Q-SMART

Quantum-Spatial Mesh Assignment with Resolution Tuning

Contents

01 MVP 1

Identifies the optimum number of claim handlers at each skill level (1-5)

Matches handlers with claims of varying severity levels (1-5)

Accounts for geographic distribution of claims

Optimizes for fastest resolution time within cost constraints

Incorporates the cost formula: Total = X + 200*(n-1) where n is days in location

Uses actual tornado claim data for realistic optimization

02 MVP 2

Make real-time adjustments of assignments as new claims arrive

Adapt to changing conditions and claim patterns

Incorporate on-site vs. virtual claim handling requirements

Factor in drive time impacts on productivity (20% loss per 30 minutes)

Integrate geographic clustering to minimize travel between claims

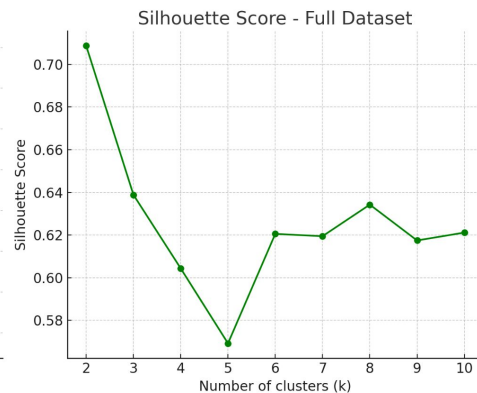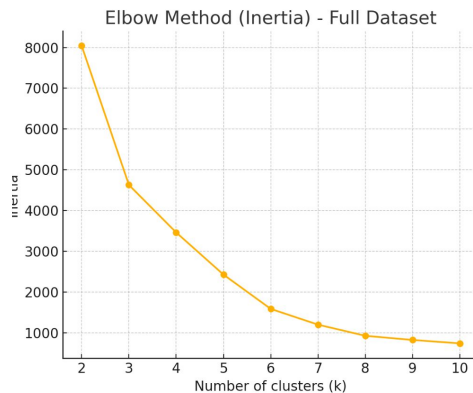Maintain 90% resolution within target timeframes while minimizing costs

