WELCOME TO TUTORIAL

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

https://janusq.github.io/tutorials/

College of Computer Science and Technology,
Zhejiang University

ASPLOS 2024

Self-introduction

Jianwei Yin

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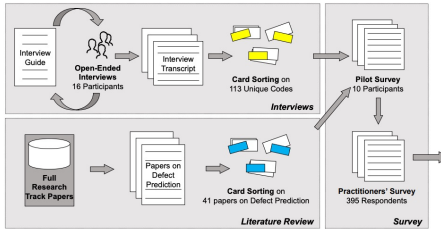
Dr. Jianwei Yin is a full professor at the College of Computer Science, Zhejiang University. He is the vice dean of the College of Computer Science and Technology. Prof. Yin has served as a PC chair or PC member for international conferences, including ICDCS, ICSOC, ICWS, WISE, etc. He has published more than 100 papers in top international journals and conferences such as MICRO, ASPLOS, ISCA, DAC, TC, TSE, TKDE, TPDS, TSC, TII, TCBY, CHI, ICDE, et al. He led the setup of two international standards/ He won the Best Paper Award in ICSOC 2017 and the SCC 2012 Best Student Paper Award.

Representative works

[Edge intelligence: The confluence of edge computing and artificial intelligence]

S Deng, J Yin, et al. Citations: 763



[Collaborative web service qos prediction with location-based regularization]

W Lo, J Yin, et al. Citations: 173

Organizers

Jianwei Yin

Professor

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Liqiang Lu

Assistant professor

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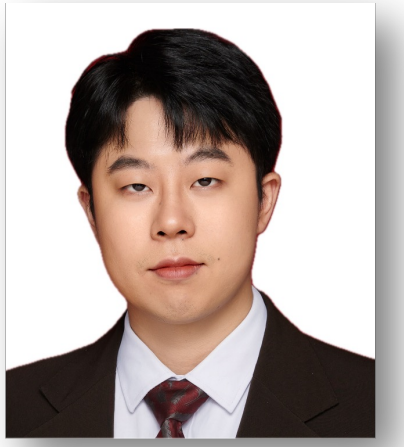


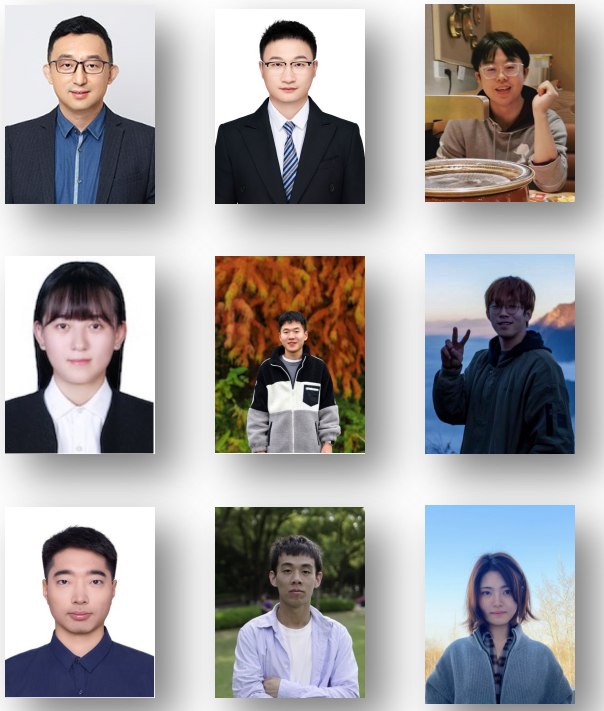
Siwei Tan

5-year PhD student

siweitan@zju.edu.cn

Advanced Computing and Emerging Service Lab

ACES Lab
ADVANCED COMPUTING AND EMERGING SERVICE LAB



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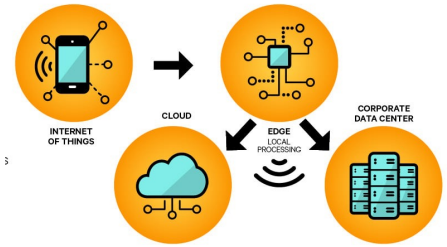
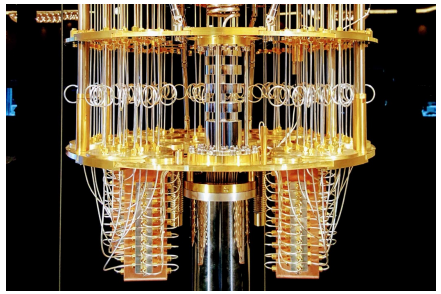
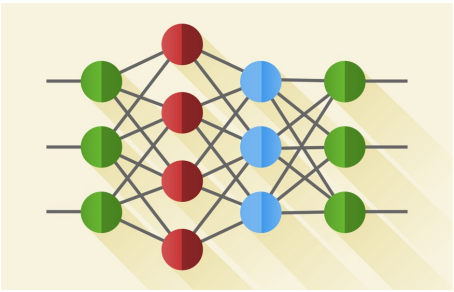
Advanced Computing and Emerging Service Lab (ACES Lab) in Zhejiang University is led by Professor Yin Jianwei. It consists of 28 teachers and 170 students from the College of Computer Science and Technique, Zhejiang University. The laboratory focuses on **quantum computing, edge computing, and artificial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



