Session 5:
Tools, Software, Design Automation

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Classical vs. Quantum Tasks

- Granted, very simplistic view…
- But, I do not see an „army“ of experts in quantum mechanics arriving soon
- “Pick up the end-users” as close as possible to their domain
- Tool support can help here!

Compilation

 Kind of “typical” EDA problems (some of them proven NP-hard)

Quantum Circuit Simulation

- Matrix vector multiplication:

$$\underbrace{\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \end{bmatrix}}_{CNOT} \times \underbrace{\begin{bmatrix} \alpha_{00} \\ \alpha_{01} \\ \alpha_{10} \\ \alpha_{11} \end{bmatrix}}_{Input} = \begin{bmatrix} \alpha_{00} \\ \alpha_{01} \\ \boldsymbol{\alpha_{11}} \\ \boldsymbol{\alpha_{10}} \end{bmatrix}$$

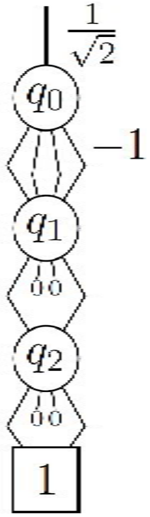
- Matrices and state vectors grow exponentially with respect to the number of qubits

□ **Dedicated data-structures**

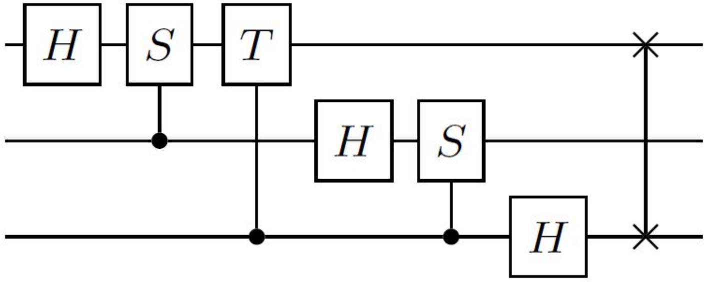
- Decision Diagrams

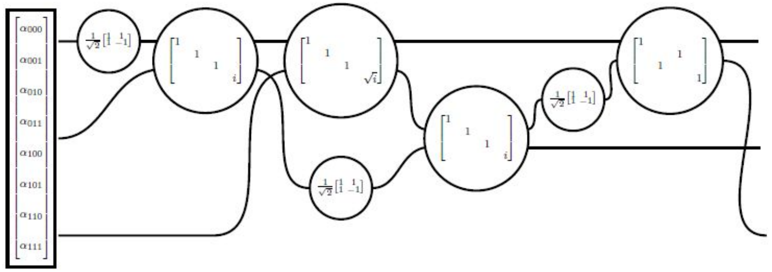
32 GB > 50 MB

$$\begin{bmatrix} \alpha_{0...00} \\ \alpha_{0...01} \\ \alpha_{0...10} \\ \alpha_{0...11} \\ ... \\ \alpha_{1...11} \end{bmatrix}$$



- Tensor Networks





Quantum Circuit Simulation

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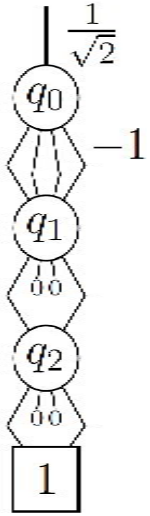

