Geometry-aware quantum cloud challenge

Hackathon overview



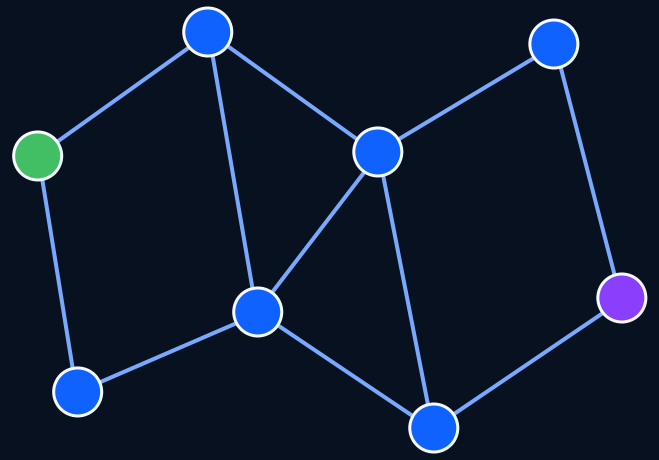
Qiskit Fall Fest 2026

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quanTA, University of Saskatchewan

Connectivity, routing and noise

Quantum circuits often require interactions between qubits that are not directly connected.

Routing introduces extra operations to realize those interactions. Under noise, these operations can reduce the quality of the result.



Two designated ports

quanTA research and the cloud context

Geometry and error protection

quanTA's research connects circuit diagrams and quantum error correction with questions about the geometry of physical implementations.

Hyperbolic superconducting architectures

Finite hyperbolic lattices motivate alternative patterns of connections and cycles. This challenge tests their consequences for routing and error-detection circuits.

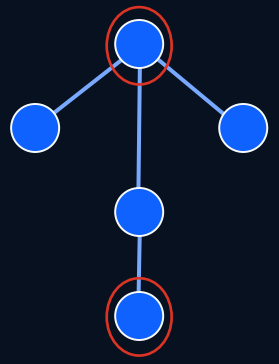
A decade of cloud access

IBM opened its five-qubit cloud processor in 2016. Qiskit now provides a common framework for comparing historical, contemporary and hypothetical processor models.