Edge computing



Quantum computing



Artificial intelligence

Agenda

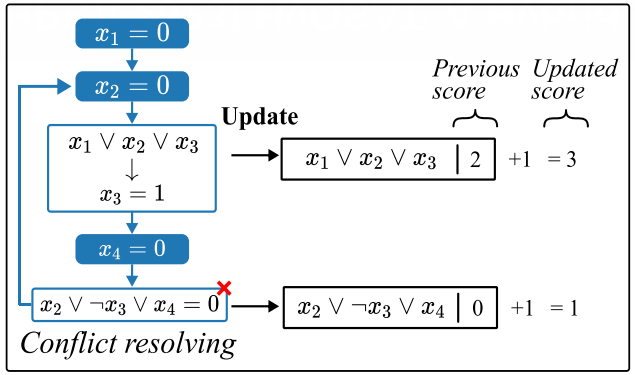
Topic	Presenter	Time
Topic-1. Overview of JanusQ 2.0 and Background of Quantum Computing	Jianwei Yin	0.5 hour
Topic-2. Installing JanusQ 2.0 and Using Janus quantum cloud platform	Liqiang Lu	0.5 hour
Topic-3. Janus-CT to optimize (a) Vectorization model using Janus-CT and code examples (b) Fidelity optimization using gate vectors (c) Unitary decomposition using gate vectors (d) Extending the framework by yourself: other downstream tasks!	Liqiang Lu	(1.0 hour) 0.25 hour 0.25 hour 0.25 hour 0.25 hour
Take a break		0.25 hour
Topic-4. Janus-FEM (a) Characterization of readout error (b) Readout calibration using Janus-FEM	Hanyu Zhang	(0.5 hour) 0.25 hour 0.25 hour
Take a break		0.25 hour
Topic-5. Implementing quantum applications (a) Introduction of SAT problem and time crystal (b) End-to-end speedup in domain problems based on quantum SAT solver (c) Simulate time crystal on the Janus quantum platform	Siwei Tan	(1.25 hour) 0.5 hour 0.5 hour 0.25 hour
Topic-6. Q & A	Siwei Tan	0.25 hour
Total		4.5 hours

Related Resources

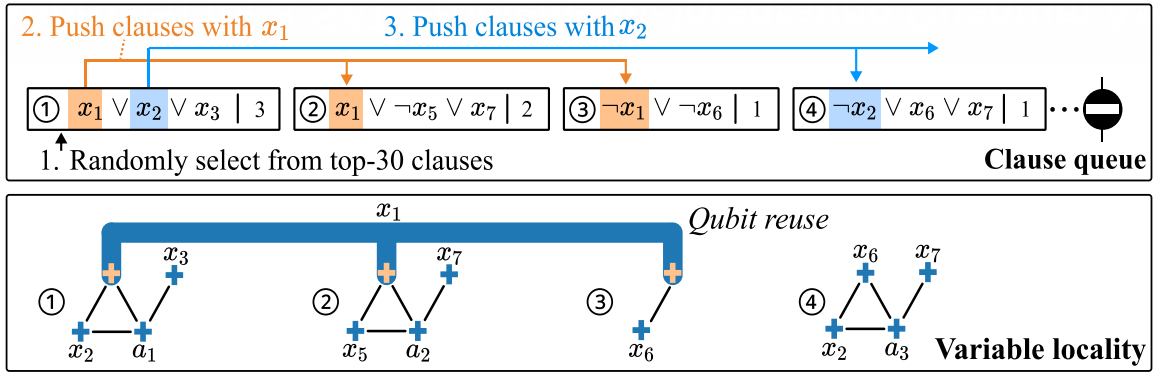
Topic	URL	QR Code
Source code	https://github.com/JanusQ/JanusQ	
Examples	https://janusq.github.io/tutorials/examples	
Slider	https://janusq.github.io/tutorials/resources	
Papers	https://janusq.github.io/tutorials/resources	

Related Works

[HPCA 2023] HyQSAT: A Hybrid Approach for 3-SAT Problems by Integrating Quantum Annealer with CDCL.