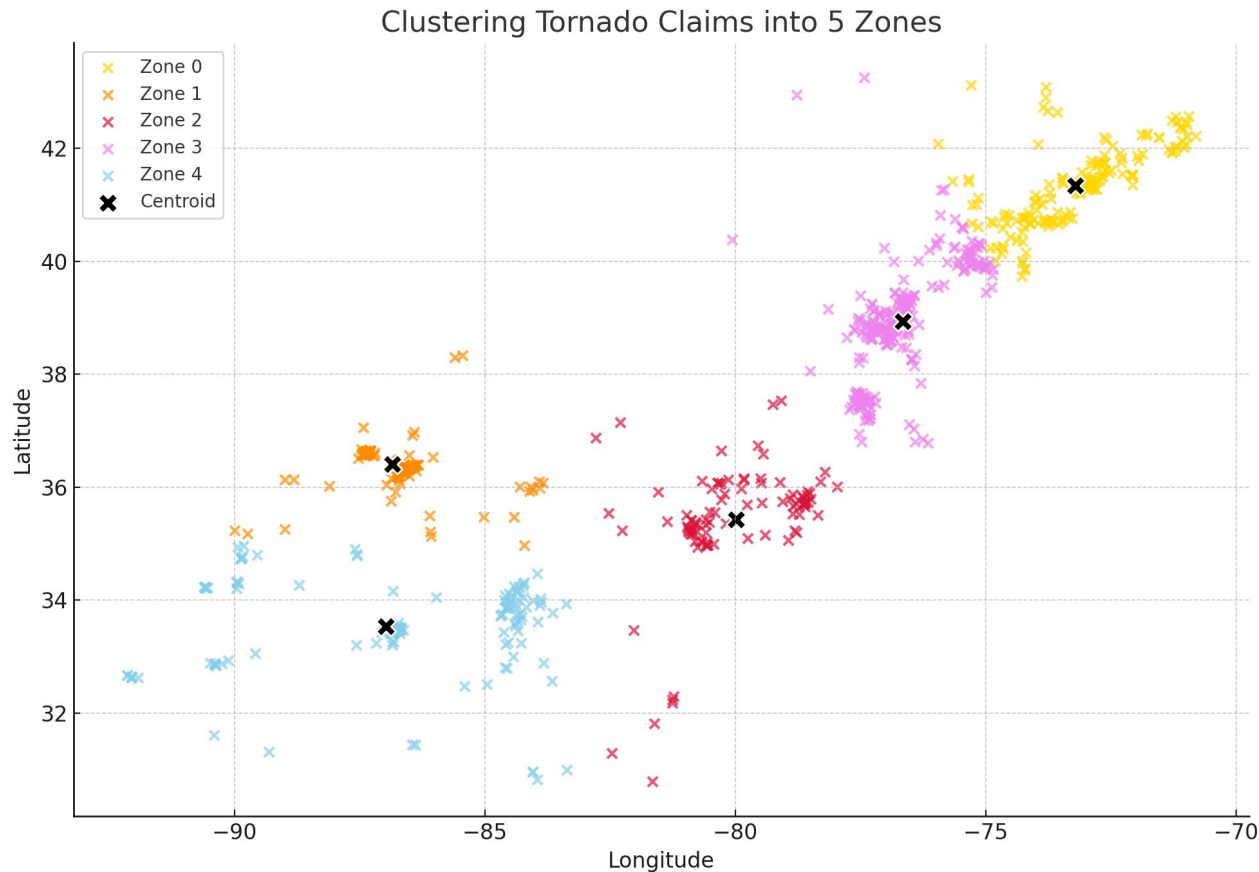# MVP

Optimal Handler Staffing Model
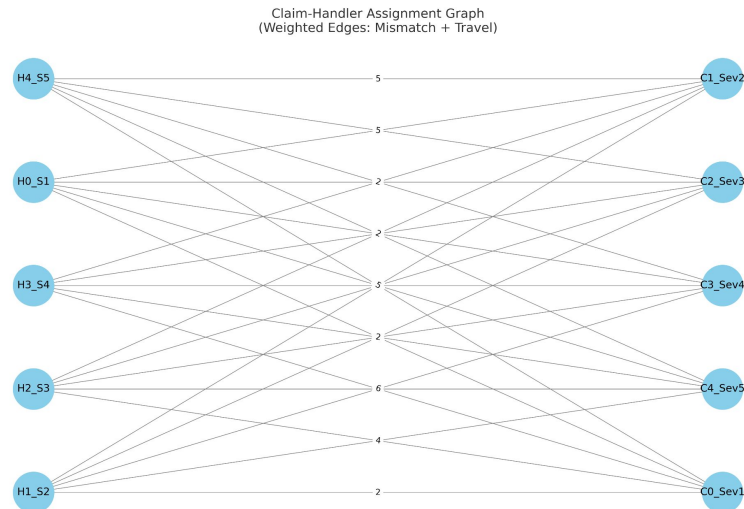
QUBO Formulation

