HPCA 2025 Tutorial

Janus 3.0: A Software Framework for Analyzing, Optimizing, Verifying, and Implementing Quantum Circuit

ACES Lab

JanusQ Cloud

Organizers: **Jianwei Yin**, Liqiang Lu, Siwei Tan

College of Computer Science and Technology
Zhejiang University (ZJU)

https://janusq.github.io/HPCA_2025_Tutorial/

Self-introduction

Jianwei Yin

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Dr. Jianwei Yin is a full professor at the College of Computer Science, Zhejiang University. He is the dean of the School of Software Technology. His interests lie in advanced computing and service computing and has published more than 300 papers in top international journals and conferences such as ASPLOS, MICRO, HPCA, DAC, VLDB, ICDE, TC, TSE, TKDE, TPDS, et al. He led the setup of two international standards and won many Best Paper Awards, such as ICSOC 2017 and ICWS 2019.

- Dean of School of Software at Zhejiang University
- Director of Development & Planning Department of Zhejiang University

Organizers

Jianwei Yin

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Liqiang Lu

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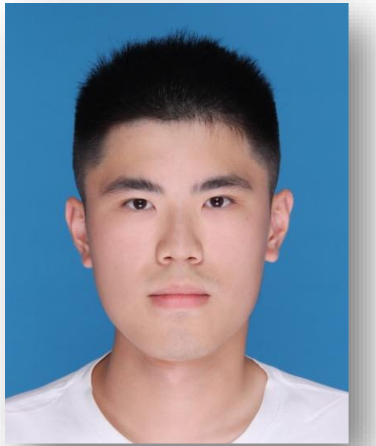

Tianyao Chu

Ph.D. Student

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Advanced Computing and Emerging Service Lab

ACES Lab

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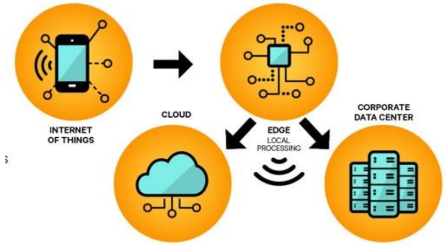
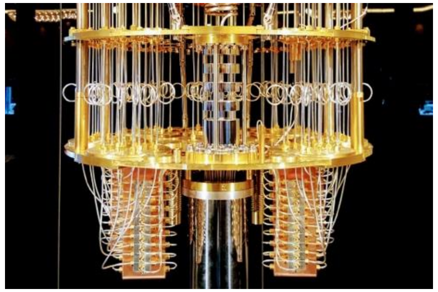
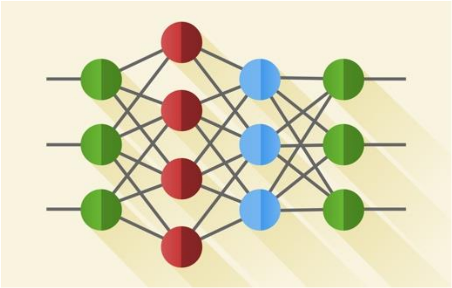
Advanced Computing and Emerging Service Lab (ACES Lab) in Zhejiang University is led by Professor Yin Jianwei. It consists of 28 faculty members and 170 students from the College of Computer Science and Technique, Zhejiang University. The laboratory focuses on **quantum computing, edge computing, and artificial intelligence**, as well as emerging services enabled by these advanced computing technologies.