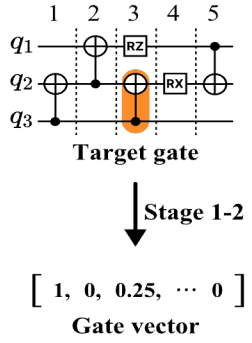
(a) Activity score updating

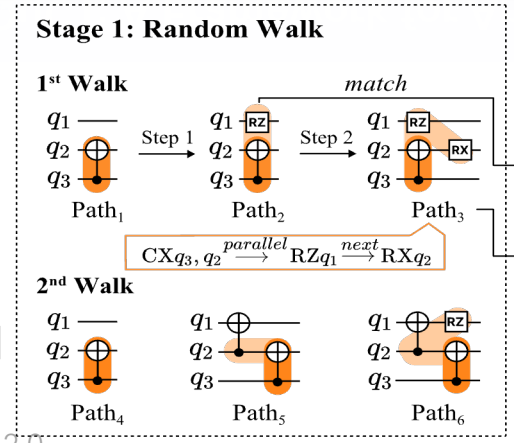


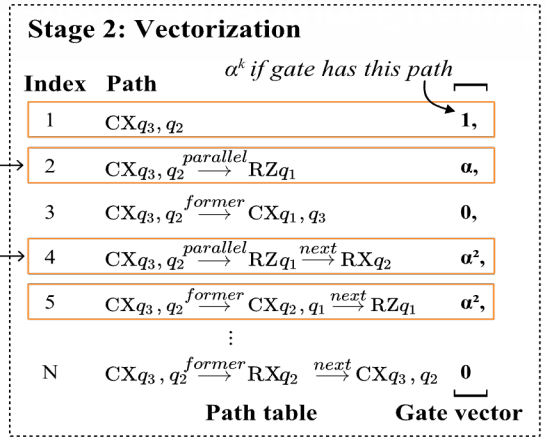
(b) Breadth-first traversal

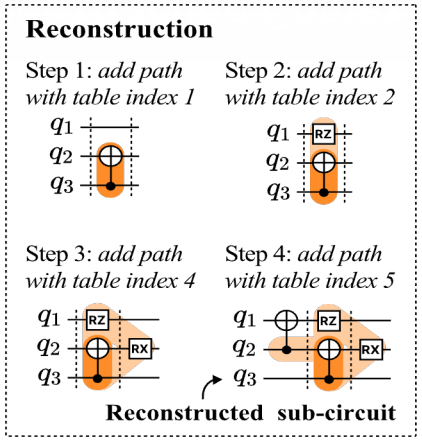
Achieve 4.2× speedup compared to the state-of-the-art SAT solver on 13 domain problems.

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





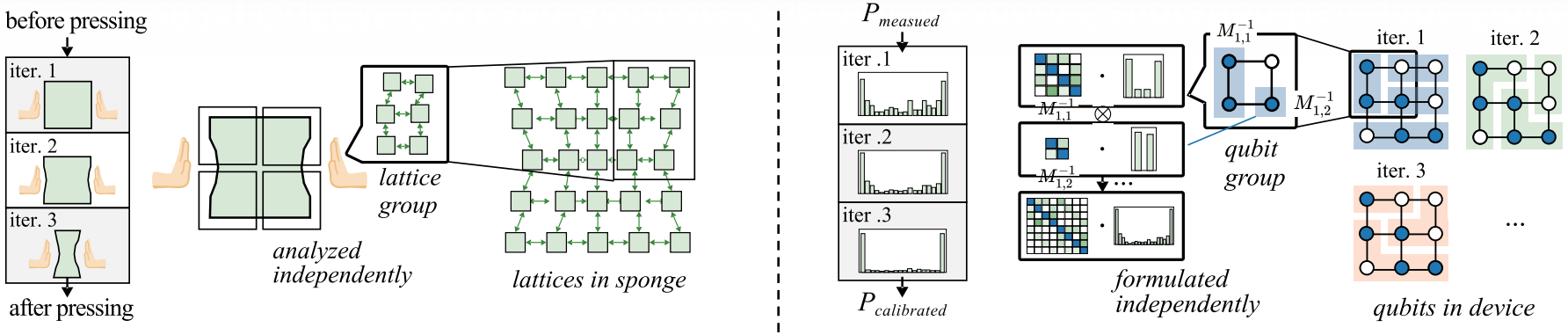




Reduce error by up-to 9.1× in noise mitigation and achieve 36.2 × speedup in unitary decomposition

