Dagstuhl Seminar on Quantum Software Engineering - Program at a Glance

	MONDAY, 16th	TUESDAY, 17th	WEDNESDAY, 18th	THURSDAY, 19th	FRIDAY, 20th
09:00 - 09:10	Opening	Plan for Day 2	Plan for Day 3	Plan for day 4	Plan for day 5
09:10 - 10:30	Talks: Personal interest presentations	Talks: Quantum Software Engineering and its Challenges (I)	Paving the way for splitting into working groups	Working Groups (I)	Group resports
10:30 - 10:50	Coffee break	Coffee break	Coffee break	Coffee break	Coffee break
10:50 - 12:00	Talks: Personal interest presentations	Talks: Quantum Software Engineering and its Challenges (II)	Groups Meeting and Plannification for Thursday	Working Groups (II)	Clossing Session
12:15 - 14:00	Lunch	Lunch	Lunch	Lunch	Lunch
14.00 - 15:15	Talks: When Software Engineering meets Quantum Mechanics (I)	Talks: Quantum Software Engineering and its Challenges (III)	Outdoor Activity	Working Groups (III)	
15:15 - 16:00	Coffee break	Coffee break		Coffee break	
16:00 - 16:45	Talks: When Software Engineering meets Quantum Mechanics (II)	Talks: Quantum Software Engineering and its Challenges (IV)		Working Groups (IV)	
16:45 - 17:30	Plenary Open Discussion	Plenary Open Discussion		Plenary Open Discussion	
17:30 - 17:45	Summary of Day 1	Summary of Day 2		Summary of Day 4	
18:00 - 19:30	Dinner	Dinner	Dinner	Dinner	

DETAILED PROGRAM FOR PRESENTATION SESSIONS

MONDAY

14.00 - 15:15 Talks: When Software Engineering meets Quantum Mechanics (I)

Classiq: Electronic design automation synthesis methods for quantum software

Yehuda Naveh, Classiq

I will claim that the right way to create complex, scalable quantum programs is through electronic design automation (EDA) synthesis methods. I will present Classiq's mature synthesis engine and related aspects. I will show results backing this claim, in particular orders of magnitude improvements in program parameters compared to common compilation techniques for quantum software. The talk is based on https://arxiv.org/abs/2412.07372

Towards Reliable Quantum Computing Architecture

Shinobu Saito, NTT - Tokyo

We have proposed a new system architecture for reliable quantum computing. It has two features: redundancy and self-adaptation. This architecture is realized by utilizing software engineering techniques in classical computing.

On HPCQC Software Stacks Needs

Laura Schulz, Leibniz Supercomputing Centre

From the last few years running a QC department in an HPC center, we've developed thoughts on what roles an HPCQC software stack needs to have for users, developers, administrators, facility team and the systems themselves. This would be an overview talk based on experience that is driving some of the requirements we're baking into our Munich Quantum Software Stack. I'd also posed some open questions based on data we're getting from the systems that may influence design decisions for the software.

16:00 - 16:45 Talks: When Software Engineering meets Quantum Mechanics (II)

Quantum Computing, Consciousness, and Software Engineering
Schahram Dustdar, TU Wien

This talk has 3 parts: Part 1 explores 9 foundational challenges for applying software engineering principles to quantum computing. Part 2 discusses Federico Faggin's OTP Theory in the light of principled challenges for Quantum Software. Part 3 delevops several baselines for utilizing OTP theory as an inspiration for the emerging field of Quantum Software

Quantum Software = Quantum minus Software?
Wolfgang Mauerer, Ostbayerische Technische Hochschule - Regensburg

We cannot think about quantum software without acknowledging that weknow only a handful of quantum algorithms---and these are almost trivial from a software engineering point of view. I will argue that little of "quantum software" is actually "quantum", and why this is not necessarily a bad thing if we slightly rethink what is "software" in this context.

TUESDAY

09:10 - 10:30 Talks: Quantum Software Engineering and its Challenges (I)

Advancing Quantum Software for Software Engineering Tasks: Current Limits and Future Possibilities

Andriy Miranskyy, Toronto Metropolitan University

When it comes to applying software engineering principles to programs for quantum computers, the path forward is well-defined, with a clear vision for the next five to ten years. In contrast, using quantum computers to address software engineering problems presents a more uncertain and complex trajectory. This talk will explore the challenges we face in this area and highlight some open questions, offering insights that may be of interest to the broader community.

View-Based Development of Quantum Software

Ina Schaefer, KIT - Karlsruher Institut für Technologie

Quantum computing is an interdisciplinary field that relies on the expertise of many different stakeholders. The views of various stakeholders on the subject of quantum computing may differ, thereby complicating communication. To address this, we propose a view-based quantum development approach based on a Single Underlying Model (SUM) and a supporting quantum Integrated Development Environment (IDE). We highlight emerging challenges for future research.

