Chair for Design Automation
TUM School of Computation, Information and Technology
Technical University of Munich

The Munich Quantum Toolkit (MQT)

Design Automation Tools and Software for Quantum Computing

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

Abstract

Quantum computers are becoming a reality. But designing applications for these devices requires automated, efficient, and user-friendly software tools that cater to the needs of end-users, engineers, and physicists at every level of the design flow. The Munich Quantum Toolkit (MQT) is a collection of design automation tools and software for quantum computing developed at the Chair for Design Automation at the Technical University of Munich. This flyer provides an overview of the provided solutions. For each step in the design flow, numbered nodes indicate the correspondingly available software repositories (summarized on the back of this flyer). All software is available as open-source.

MUNICH QUANTUM TOOLKIT

Data Structures / Core Methods 11 12 13 14 15 16

In order to tackle the complexity of important design tasks, the MQT utilizes efficient data structures (e.g., for the representation and manipulation of quantum states and operations) as well as dedicated core methods (e.g., allowing to realize optimal methods) including:

- Decision Diagrams
- Tensor Networks
- ZX-Calculus
- SAT/SMT Solvers
- Machine Learning
- Heuristics

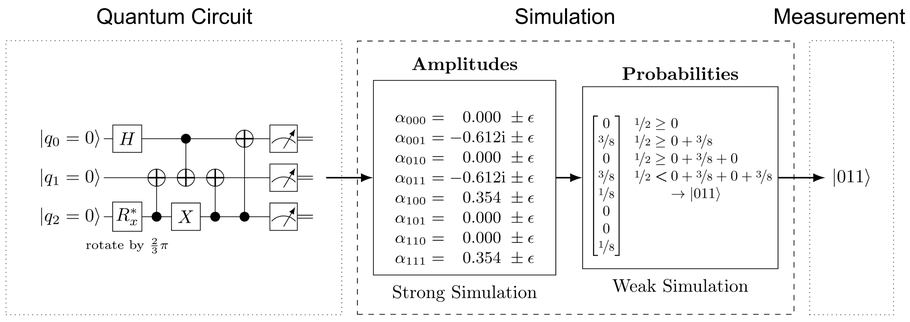
For performance reasons, all tools are implemented in C++ with convenient Python bindings and compatibility to other tools.

Application 1 2

- Workflow from classical problem to quantum solution
- Automated problem encoding, execution, and decoding

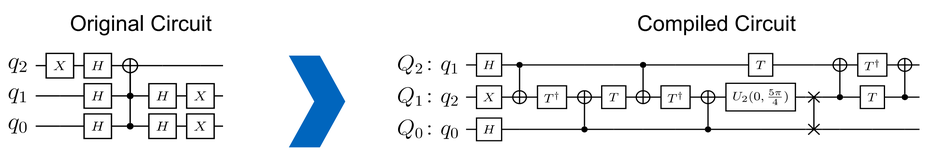
Simulation 3

- Simulation of gate-based quantum circuits based on decision diagrams
- Includes sampling, noise-aware simulation, Hybrid Schrödinger Feynman approaches, approximation strategies, etc.



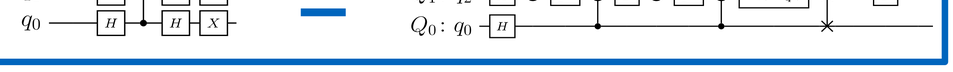
Compilation 4 5 6 7 8

- Determining good compilation options
- Reversible circuit/quantum oracle synthesis
- Technology-specific mapping
  - Quantum circuit mapping/SWAP gate insertion
  - Shuttling for Trapped Ions
- Multi-level (Qudit) Compilation



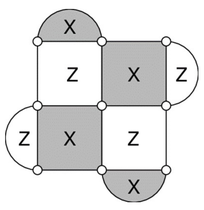
Verification 9

- Equivalence checking of quantum circuits
- Verification of compilation results



Error Correction 10

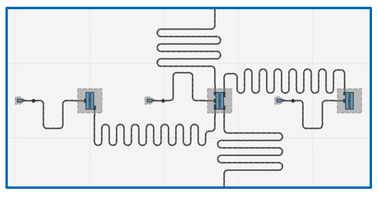
- Decoding algorithms
- Automated code construction and numerical simulations



All tools are available as open-source implementations on GitHub.