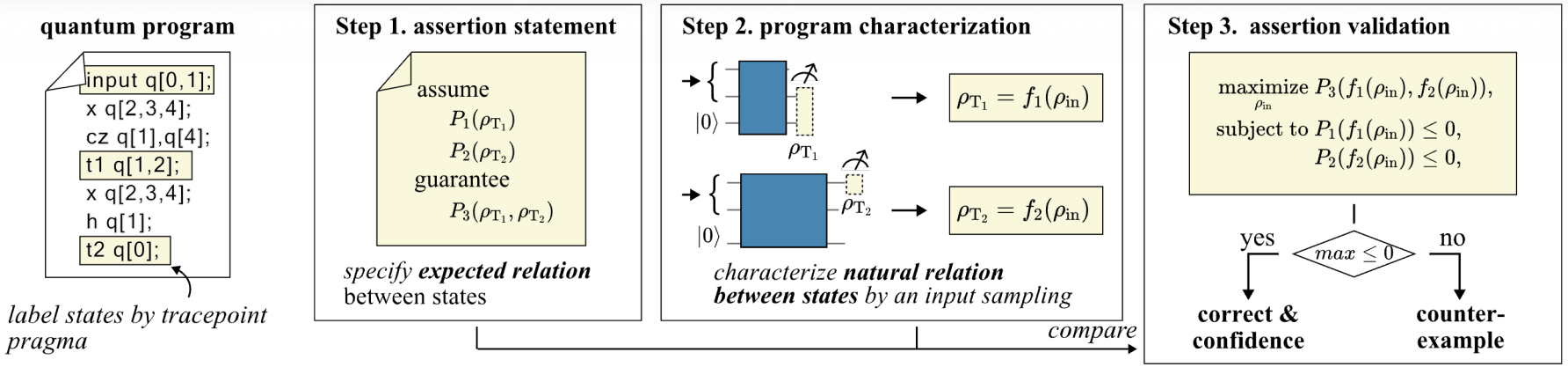
Related Works

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



Improve the scalability of readout calibration. Achieve 119.4× speedup in calibrating 136-qubit readout output.