Service computing



Quantum computing



Artificial intelligence

Milestone of Janus Quantum

2022/07

JanusQ Software 2.0

- Cluster I/O
- Quantum compilation

JanusQ Software

2023/02

Hybrid quantum-classical SAT solver

Revealed with JanusQ cloud in HPCA 2023

2023/10

Achievements published in top conferences

- MICRO & ASPLOS
- ICCAD quantum chemistry competition

2024/04

ASPLOS & Janus 2.0 tutorial

- Ultra-fast readout calibration
- First China quantum tutorial

2025/03

HPCA & Janus 3.0 tutorial

- Constrained binary optimization QAOA
- Second time of Janus tutorial

High Performance Computer Architecture

HPCA 2025

2025/06

Follow our work accepted by DAC

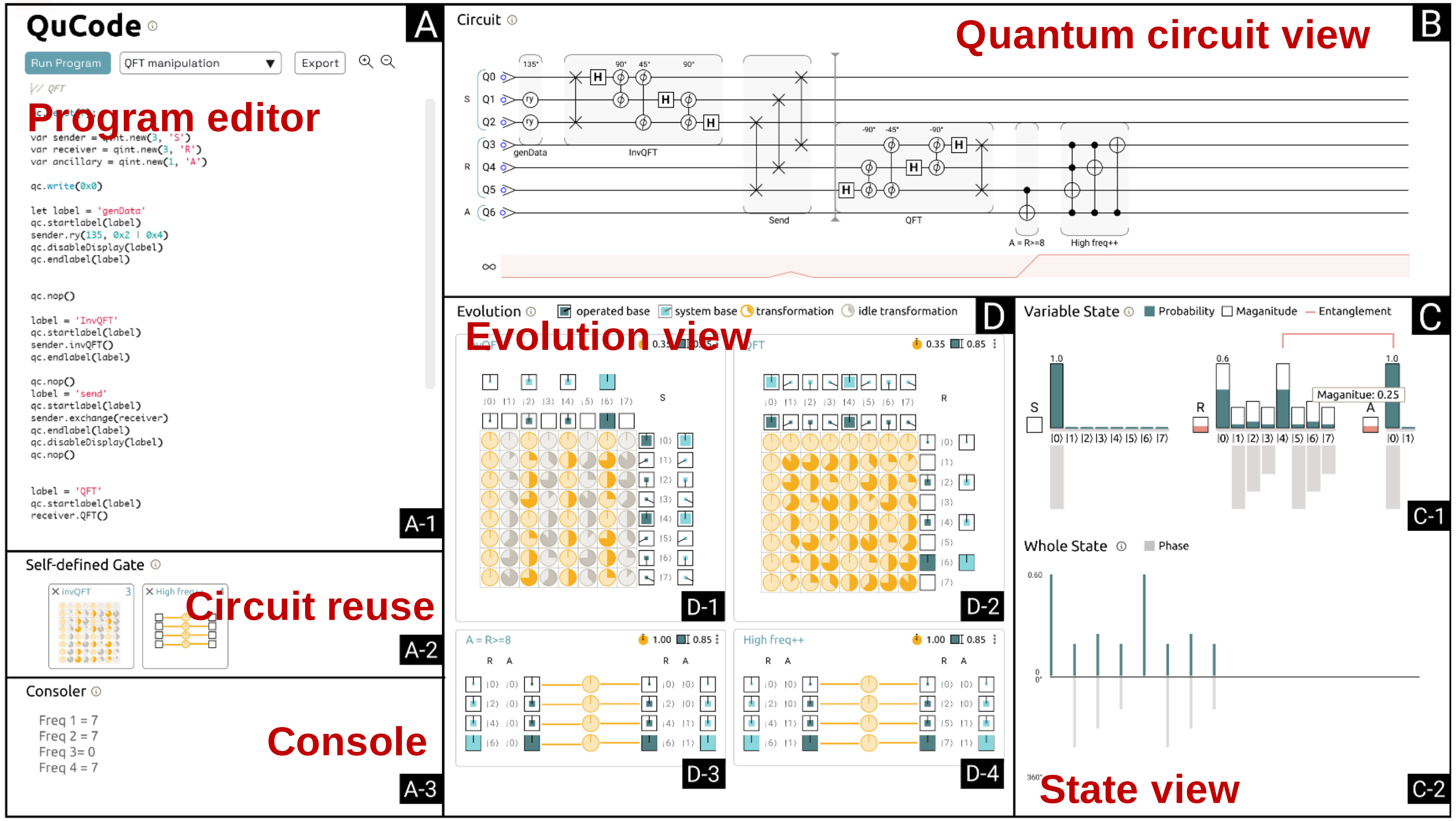
62 THE CHIPS TO SYSTEMS CONFERENCE

SHAPING THE NEXT GENERATION OF ELECTRONICS

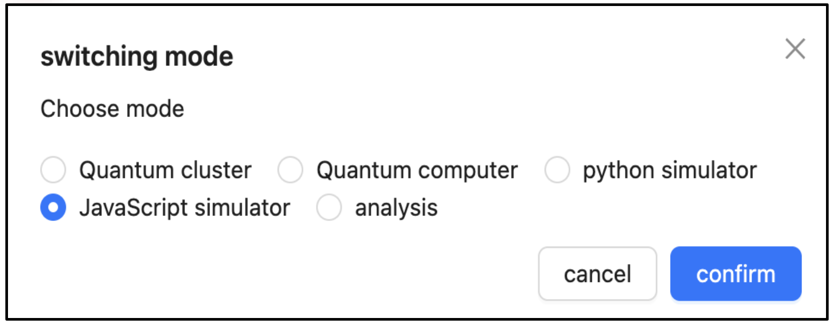
JanusQ Quantum Cloud