$$\text{Minimize} \quad \sum_{i<j} d_{ij} \cdot x_i x_j - \lambda \sum_i x_i$$

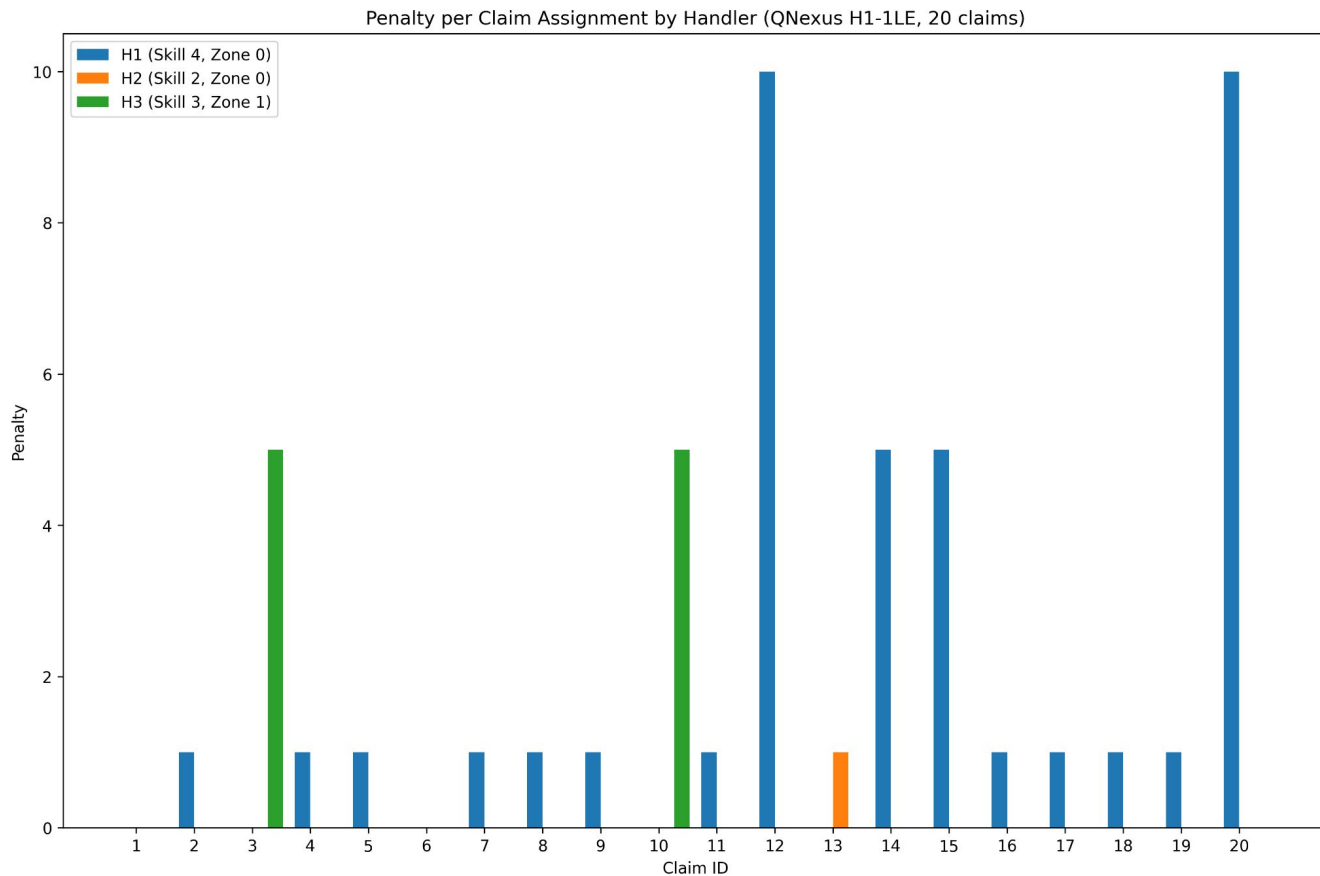$$\text{Subject to:} \quad \sum_i x_i = k$$

Elbow Method (Inertia) - Full Dataset

Silhouette Score - Full Dataset

| QUBO | $\Rightarrow$ | Quantum Circuit | $\Rightarrow$ | Optimal Binary Solution |

Clustering Tornado Claims into 5 Zones

- Formulate handler-chain assignment as a ***graph***:
- Nodes: handlers * skill level
- Edges: potential assignments weighted by
  - productivity
  - claim severity compatibility
  - travel penalty

- Quantum Approximate Optimization Algorithm (QAOA) to find optimal matching

- Not just solving a binary yes/no QUBO, we are modelling relationship quality in assignments.

