into practical applications because much of the algorithm development is often abstract and not directly relevant to real-world problems. Key areas where quantum computing could excel include molecular and materials simulation, solving classical differential equations, quantum machine learning, and optimization. These applications promise significant impacts, such as new medicines, efficient catalysts, and renewable energy solutions. Her talk explored current research efforts, potential applications, and strategies to bridge the gap between theory and practice in quantum computing. Additionally, she explored the XPRIZE Quantum Applications Competition, which incentivizes the development of quantum solutions that address global challenges by encouraging the creation of quantum applications with clear quantum advantage for real-world impact.

Rihan Hai (TU Delft) gave the second keynote talk with the title *Quantum Data Management in the NISQ Era*. Her talk provided a comprehensive overview of current research efforts leveraging quantum technologies to address classical database challenges, such as query optimization, data integration, and transaction management. She presented data management and engineering challenges posed by near-term quantum processors. She described innovative strategies that can facilitate the integration of quantum computing into existing data management frameworks. By bridging the gap between classical database problems and quantum computing, the talk shed light on the synergies and potential advancements at this interdisciplinary frontier.

The Appendix of this workshop summary contains the short biographies of our keynote speakers.

7 ACCEPTED PAPERS

The accepted papers include four research papers and one demo paper.

Quantum Storage Design for Tables in RDBMS [2] by Tuodu Li, Gongsheng Yuan, Chang Yao, Meng Shi, Ziyue Wang, Ling Qian, and Jiaheng Lu proposes two quantum computing-based storage methods, *Quantum Column-oriented Store* (QCOS) and *Quantum Row-oriented Store* (QROS), to store relational tables on universal quantum computers.

Supervised Learning on Relational Databases with Quantum Graph Neural Networks [4] by Martin Vogrin, Rok Vogrin, Sven Groppe and Jinghua Groppe present a framework that integrates supervised machine learning on relational databases with graph neural networks and quantum graph neural network-based deep learning. They identify how this type of framework would answer challenges

in processing complex and linked data. They point out the key difficulties in implementing the framework and discuss possible solutions to the difficulties.

Quantum Data Structures for Enhanced Database Performance [3] by Tim Littau, Ziyu Li, and Rihan Hai describes novel quantum data structures to optimize database querying and manipulation by utilizing quantum mechanical capabilities. They introduce a Quantum Partitioned Database utilizing a modified Grover's algorithm for data retrieval and show an implementation of circuit-based quantum data structures.

Graphs on Qubits: Demonstrating Three Graph Algorithms on Quantum Computers [5] by Lauri Vuorenkoski and Valter Uotila represents a demonstration system that implements three central graph algorithms representing three different computational complexity classes. The algorithms are all-pairs shortest path, graph isomorphism, and community detection.

Is Quantum-Based SQL Query Execution Viable? [1] by Manish Kesarwani and Jayant R. Haritsa identifies multiple challenges that are likely to arise when hosting SQL query execution on quantum platforms. They also discuss potential methods for addressing these challenges.

8 SUMMARY AND CONCLUSIONS

We are looking forward to motivating, insightful, and enthusiastic discussions at the workshop. The submitted papers and the expertise of the keynote speakers and the authors are among the first to propose quantum computing solutions to data science and data management problems. We are confident that our workshop will foster the collaboration of researchers and practitioners and support networking for long-lasting professional connections after the workshop.

REFERENCES

[1] Manish Kesarwani and Jayant R. Haritsa. 2024. Is Quantum-Based SQL Query Execution Viable?. In *VLDB 2024 Workshop: The Second International Workshop on Quantum Data Science and Management (QDSM'24)*. Guangzhou, China.

[2] Tuodu Li, Gongsheng Yuan, Chang Yao, Meng Shi, Ziyue Wang, Ling Qian, and Jiaheng Lu. 2024. Quantum Storage Design for Tables in RDBMS. In *VLDB 2024 Workshop: The Second International Workshop on Quantum Data Science and Management (QDSM'24)*. Guangzhou, China.

[3] Tim Littau, Ziyu Li, and Rihan Hai. 2024. Quantum Data Structures for Enhanced Database Performance. In *VLDB 2024 Workshop: The Second International Workshop on Quantum Data Science and Management (QDSM'24)*. Guangzhou, China.

[4] Martin Vogrin, Rok Vogrin, Sven Groppe, and Jinghua Groppe. 2024. Supervised Learning on Relational Databases with Quantum Graph Neural Networks. In *VLDB 2024 Workshop: The Second International Workshop on Quantum Data Science and Management (QDSM'24)*. Guangzhou, China.

[5] Lauri Vuorenkoski and Valter Uotila. 2024. Graphs on Qubits: Demonstrating Three Graph Algorithms on Quantum Computers. In *VLDB 2024 Workshop: The Second International Workshop on Quantum Data Science and Management (QDSM'24)*. Guangzhou, China.