Hardware

- Application-specific physical design for superconducting platform



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MUNICH QUANTUM TOOLKIT

1 MQT ProblemSolver

Application

A Tool for Solving Problems Using Quantum Computing

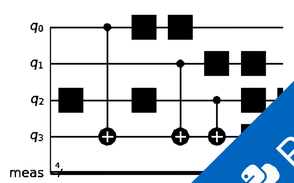
PyPI

github.com/cda-tum/mqtproblemsolver

2 MQT Bench

Application

A Quantum Circuit Benchmark Suite



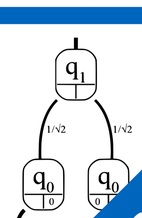
PyPI

www.cda.cit.tum.de/mqtbench
github.com/cda-tum/mqtbench

3 MQT DDSIM

Simulation

A Tool for Classical Quantum Circuit Simulation based on Decision Diagrams



PyPI

github.com/cda-tum/ddsim

4 MQT Predictor

Compilation

A Tool for Determining Good Quantum Circuit Compilation Options

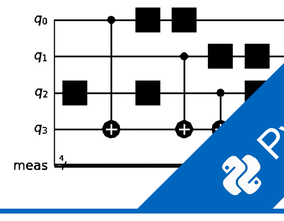
PyPI

github.com/cda-tum/mqtpredictor

5 MQT SyReC

Compilation

A Tool for the Synthesis of Reversible Circuits/Quantum Computing Oracles



PyPI

github.com/cda-tum/syrec

6 MQT QMAP

Compilation

A Tool for Quantum Circuit Mapping

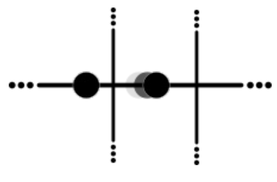
PyPI

github.com/cda-tum/qmap

7 MQT IonShuttler

Compilation

A Tool for Generating Shuttling Schedules for QCCD Architectures

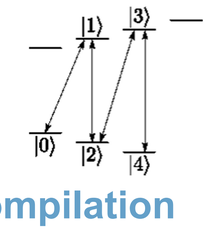


github.com/cda-tum/ion-shuttler

8 MQT Qudits

Compilation

A Tool for Compiling High-Dimensional Quantum Systems

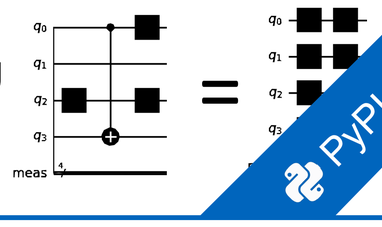


github.com/cda-tum/qudit-compilation
github.com/cda-tum/qudit-entanglement-compilation

9 MQT QCEC

Verification

A Tool for Quantum Circuit Equivalence Checking



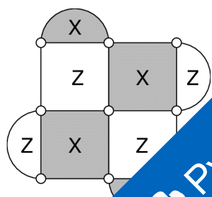
PyPI

github.com/cda-tum/qcec

10 MQT QECC

QECC

A Tool for Quantum Error Correcting Codes



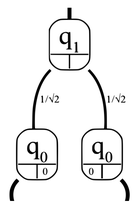
PyPI

github.com/cda-tum/qecc

11 MQT DDPackage

Data Structures

A Decision Diagram Package for Quantum Computing



github.com/cda-tum/dd_package

12 MQT DDVis

Data Structures

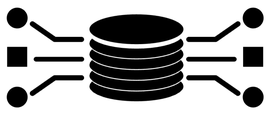
A Web-Application visualizing Decision Diagrams for Quantum Computing

www.cda.cit.tum.de/app/ddvis
github.com/cda-tum/ddvis

13 MQT QFR

Data Structures

An Intermediate Representation for Quantum Circuits and Computations

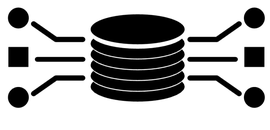


github.com/cda-tum/qfr

14 MQT Logic Blocks

Data Structures

An Interface Library for SAT/SMT Abstractions

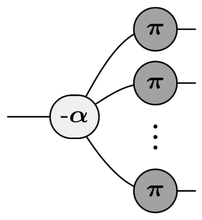


github.com/cda-tum/logicblocks

15 MQT ZX

Data Structures

A ZX-Calculus Package



github.com/cda-tum/zx

16 MQT QuSAT

Core Methods

A Tool for Encoding Quantum Computing using Satisfiability Testing (SAT) Techniques

$$F \wedge (x_1 \wedge \neg x_2)$$
$$F \wedge (x_3 \wedge x_$$

PyPI

github.com/cda-tum/qusat

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Munich Quantum Valley