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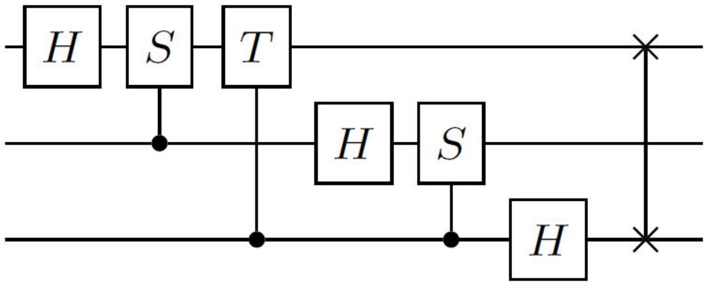
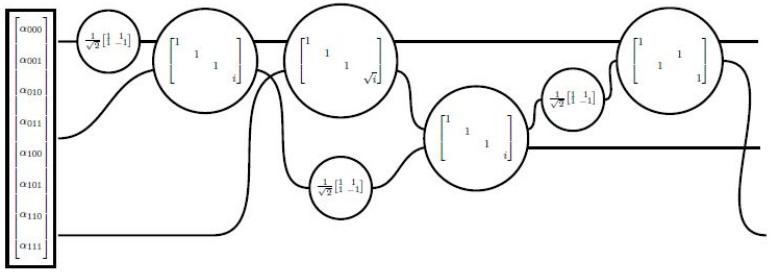
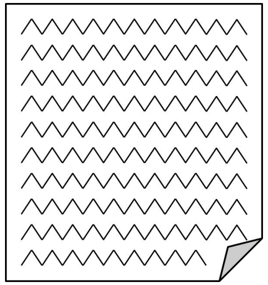
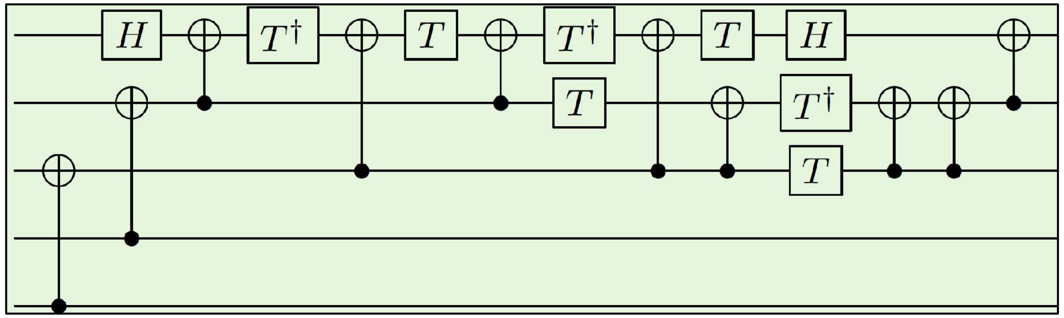