ZHEJIANG UNIVERSITY

Coding interface of JanusQ

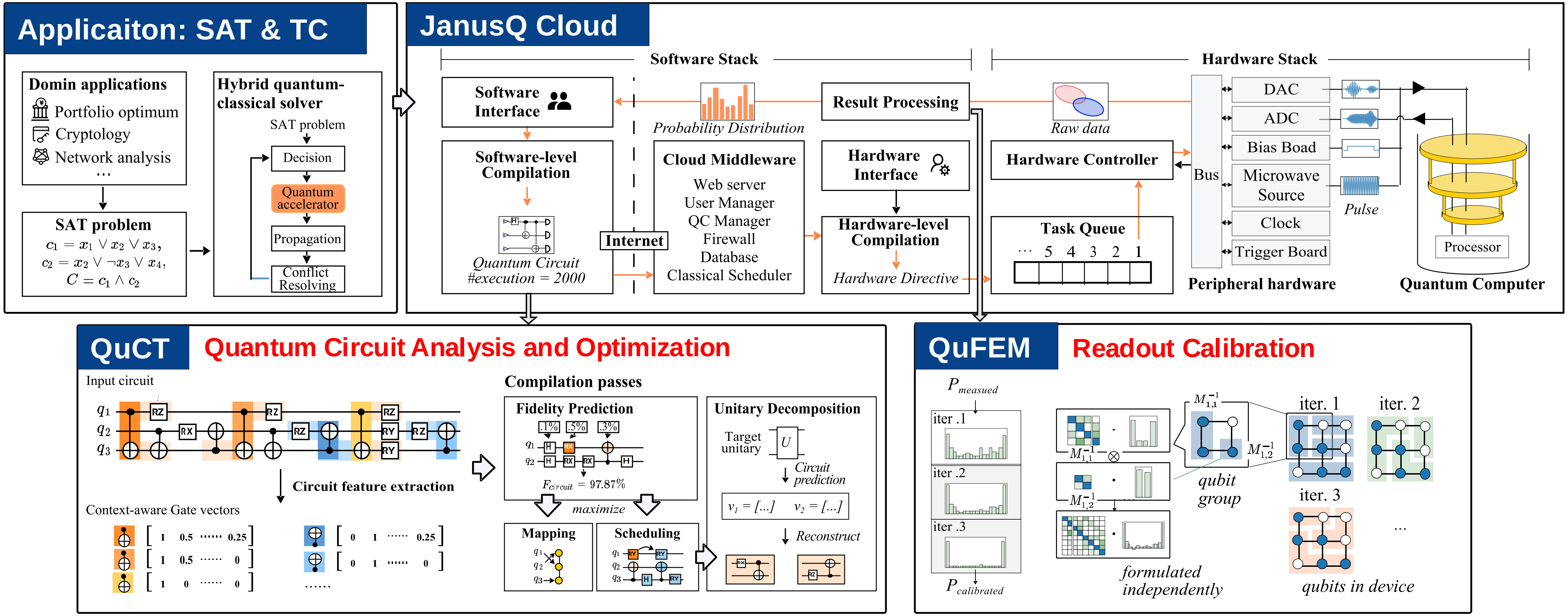


Execution modes



Provided quantum processors

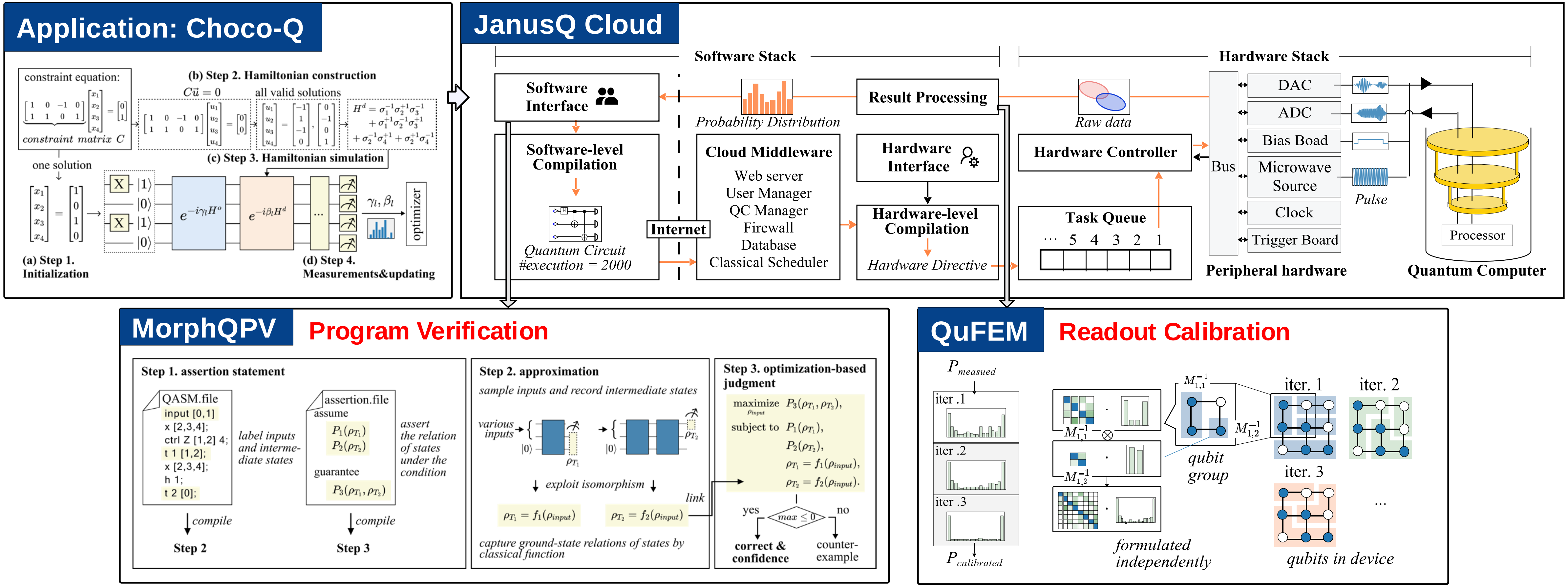
Janus 2.0: A Software Framework for Analyzing, Optimizing and Implementing Quantum Circuit



JanusQ 3.0 Overview

浙江大學 ZHEJIANG UNIVERSITY

Janus 3.0: A Software Framework for Analyzing, Optimizing, Verifying, and Implementing Quantum Circuit