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

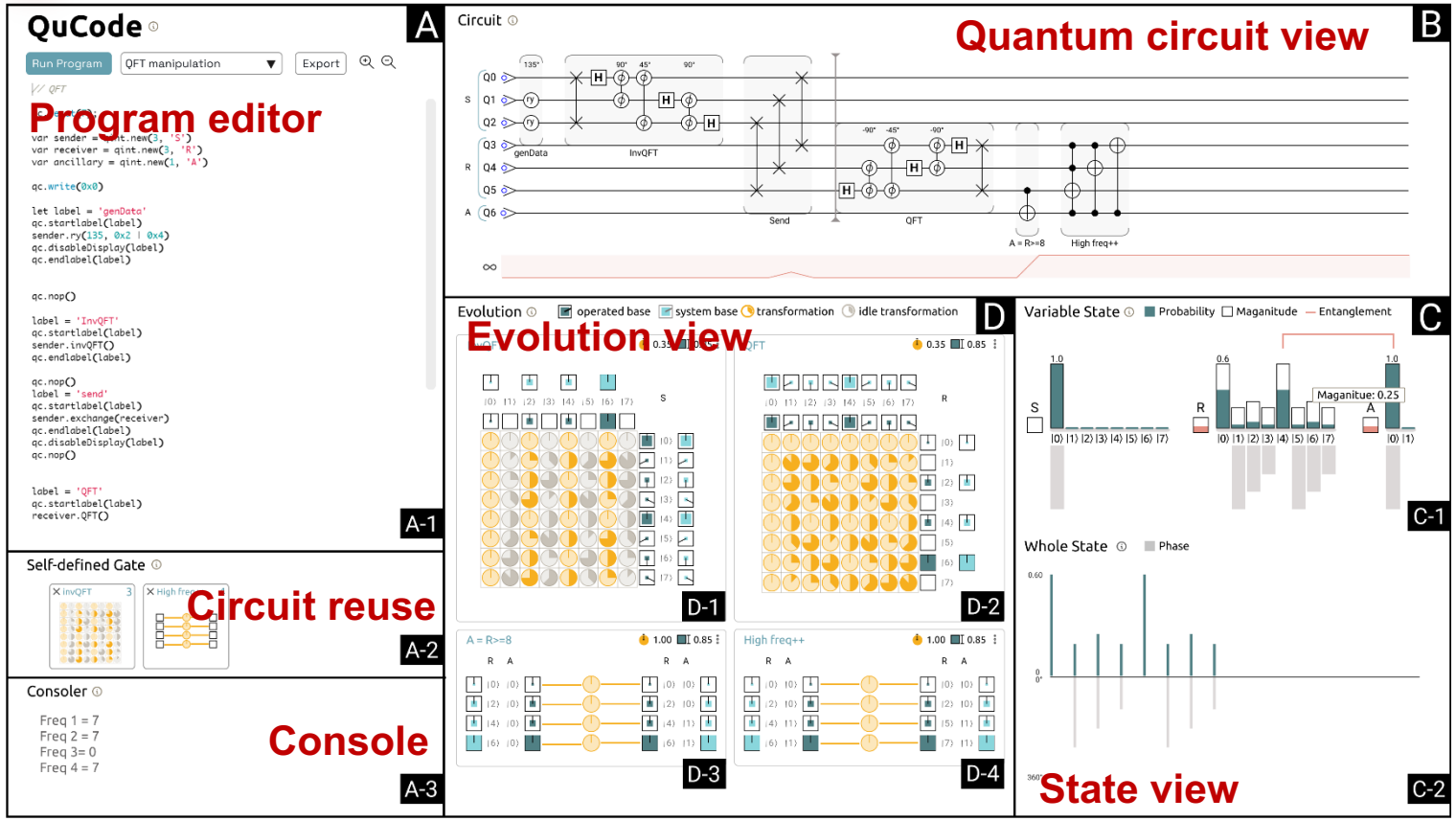


Provide a confident program verification framework and theoretical guarantee of its low complexity.

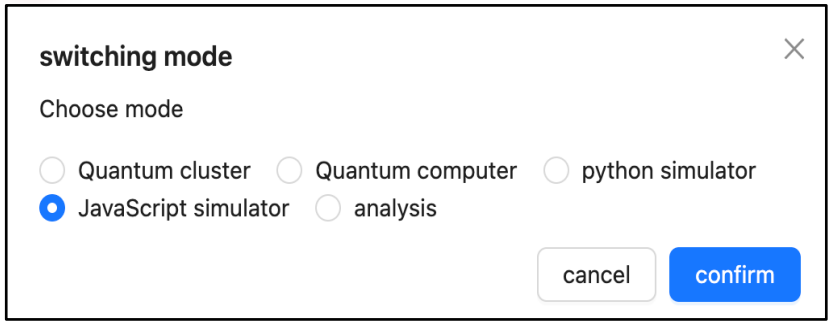
JanusQ Quantum Cloud

JanusQ provides an open-access to 36-qubit quantum hardware.

