Amaravati Quantum Valley Hackathon 2025

TITLE PAGE

- **Problem Statement ID – AQVH919**
- **Problem Statement Title- Quantum path planning for Delivery Vehicles**
- **Theme- Logistics: Fleet Optimization**
- **PS Category- Software**
- **Team ID- C-26817/230377165066**
- **Team Name - Hexaholics**

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IDEA TITLE

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❖Proposed Solution

Proposed Solution:

- Build a **quantum-enhanced path planning system** for delivery vehicles.
- Encode the Vehicle Routing Problem (VRP) into a **QUBO model**.
- Use **QAOA (Quantum Approximate Optimization Algorithm)** to find efficient routes.

How it addresses the problem:

- Optimizes delivery routes → reduces **time, cost, and fuel usage**.
- Handles **complex fleet logistics** better than classical heuristics.
- Enables **scalable and efficient** planning for large delivery networks.
- Lays foundation for **quantum advantage** in real-world logistics.

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TECHNICAL APPROACH

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Technologies to be used:

- **Languages/Frameworks:** Python, Qiskit, PennyLane, NumPy, Pandas
- **Quantum Techniques:** QAOA(Quantum Approximate Optimization Algorithm), QUBO Formulation

Methodology / Process:

- **Input Data** – Delivery locations, fleet size, traffic constraints.
- **Preprocessing** – Build distance matrix, apply clustering to reduce complexity.
- **Problem Encoding** – Formulate Vehicle Routing Problem (VRP) as **QUBO**.
- **Quantum Optimization** – Apply **QAOA** on quantum simulator/hardware.
- **Benchmarking** – Compare results with classical solvers (e.g., OR-Tools).
- **Visualization** – Plot optimized delivery routes and efficiency gains.

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FEASIBILITY AND VIABILITY

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Feasibility:

- Available Tools – Qiskit, PennyLane, D-Wave, and open VRP/TSP datasets.
- Prototype's – Small-scale problems can be solved on quantum simulators.

Challenges & Risks:

- **Scalability** – Limited qubits restrict large VRP instances.
- **Quantum Noise** – Hardware errors may affect solution quality.
- **Classical Dependency** – Preprocessing and clustering still rely on classical methods.

Overcoming Challenges:

- **Hybrid Models** – Combine classical preprocessing with quantum optimization.
- **Incremental Scaling** – Start with small delivery networks, expand gradually.
- **Efficient Formulation** – Use clustering and heuristics to simplify QUBO encoding.

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IMPACT AND BENEFITS

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Impact:

- **Logistics Companies** – Reduced fuel cost, faster deliveries, higher efficiency
- **E-commerce & Retail** – Improved customer satisfaction with timely deliveries.
- **Society** – Lower traffic congestion and carbon emissions.

Benefits:

- **Social:** Faster, reliable deliveries → improved customer experience.
- **Environmental:** Reduced fuel consumption & emissions → greener logistics.
- **Economic:** Lower operational costs → higher efficiency & savings.

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RESEARCH AND REFERENCES

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- **Qiskit Optimization Documentation** – https://qiskit.org/optimization
- **Google OR-Tools (Classical Benchmarking)** – https://developers.google.com/optimization
- **Research Paper:** *Quantum Approximate Optimization Algorithm (QAOA)*
- **Research Paper:** *Quantum Optimization for Vehicle Routing*