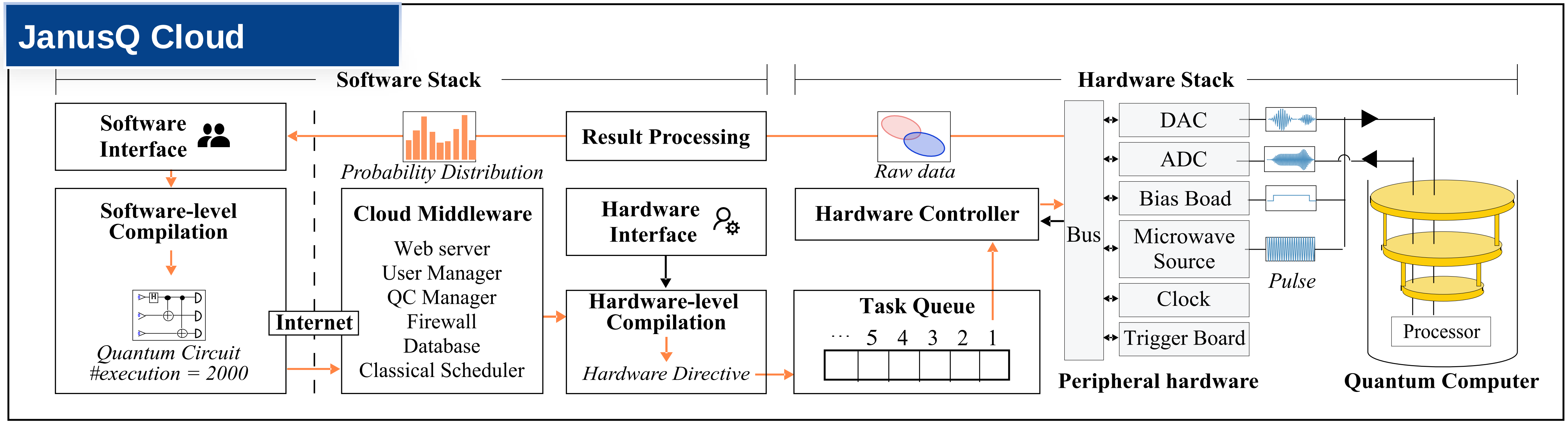
Outline

Topic	Presenter	Time
Topic-1. Introduction of Janus quantum cloud platform	Jianwei Yin & Liqiang Lu	0.5 hour
Topic-2. QuCT Details	Tianyao Chu	(1.0 hour)
(a) Vectorization model and code examples		0.25 hour
(b) Fidelity optimization & Unitary decomposition using gate vectors		0.5 hour
(c) Extending the framework by yourself: other downstream tasks!		0.25 hour
Topic-3. MorphQPV Details	Siwei Tan	(1.25 hour)
(a) MorphQPV overview		0.5 hour
(b) Assertion statement		0.25 hour
(c) Implementation details of the automatic verification and repair		0.5 hour

Outline

Topic	Presenter	Time
Topic-4. QuFEM Details (a) Characterization of readout error (b) Readout calibration using QuFEM	Kaiwen Zhou	(0.5 hour) 0.25 hour 0.25 hour
Topic-5. Choco-Q Details (a) Introduction of constained binary optimization problem (b) Choco-Q overview (c) Solve real-world problems with Choco-Q	Liqiang Lu	(0.5 hour) 0.12 hour 0.25 hour 0.12 hour
Topic-6. Q & A	All	0.25 hour
Total		~4 hours

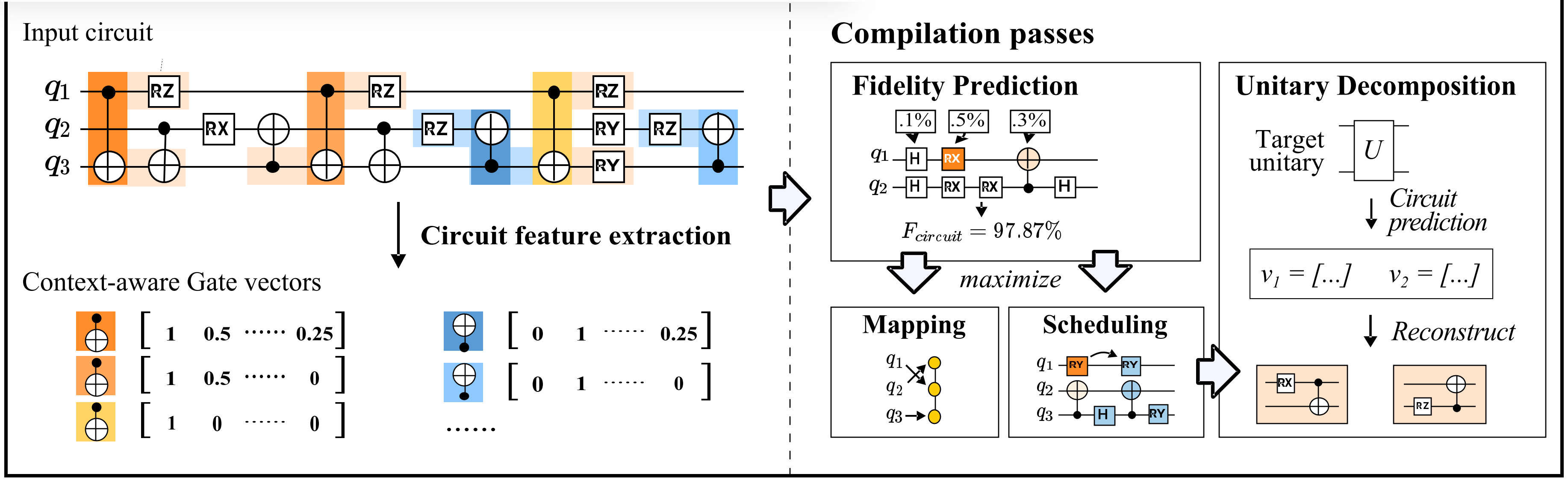
JanusQ Cloud



Janus Quantum Infrastructure:
- How do you use the code editor on the cloud platform?
- How do we submit the task to quantum hardware via API?
- How do we take advantage of JanusQ architecture?

