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Hackathon Teaser: “Quantum Catan Challenge”

Can quantum computers build empires?

Trade, build, and optimize your way to victory — but this time, your tools aren’t dice and cards... They're **qubits** and **Hamiltonians**.

In this year’s Quantum Computing Hackathon, you’ll enter the world of *Mini-Catan*: a compact, strategy-rich version of the classic board game where every decision — from road building to resource trading — hides a deep optimization problem.

Your mission? Harness the power of quantum algorithms to outsmart chance, balance resources, and find the best moves in a world ruled by probability.

Whether you’re optimizing the perfect settlement spot, finding the longest road, or building a quantum-enhanced trading agent — creativity, ingenuity, and entanglement are your greatest allies.

❗ No prior Catan experience required. Just bring your curiosity, your favorite quantum framework, and a few well-placed qubits.

⚡ *Think you can build the future of quantum strategy?*

Quantum Catan Challenge – Overview

In this track, participants will explore how **quantum algorithms can optimize strategic decisions** in a simplified version of *Settlers of Catan*.
Each mini-challenge corresponds to a classic sub-problem in combinatorial optimization and resource management — ideal for algorithms such as **QAOA (Quantum Approximate Optimization Algorithm)**, **VQE (Variational Quantum Eigensolver)**, or hybrid quantum-classical heuristics.

After completing the core tasks, teams are encouraged to go beyond and design their own creative extensions — such as multi-agent simulations, learning-based strategies, or hybrid reinforcement learning.

🏠 Problem 1: Quantum Settlement Planner

Theme: Optimal resource placement using quantum optimization
Core Algorithm: QAOA / VQE
Difficulty: Medium

Background

In *Mini-Catan*, settlements produce resources based on dice rolls and adjacency to terrain tiles.
Your task is to place **two (or more?) settlements** on a small hex board to **maximize expected resource yield**.
Each tile produces one of five resources — brick, wood, grains, ore, sheep — when the sum of the 2 dice matches their tile number (2–12).

Objective

Formulate settlement placement as an **optimization problem**:

- Binary variable = 1 if a vertex hosts a settlement
- Constraints: settlements must be at least 2 edges apart
- Objective: maximize the weighted sum of resource values accessible to each settlement
- Optional: add bonuses for resource diversity

Use **QAOA or VQE** to find the best configuration.

Expected Deliverables

- Quantum encoding (graph vertices → qubits)
- QAOA/VQE implementation and comparison with a classical baseline
- Visualization of the optimal settlement placements
- Optional: Creative extensions (multi-player fairness, probabilistic yields)

🛣️ Problem 2: The Quantum Longest Road

Theme: Path finding and connectivity optimization
Core Algorithm: QAOA / Quantum Annealing
Difficulty: Medium–High

Background

In *Catan*, the “Longest Road” is a key milestone — a continuous sequence of connected roads that earns extra points.
In this quantum variant, you’re given a reduced Catan road network (e.g., 8–12 possible road edges) and a limited number of road pieces to place.

Objective

Find the **longest connected path** you can build while respecting:

- Resource constraints (e.g., only 6 road segments available)
- Blocked edges representing rival players’ roads

Model this as a **Max Path problem** or **MaxCut-like Hamiltonian** and use QAOA to find the optimal configuration.

Expected Deliverables

- Quantum graph encoding (edges as qubits)
- QAOA or hybrid approach to maximize connected path length
- Comparison with a classical heuristic (DFS or greedy expansion)
- Optional creativity: dynamic updates (adding/removing roads) or probabilistic obstacles

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🌾 Problem 3: Quantum Resource Trader

Theme: Resource optimization under constraints
Core Algorithm: QAOA / Grover / Hybrid Classical-Quantum
Difficulty: Medium

Background

Building settlements and roads in *Catan* requires smart resource management and trading. Given an inventory of resources (wood, brick, ore, wheat, sheep) and a list of possible trades or builds, you must decide **which actions to execute** to **maximize your score**.

Objective

Model the problem as a **quantum knapsack**:

- Each action (build/trade) = binary decision variable
- Each consumes certain resources and gives points

- Constraint: total resource availability must not be exceeded
- Objective: maximize total points

Use **QAOA, Grover's search**, or hybrid methods to find feasible and optimal build/trade plans.
Optionally, explore **stochastic extensions**, where trade outcomes are probabilistic.

Expected Deliverables

- Encoding of resource constraints and actions into qubit space
- Quantum optimization algorithm implementation
- Benchmark vs. classical integer programming baseline
- Optional: creative economic extensions (dynamic trades, quantum negotiation protocols)

Open Creative Phase — *Catan Quantum Sandbox*

After completing the three core challenges, teams can:

- Combine problems into a **full quantum Catan agent**,
- Formulate and solve other **Catan Optimization Problems**,
- Explore **multi-player equilibria** using quantum game theory,
- Implement **hybrid quantum reinforcement learning**, or
- Visualize **quantum-assisted strategy exploration**.

Deliverables

- Jupyter notebook(s) with clear code and explanations.
- Short presentation summarizing approach, visualization, and insights.
- Creativity and clarity are valued more than raw performance!

Closing Note

This challenge is about more than optimizing settlements and roads — it's about exploring how quantum computing can reshape strategy itself.

Build the smartest, most resourceful, and most inventive quantum approach to Catan — and maybe, uncover strategies no classical player has ever imagined.

Evaluation Criteria

Criterion	**Weight**
Optimization Performance	**35%**
Quantum Implementation	**30%**
Creativity & Data Augmentation	**20%**
Presentation & Clarity	**15%**

Relevant Resources

If you're new to quantum programming or need a quick refresher on qubits, superposition, and basic circuits, start with the **Hello World Quantum Computing** tutorial. It covers essential concepts to get your first quantum program running.

If your solution involves **optimization on graphs** — for example, finding the best cut or partition — check out the **QAOA Tutorial on MaxCut**, which demonstrates how the Quantum Approximate Optimization Algorithm can tackle discrete combinatorial problems.

If your problem deals with **molecular structures** or **ground-state energy estimation**, explore the **Variational Quantum Eigensolver (VQE)** tutorial. It shows how hybrid quantum–classical methods can compute molecular energies, serving as a bridge between chemistry and quantum optimization.

If your solution leans toward **quantum-enhanced machine learning**, the **Variational Quantum Classifier (VQC)** tutorial will guide you through building and training a simple quantum classifier using parameterized circuits and classical optimization.

Finally, check **IBM Quantum Learning** for more resources, courses and tutorials.