Verification/Equivalence Checking

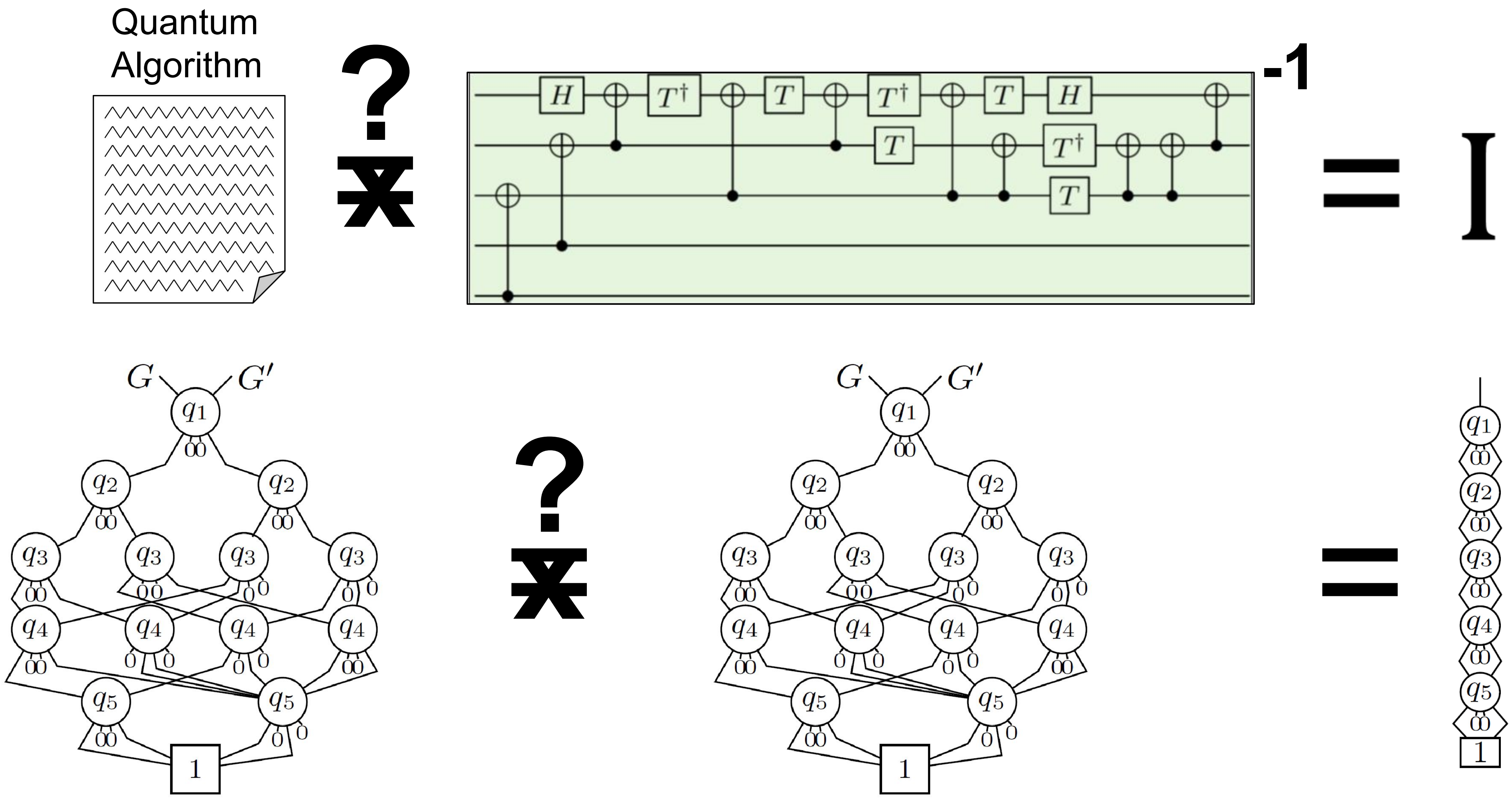




Complementary approaches:

- Simulation (again)
- Formal Verification
- …

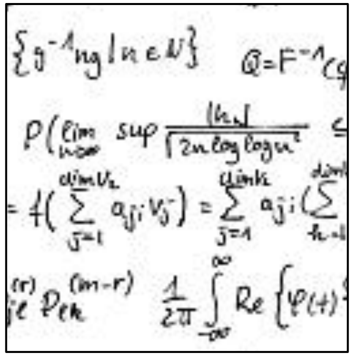
Verification/Equivalence Checking



Connect to Experimentalists and End-Users

Complexity

Connect to Experimentalists and End-Users

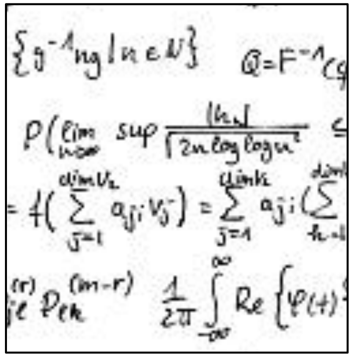


Terminology
and Formalizations

Complexity

Connect to Experimentalists and End-Users

Interdisciplinarity

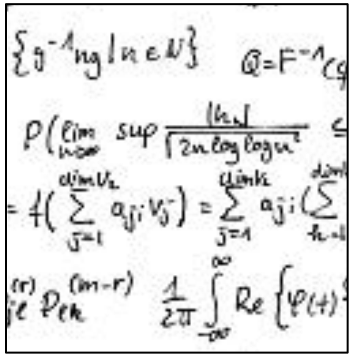


Terminology and Formalizations

Complexity

Connect to Experimentalists and End-Users

Interdisciplinarity



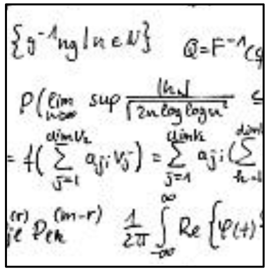
Terminology and Formalizations

Complexity

Connect to Experimentalists and End-Users

Interdisciplinarity

- Identify design tasks



Terminology and Formalizations

- Define and disseminate design problems

Complexity

- Develop design solutions

MUNICH QUANTUM SOFTWARE FORUM

5-6th of OCTOBER 2023

- Connecting the “Who’s Who” in Quantum Computing Software to their end-users
- Many speakers from industry
- October 5th & 6th, 2023 in Munich
- More at www.cda.cit.tum.de/research/quantum/mqsf/

MUNICH QUANTUM SOFTWARE FORUM

https://www.cda.cit.tum.de/research/quantum/mqsf

Save the date!