APPENDIX

Workshop Chairs and Organizers

Sven Groppe is a Professor at the University of Lübeck, Germany. He received 7 project grants from DFG, BMBF, and BMWi in the area of data management. He is the project coordinator of the BMBF-funded QC4DB project about accelerating relational database management systems via quantum computing. He published more than 180 journal, conference, and workshop papers at top-ranked publication venues, including SIGMOD, VLDB, and ICPP, with over 190 co-authors from 28 countries on 6 continents worldwide. He is a member of over 120 program committees of various conferences and workshops and a reviewer of over 40 journals. He is a workshop chair of SBD@SIGMOD (2016-2020), BiDEDE@SIGMOD (2021-2023), VLIoT@VLDB (2017-2022) and QDSM@VLDB (2023-2024). He is a general chair of the International Semantic Intelligence Conference (ISIC) (2021-2022), the International Health Informatics Conference (IHIC) (2022- 2023), and the International Conference on Applied Machine Learning and Data Analytics (AMLDA) in 2023. More information is available on www.ifis.uni-luebeck.de/ groppe/.

Jiaheng Lu is a Professor at the University of Helsinki, Finland. His current research interests focus on multi-model databases and quantum computing for database applications. He has written four books on Hadoop and NoSQL databases and more than 130 journal and conference papers published in SIGMOD, VLDB, TODS, etc. He was the workshop co-chair of Keyword search and data exploratory with ICDE 2016, Keyword search on structured data with SIGMOD 2012, and Cloud databases with CIKM 2010.

Wolfgang Mauerer is a Professor of Quantum Computer Science at the Technical University of Applied Sciences Regensburg and a Senior Research Scientist at Siemens Technology. His interests focus on software/systems engineering and quantum computing. He has published strongly multi-disciplinary work in venues and journals from Nature Photonics and PRL via ICSE and TSE to SIGMOD and VLDB, and is the author of three books. For more details, see www.lfdr.de.

Le Gruenwald is a Professor, Dr. David W. Franke Professor, and Samuel Roberts Noble Foundation Presidential Professor in the School of Computer Science at The University of Oklahoma, U.S.A. She also worked for the National Science Foundation (NSF) in the Directorate for Computer & Information Science & Engineering (CISE) as a Cluster Lead and Program Director of the Information Integration and Informatics cluster and a Program Director of the Cyber Trust program. Her major research interests include Machine Learning Enabled Cloud Data Management, Quantum Data Management and Mining, Semantic Web, Data Stream Management and Mining, and Mobile Data Management. She has published more than 200 technical articles in journals, books, and conference proceedings.

Proceedings Chair

Valter Uotila is a Ph.D. student researching quantum computing applications for databases and data management at the University of Helsinki, Finland. He is also interested in applied category theory and its synergy with quantum computing and databases. Besides academic work, he has achieved multiple top-3 placements in international quantum computing hackathons, such as QHack 2022 and 2023, as well as in QIA's Quantum Internet Application Challenge and BMW's Quantum Computing for Automotive Challenges.

Publicity Chair

Dr. **Eleazar Leal** is an associate professor of the Department of Computer Science at the University of Minnesota Duluth. He received his Ph.D. in Computer Science (2017) from the University of Oklahoma. Dr. Leal's research interests include spatial database

management, stream data management, and database management on modern hardware. He has served as a program committee member of the IEEE International Big Data Conference (IEEE BIGDATA) and IEEE International Conference on Data Mining (IEEE ICDM).

Keynote Speakers

Kathrin Spendier is the Technical Prize Director for XPRIZE Quantum Applications. Prior to XPRIZE, she was the Quantum Computing Technology Evangelist at Quantinuum and spent over a decade at the University of Colorado, Colorado Springs, as an Associate Professor of Physics and Director of Research Programs. She holds a Ph.D. in Physics from the University of New Mexico. Kathrin focuses on advancing the quantum technology ecosystem by enabling researchers to deliver breakthrough quantum solutions.
Rihan Hai is an assistant professor at Delft University of Technology (TU Delft), Netherlands. Before joining TU Delft, she received her Ph.D. degree from RWTH Aachen University, Germany. She received her master's and bachelor's degrees from Tsinghua University, China. Her research focuses on data lakes, data privacy, and quantum data management.

Program Committee

Our program committee consists of the following experts:

- Umut Çalikyilmaz, University of Lübeck, Germany
- Maja Franz, OTH Regensburg, Germany
- Srinjoy Ganguly, Woxsen University, India
- Natacha Kuete Meli, University of Siegen, Germany
- Nitin Nayak, University of Lübeck, Germany
- Jukka K. Nurminen, University of Helsinki, Finland
- IIya Safro, University of Delaware, USA
- Manuel Schönberger, OTH Regensburg, Germany
- Ghanshyam Singh, Malaviya National Institute of Technology Jaipur (MNIT), India
- Valter Uotila, University of Helsinki, Finland
- Sanjay Vishwakarma, IBM Quantum, IBM Research - Almaden, USA
- Zhengtong Yan, University of Helsinki, Finland