Three processor models

2016-inspired reference

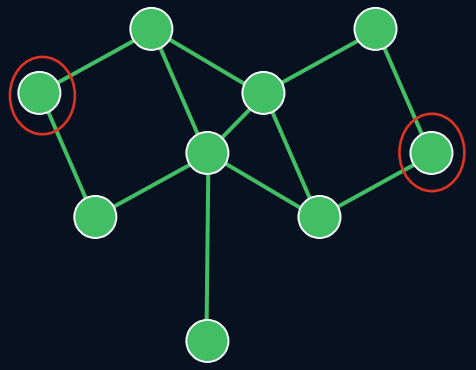
Five qubits



Five-node reference graph
Synthetic noise model

Contemporary IBM-style

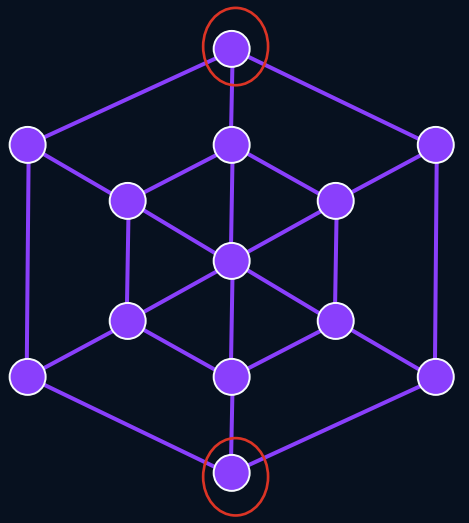
Backend snapshot or fake backend



Native target and gate set
Contemporary compilation baseline

Hyperbolic-inspired model

Finite lattice-derived coupling graph



Hypothetical qubit connectivity
Circuit-level model only

Challenge objective

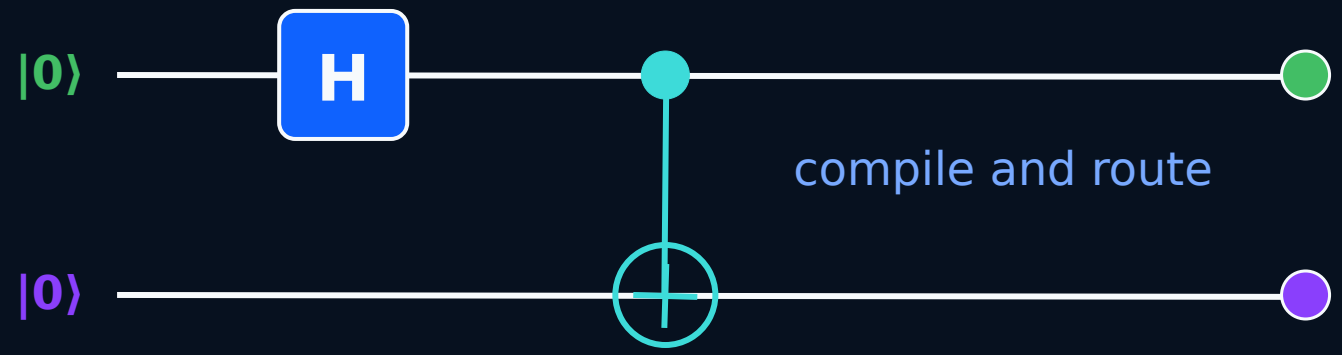
Create a verified Bell correlation between two designated ports on each processor model.

Establish an ideal and noisy baseline, then test one justified error-detection or protection strategy.

Compare the resulting fidelity with the circuit cost and any discarded shots. Explain the differences between the three architectures.

The Bell-correlation task

Target: $|\Phi^+\rangle = (|00\rangle + |11\rangle) / \sqrt{2}$ at two designated ports



Verification correlations

XX **YY** **ZZ**

Together, these estimate fidelity with the target Bell state.

A Bell pair gives a small, interpretable test of quantum coherence. Agreement in the Z basis alone would also occur for a classical mixture of 00 and 11.

Core comparison

Processor model	Ideal baseline	Noisy baseline	Noisy + protection
2016-inspired	Case 1	Case 2	Case 3
Contemporary IBM-style	Case 4	Case 5	Case 6
Hyperbolic-inspired	Case 7	Case 8	Case 9

For each model, compare the noisy baseline with the protected result and its additional cost.

Protection strategies

Parity or stabilizer checks

Additional measurements can reveal particular errors without directly measuring the encoded information.

Syndrome postselection

Keep outcomes that pass a specified check. Any improvement in conditional fidelity must be reported together with the fraction of accepted shots.

Geometry-aware encodings

More advanced teams can adapt an encoding or check network to the available connections, then measure its overhead.

Challenge rules

Common requirements

Use the common processor definitions, fixed output ports and noise assumptions.

Complete the three-model comparison and test one justified protection method.

Report reproducible results, including added operations and postselection yield.

Choices and extensions

Choose the layout, routing method and protection strategy.

Explore alternative noise models, larger circuits or geometry-aware encodings.

Keep optional studies and QPU results separate from the common benchmark.

Required measurements

Bell fidelity $F(\Phi^+) = [1 + \langle XX \rangle - \langle YY \rangle + \langle ZZ \rangle] / 4$

Measure	Report
Output quality	Bell fidelity with uncertainty
Circuit cost	Depth and number of two-qubit gates
Routing	SWAP overhead
Qubit use	Physical qubits, including ancillas
Postselection	Acceptance fraction and discarded shots

Approaches for different experience levels

Experience	Suggested approach	Main comparison
Explorer	Bell preparation and a simple error-detection check	Ideal, noisy and protected results
Builder	Placement, routing or improved checks	Fidelity benefit versus extra operations
Research	Geometry-aware encoding or stabilizer network	Scaling and sensitivity to noise

Interpreting the comparison

Noise and compilation

Relate changes in fidelity to the operations introduced by compilation and to the assumed noise model.

Protection overhead

Assess whether the protection method compensates for its extra gates, ancillas and discarded shots.

Architectural conclusions

Distinguish connectivity effects from differences in gate sets or noise. A result from one finite model does not establish a universal advantage.

Required submission materials

01	**Reproducible notebook**	Qiskit code, assumptions and recorded results
02	**Graphs and circuits**	The three coupling graphs with ports and the transpiled circuits
03	**Quantitative comparison**	Fidelity, circuit cost and yield across the core cases
04	**Scientific interpretation**	An explanation of the results and their limitations
05	**Hardware or software recommendation**	One specific design choice for future cloud systems, supported by your results

Judging rubric