Distributing Quantum Computations

Antonio Brogi, University of Pisa

I will present the work that we have been carrying on to develop a methodology for distributing the shots of a quantum computation across multiple, heterogeneous Quantum Processing Units. I will discuss the potential advantages of such a methodology both quantitatively and qualitatively. Finally, I will briefly point to our most recent work, devoted to exploring the potential advantages of combining circuit-cutting and shot-wise distribution tehcniques.

Quantum Services: Load balancing and scheduling to improve usage of QPUs

José Manuel García Alonso, University of Extremadura

In this talk we will explore different approaches to improve the usage of QPUs inspired by classical service-oriented computing techniques. Load balancing techniques could be used to improve resilience of quantum executions while scheduling can be used to include an initial layer of parallelization in quantum executions.

10:50 - 12:00 Talks: Quantum Software Engineering and its Challenges (II)

Developing hybrid quantum-classical software: a software product line approach

Ricardo Pérez-Castillo, University of Castilla-La Mancha

Quantum computing is rapidly emerging as a transformative force in technology. In the near future we will increasingly encounter hybrid systems that combine quantum technology with classical software. I will introduce preliminary ideas for developing quantum-classical software using a Software Product Line approach in line with the Model-Driven Engineering principles.

Quantum software testing

Paolo Arcaini, National Institute of Informatics - Tokyo

The talk will provide an overview of a series of work on quantum software testing. It will describe test coverage criteria for quantum programs, test generation approaches based on evolutionary search, and a mutation analysis approach to assess the adequacy of test suites

KetGPT - Dataset Augmentation of Quantum Circuits using Transformers

Sebastian Feld, Delft University of Technology

Quantum algorithms, represented as quantum circuits, can be used as benchmarks for assessing the performance of quantum systems. Existing datasets, widely utilized in the field, suffer from limitations in size and versatility, leading researchers to employ randomly generated circuits. Random circuits are, however, not representative benchmarks as they lack the inherent properties of real quantum algorithms for which the quantum systems are manufactured. This shortage of `useful' quantum benchmarks poses a challenge to advancing the development and comparison of quantum compilers and hardware. Our goal is to enhance existing quantum circuit datasets by generating what we refer to as `realistic-looking' circuits by employing the Transformer machine learning architecture. For this purpose, we introduce KetGPT, a tool that generates synthetic circuits in OpenQASM language, whose structure is based on quantum circuits derived from existing quantum algorithms and follows the typical patterns of human-written algorithm-based code (e.g., order of gates and qubits).

14.00 - 15:15 Talks: Quantum Software Engineering and its Challenges (III)

Design Automation for Quantum Computing
Robert Wille, TU München

With physical realizations of quantum computing becoming accessible to a broader audience and several potential applications on the horizon, the efficient design of quantum computing solutions is now a key focus. As with classical systems, software plays a crucial role. But can we simply repurpose established software from the classical realm, or must we start from scratch for quantum computing? Additionally, how do we build bridges between computer scientists, who can develop efficient tools, and platform providers, who possess deep technological knowledge? This talk aims to provide answers to these questions, illustrated by current developments from the Munich Quantum Toolkit (https://www.cda.cit.tum.de/research/quantum/).

Multi-Objective Optimization of Quantum Programs
Manuel Wimmer, Johannes Kepler Universität Linz

The processing of quantum information is defined by quantum circuits. The design of such quantum circuits and aggregated higher-level quantum operators is a challenging task which requires significant knowledge in quantum information theory. Moreover, finding an accurate solution with low computational cost represents a significant trade-off, particularly for the current generation of quantum computers. To tackle these challenges, we propose a multi-objective programming approach to automate the synthesis of parameterized quantum operators.

Generation of Fixed Margin Binary Matrices using Quantum Annealing
Rui Abreu, Meta Platforms

Fixed-margin binary matrices widely used in fields like ecology and software engineering serve as essential tools for tasks such as hypothesis testing and fault localization. Generating such matrices with fixed row and column sums is critical for null model analysis but computationally challenging.This talk presents a novel approach using quantum annealing formulating the problem as a Quadratic Unconstrained Binary Optimization (QUBO) task. We share experimental results from the D-Wave Advantage quantum computer and Fixstars Amplify Annealing Engine showcasing the potential of quantum technologies to solve these problems efficiently.

16:00 - 16:45 Talks: Quantum Software Engineering and its Challenges (IV)

Quantum Software Ecosystem Design
Michael Felderer, DLR - Köln

The German Aerospace Center (DLR) is currently developing a quantum software ecosystem integrating software and hardware from various academic and industrial stakeholders. In this talk, I give an overview of these activities, share experiences and highlight different research perspectives in that context.