QuCT

QuCT　C: Contextual, T: Topological



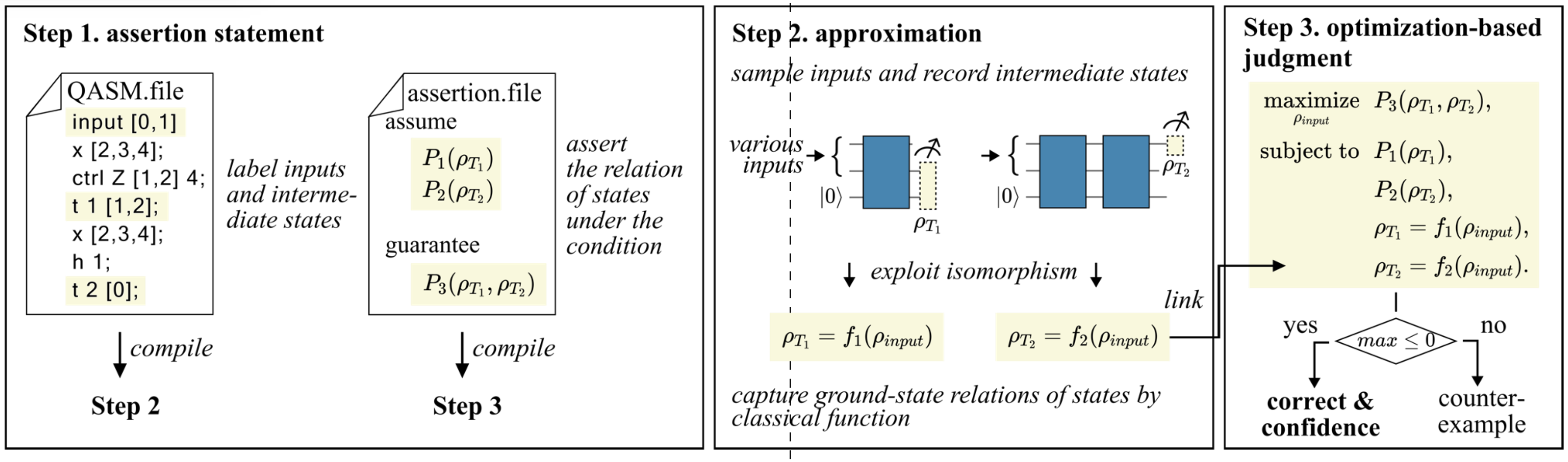
QuCT: Topology-aware quantum circuit optimizer (MICRO 2023)

- Why is topological information important in circuit analysis and optimization?
- How do we use topological information to analyze and optimize noise?
- How can we speed up the unitary decomposition with an upstream model?

Related paper: QuCT: A Framework for Analyzing Quantum Circuit by Extracting Contextual and Topological Features. **[MICRO 2023]**

MorphQPV

MorphQPV



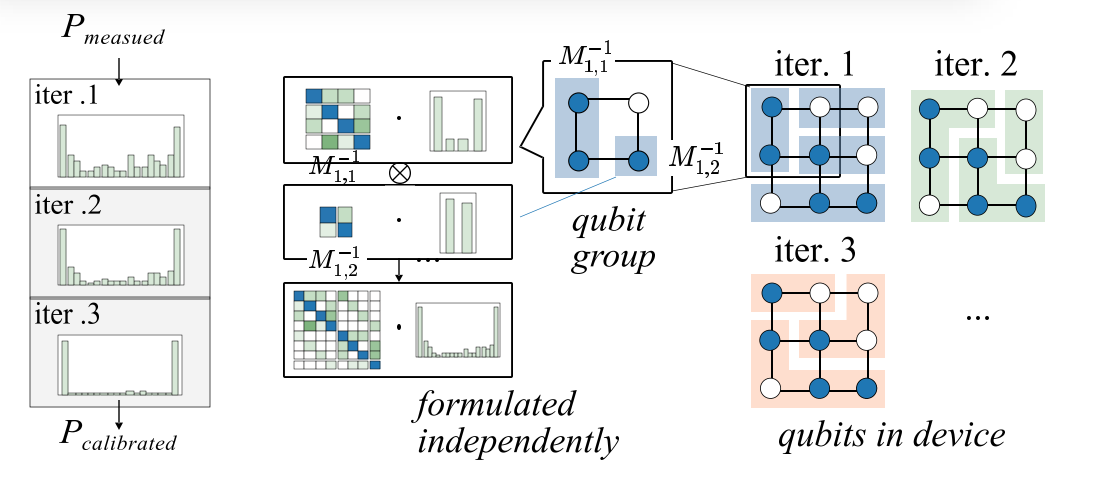
MorphQPV: Isomorphism-based quantum program verification (ASPLOS 2024)