October 5-6, 2023
Munich, Germany

CONNECTING THE „WHO’S WHO“ IN QUANTUM COMPUTING SOFTWARE TO THEIR END-USERS

Quantum computing is becoming a reality and, with recent accomplishments, software for this promising technology is becoming key for successful utilization. Numerous players (from both, academia and industry) introduce new software solutions frequently. The Munich Quantum Software Forum aims to bring the "who's who" in quantum computing software together and connect them to their end-users. The forum features renowned representatives from academia and industry who present existing software tools as well as recent developments including:

- **Leon Stok (IBM), Qiskit**
- **Austin Fowler (Google), Cirq**
- **Mathias Soeken (Microsoft), Azure Quantum**
- **Eric Kessler (Amazon Web Services), Amazon Braket**
- **Ross Duncan (Quantinuum), TKET**
- **Nir Minderbi and/or Yehuda Naveh, Classiq platform**
- **Fred Chong (UChigaco), ColdQuanta platform**
- **Costin Iancu (Berkeley), BQSKit**
- **Ivana Kurečić (Xanadu), PennyLane**
- **Laura Schulz (LRZ), Munich Quantum Ecosystem**

More information and a link for registration to the event will follow soon. ***Save the date today!***

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The audience will be composed of other fellow software developers, end-users, and stakeholders. **The forum will take place in Munich with a vibrant quantum computing community**, home of the Munich Quantum Valley Initiative (one of the biggest interdisciplinary initiatives on quantum computing worldwide), and several key players "in the neighborhood". We are expecting plenty of opportunities for networking and reaching out to potential collaborators.

The Munich Quantum Software Forum will be organized by the Technical University of Munich and is supported by the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation program (grant agreement No. 101001318), the Bavarian State Ministry for Science and Arts through the Distinguished Professorship Program, as well as the Munich Quantum Valley, which is supported by the Bavarian state government with funds from the Hightech Agenda Bayern Plus.

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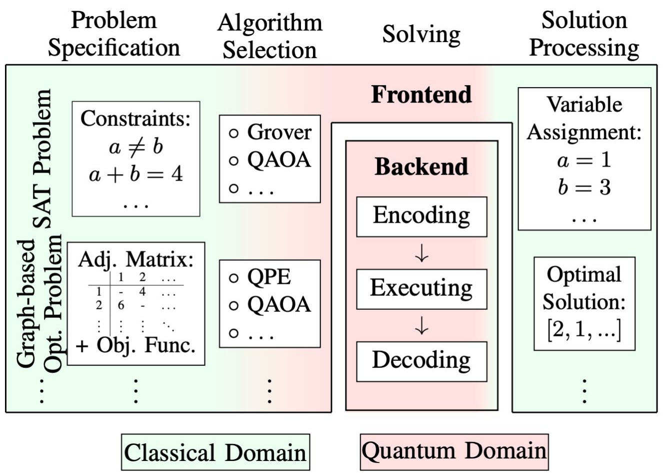
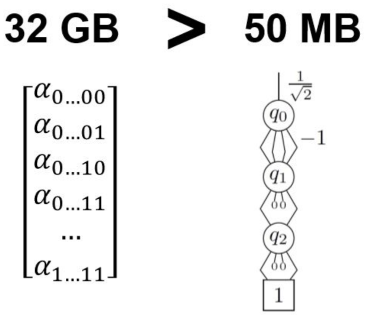
Munich Quantum Valley

Conclusions/Take-home messages

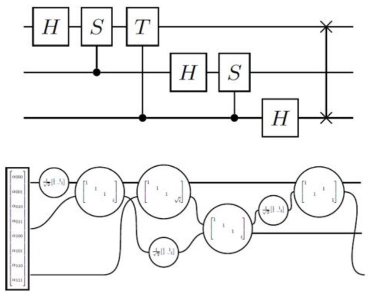
- Utilize “classical expertise/tools“



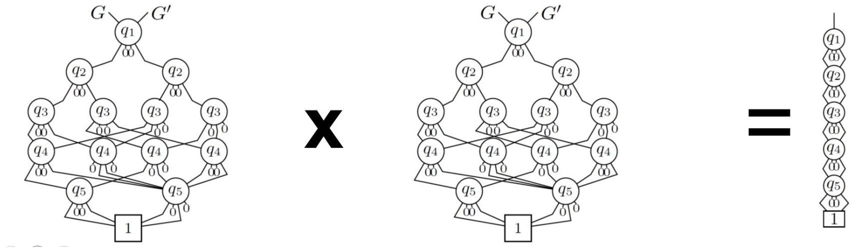
- Develop complementary solutions
  - Decision Diagrams



  - Tensor Networks



- Don’t take additional req. only as a burden; exploit them as well



- Connect, define, disseminate