Claim-Handler Assignment Graph
(Weighted Edges: Mismatch + Travel)

Penalty per Claim Assignment by Handler (QNexus H1-1LE, 20 claims)

$$\text{Zone Load Capacity} = \sum_{\text{severity}} (\text{Claim Count}_s \times \text{Productivity}_s \times \text{Resolution Time}_s)$$

$$\text{Minimize:} \quad \sum_{i<j,z} w_{ij} x_{i,z} x_{j,z} + \lambda \sum_z \left(\sum_i w_i x_{i,z} - T \right)^2$$

If workload > threshold, we allow lower-skilled handlers to pick up more severe claims with penalty-adjusted productivity.
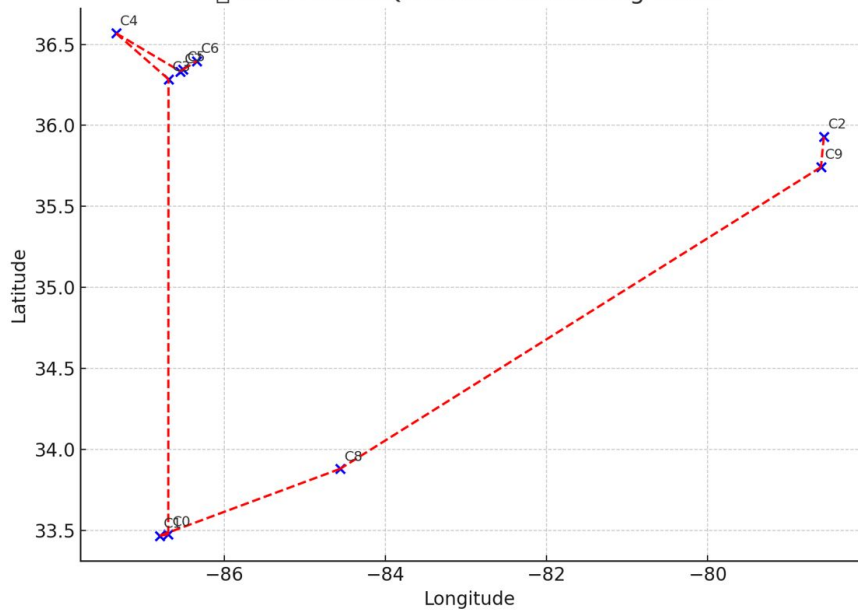
(ex. Skill 3 handler assigned a Severity 4 → incurs productivity penalty (e.g. 0.75x efficiency))