Coding interface of JanusQ

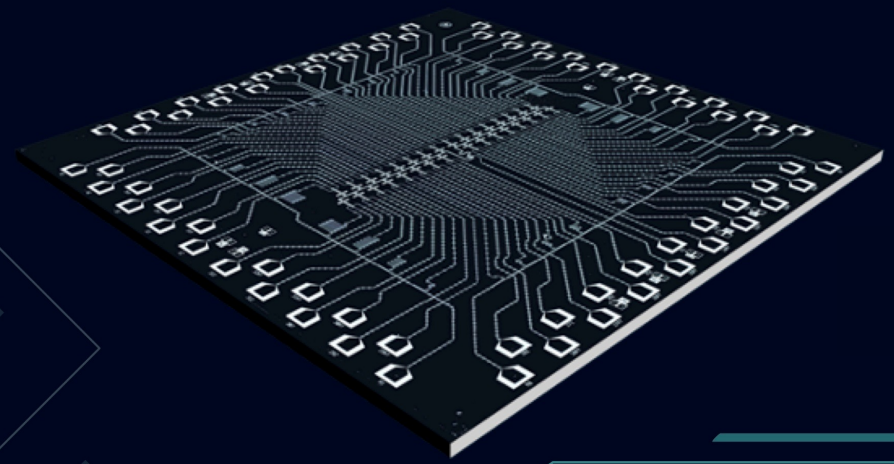


Execution modes



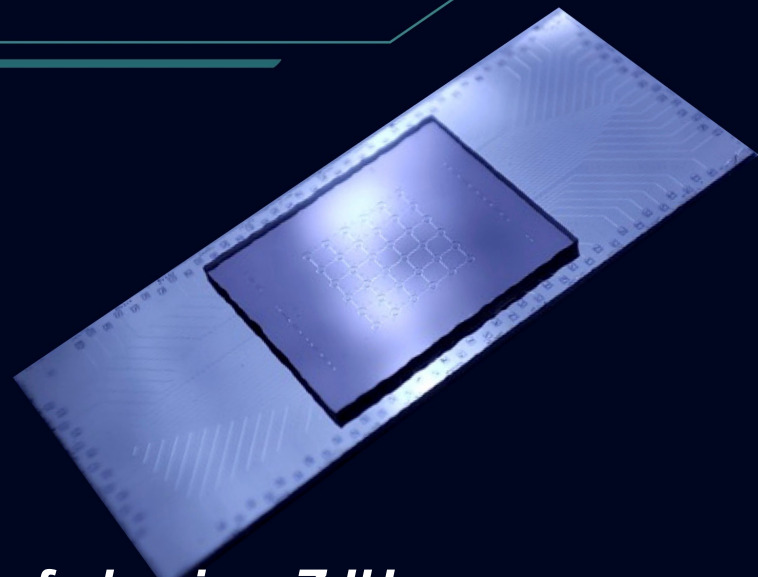
Provided quantum processors

Quantum Processor on JanusQ



Mogan

32 qubits/ 30μs relaxation time / Fully connected topology



Tianmu

36 qubits/ 100μs relaxation time/
60ns two-qubit gate time

Collaborate with the department of physics, ZJU

News of JanusQ Quantum Cloud

The laboratory was established

ACES

JanusQ Software

Software-hardware co-design system for 121-qubit hardware

JanusQ Software

JanusQ 2.0

- Compiler v2
- Distributed quantum Computing

JanusQ Adaptive Distributed Computing

2021/1

2022/7

2022/12

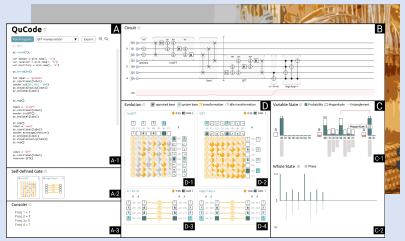
2023/2

2023/8

2023/11

JanusQ Quantum Cloud

36-qubit quantum hardware can be accessed on the cloud platform.