- What is program verification in quantum circuit analysis? Why is it difficult?
- How do we use isomorphism relationship to verity quantum programs?
- How do we realize the assertion statement in quantum programs?

Related paper: MorphQPV: Exploiting Isomorphism in Quantum Programs to Facilitate Confident Verification. **[ASPLOS 2024]**

QuFEM

QuFEM FEM: Finite Element Method

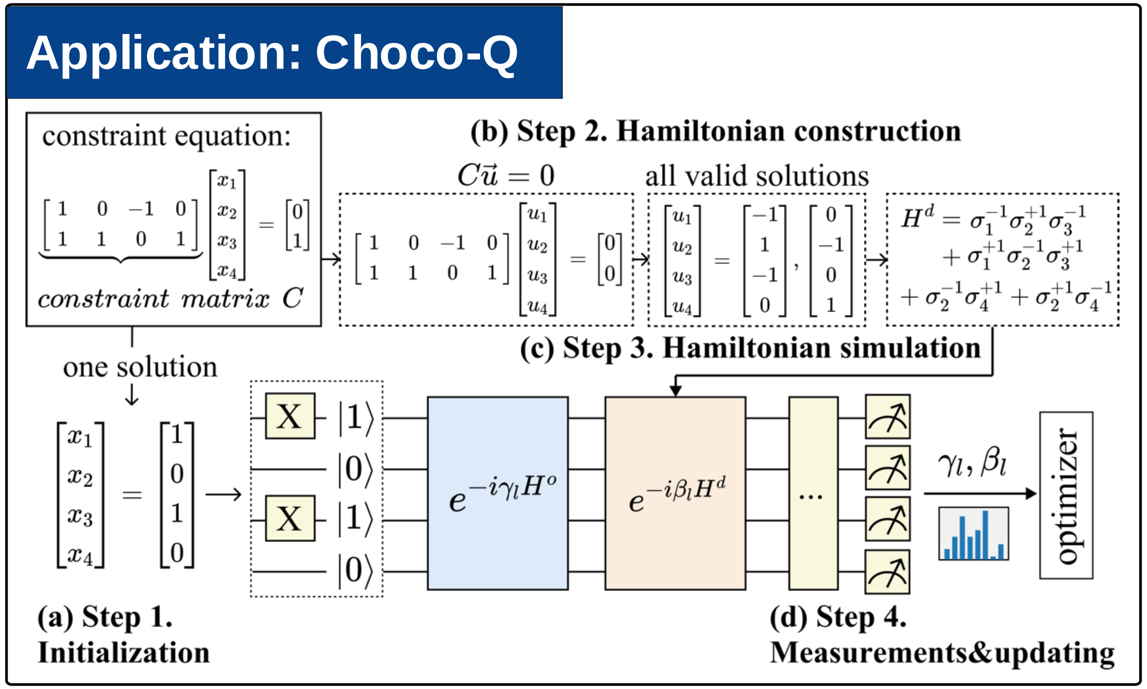


QuFEM: Readout Calibration based on finite element method (ASPLOS 2024)

- What is readout error and the difficulty of calibrating it?
- What is the finite element method?
- How do we mitigate the readout noise using the finite element method?

Related papers: QuFEM: Fast and Accurate Quantum Readout Calibration Using the Finite Element Method. **[ASPLOS 2024]**

Choco-Q



Choco-Q: Constrained Binary Optimization (HPCA 2025)

- What is constrained binary optimization?
- How do we use commute Hamiltonian to squeeze the searching space of QAOA?

Related papers:
Choco-Q: Commute Hamiltonian-based QAOA for Constrained Binary Optimization. **[HPCA 2025]**

Thanks for listening!