Top 10 Handlers' Workload Before and After Optimization
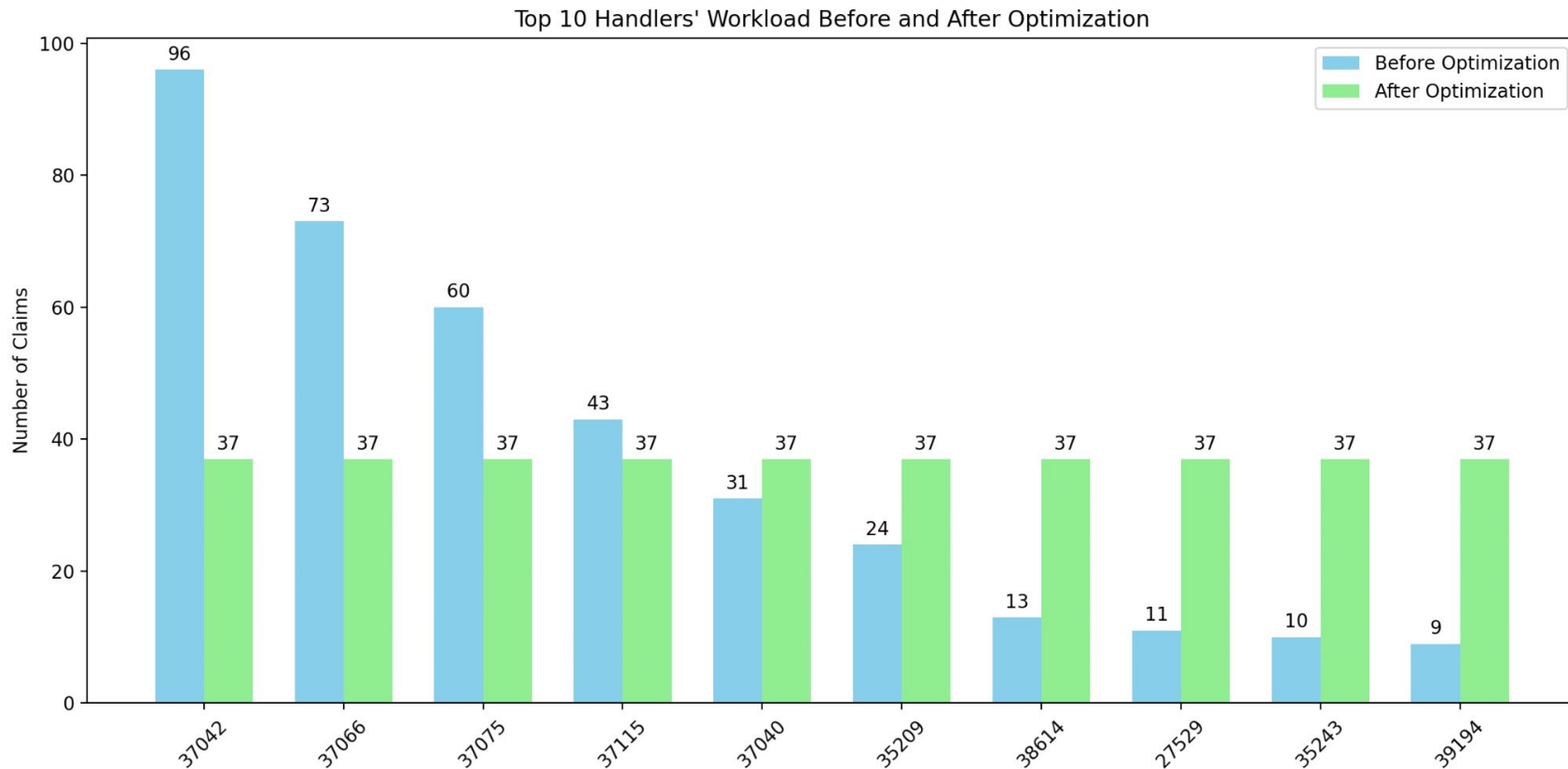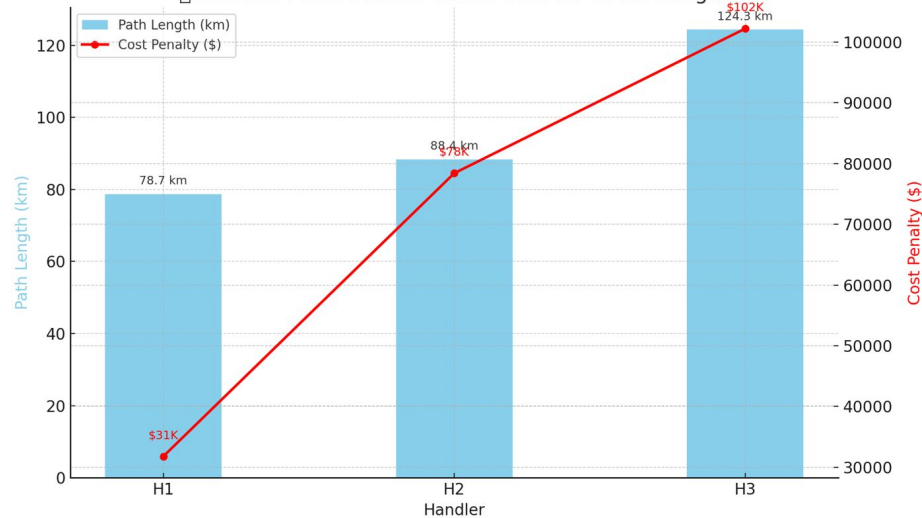
Cost-Aware Quantum Pathfinding Route

Handler Performance: Travel Cost vs. Route Length

$$\text{Effective Productivity} = \text{Base Rate} \times (1 - 0.2 \times \text{DriveTime}_{\text{hrs}}/0.5)$$

|	Handler	Num_Claims	Euclidean_Path_Length	Estimated_Travel_Hours	Productivity_Loss_%	Cost_Penalty_$
0	H1	160	78.71	157.42	6296.73	31800
1	H2	393	88.36	176.72	7068.83	78400
2	H3	512	124.33	248.65	9946.14	102200

```python
claims_df['mode'] = np.where(claims_df['severity'] >= 3, 'on-site', 'virtual')
```