Hybrid quantum-classical SAT solver

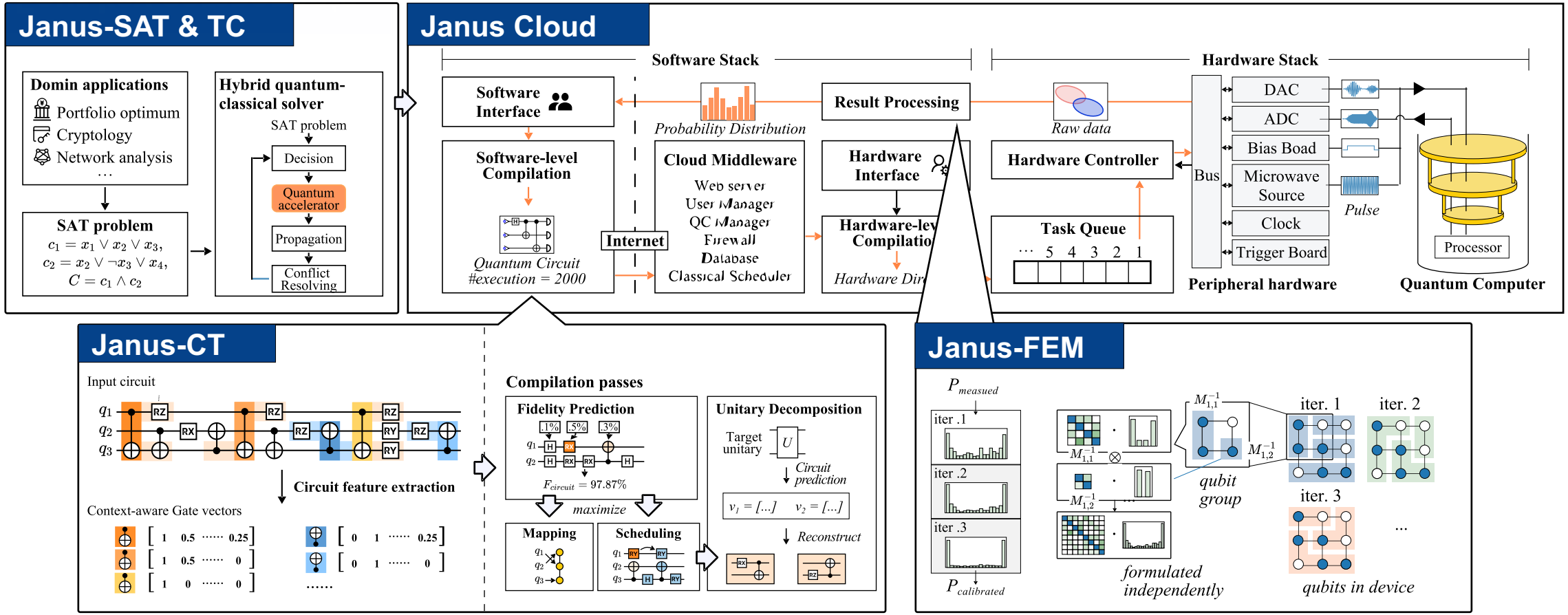
Revealed with JanusQ cloud in HPCA 2023

Topology-aware circuit optimizer

Revealed in MICRO 2023

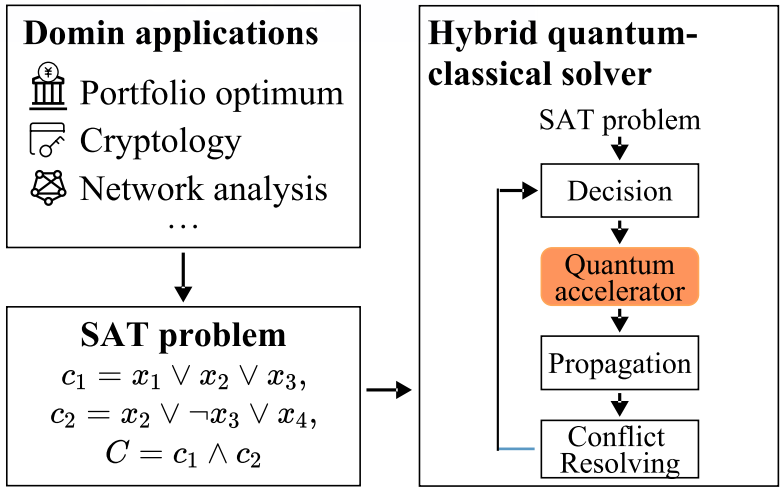
JanusQ Overview

Four key components



JanusQ Overview

Janus-SAT & TC



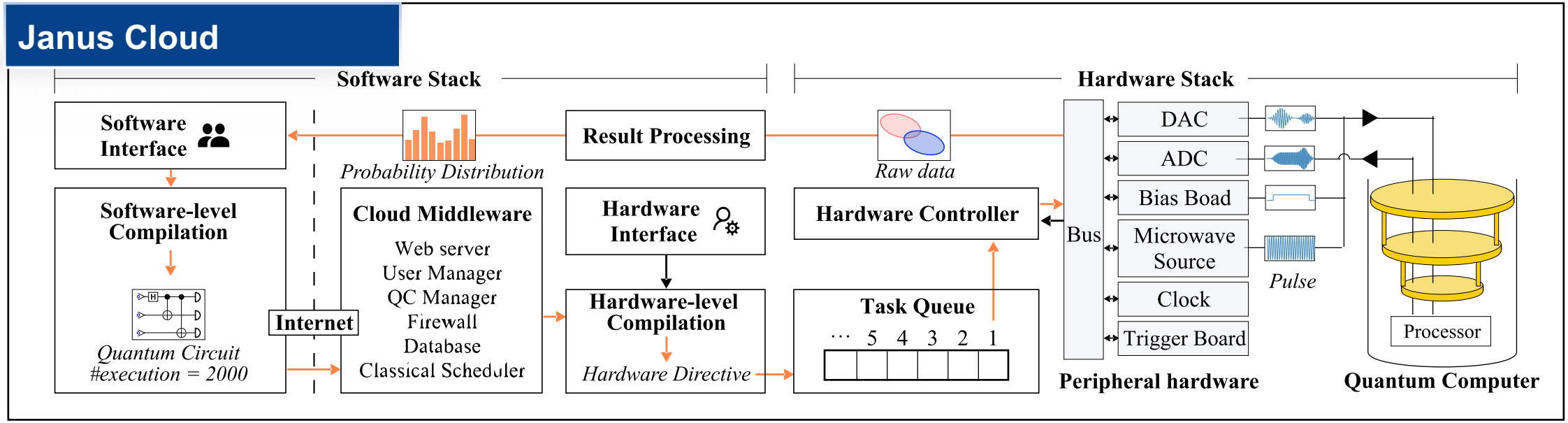
Janus-SAT: Hybrid Quantum-Classical SAT solver (HPCA 2023)

- What is the SAT problem? Why is it important?
- How to achieve 4.2× end-to-end speedup compared to the state-of-the-art SAT solver?

Janus-TC: Topological Time Crystal (Nature 2022)

- What is time crystal?
- How can a topological time crystal with high fidelity be simulated on JanusQ Cloud?