Claim Type	Productivity Score	Travel Penalty	Travel Cost	Assignment Restriction
Virtual	Use standard productivity from matrix	❌ Not applicable	❌ None	✅ Allowed (no geographic constraint)
On-site	Adjust productivity ↓ based on distance: `1.0 - 0.2 × (distance / 30)`	✅ Yes (20% loss per 30 mins)	✅ Add to QUBO cost function	✅ Restrict if distance > max allowed threshold (e.g., 60 mins)

- Multiple solutions simultaneously **(quantum superposition)**
- Solution space grows exponentially with the number of handlers, skills, and claim types **(~ Hilbert space growth)**

Quantum Advantage in Skill-Matching for Insurance Claims

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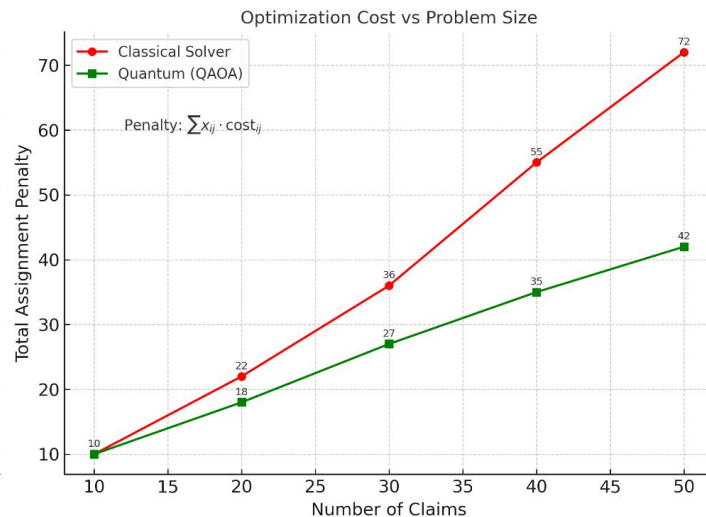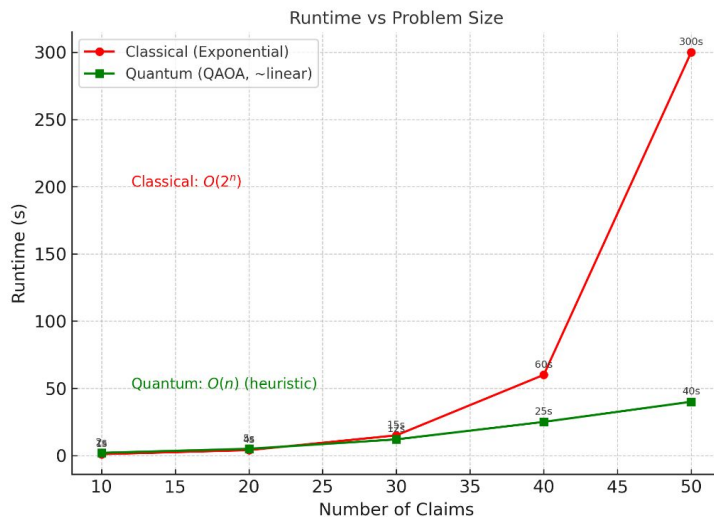
[1] Matsumoto, Nasa, et al. "Distance-Based Clustering Using Qubo Formulations." Nature News, Nature Publishing Group, 17 Feb. 2022, www.nature.com/articles/s41598-022-06559-z.

[2] Otterbach, J. S., et al. "Unsupervised Machine Learning on a Hybrid Quantum Computer." arXiv preprint, Cornell University, 5 Dec. 2017, https://arxiv.org/abs/1712.05771.

[4] Cerezo, M., et al. "Variational Quantum Algorithms." Nature Reviews Physics, vol. 3, no. 9, 11 Aug. 2021, pp. 625-644, https://www.nature.com/articles/s42254-021-00348-9.

[5] Phillipson, F. "Quantum Computing in Logistics and Supply Chain Management: An Overview." arXiv preprint, Cornell University, 27 Feb. 2024, https://arxiv.org/abs/2402.17520.