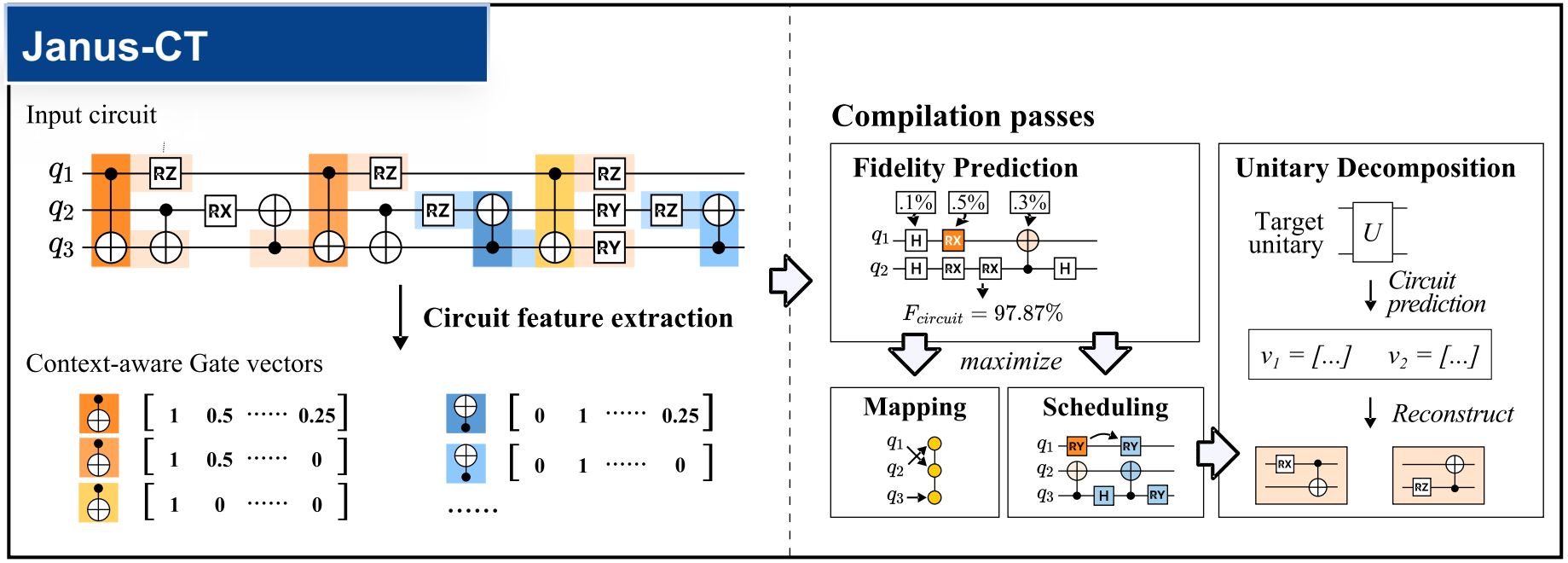
JanusQ Overview



Janus Cloud:

- 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?

JanusQ Overview

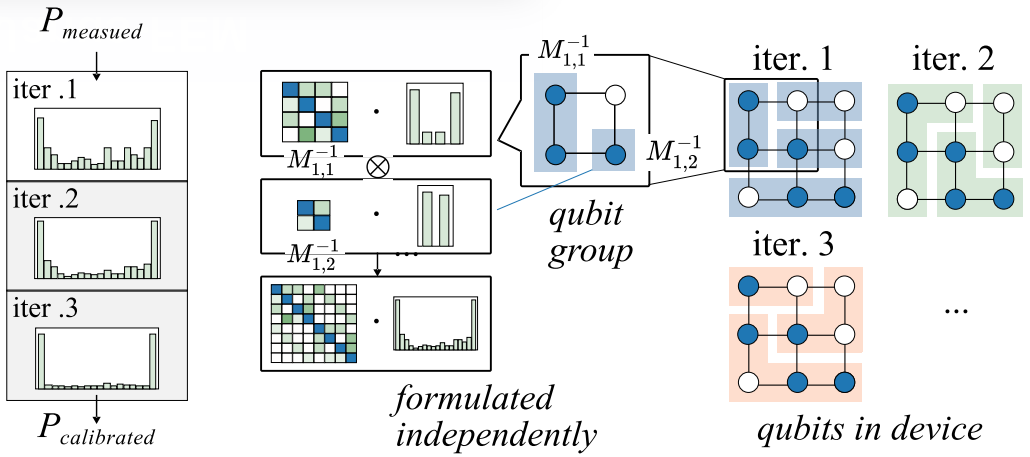


Janus-CT: Topology-aware quantum circuit optimizer

- 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?

JanusQ Overview

Janus-FEM



Janus-FEM: Readout Calibration based on finite element method

- 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?