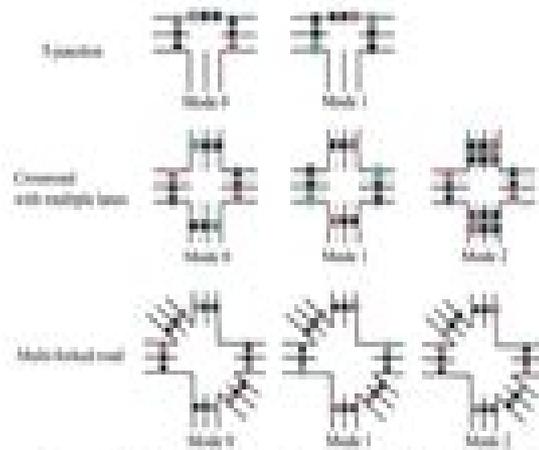


# Traffic Signal Optimization using Quantum Annealing

## Intersection State Definitions

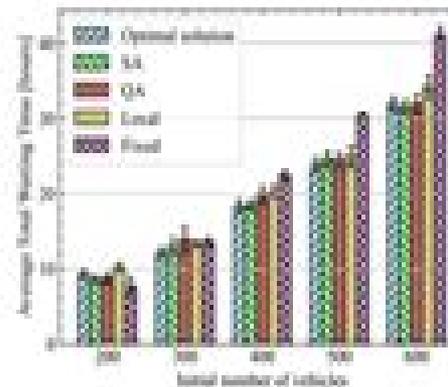


## QUBO Formulation

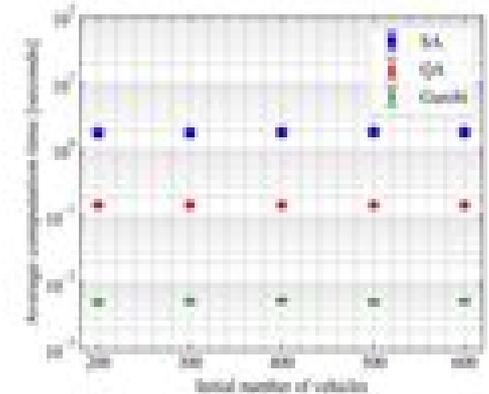
$$\min_{\vec{x}} H(\vec{x}) = - \sum_{lm} C_{lm} x_{lm} - \beta \sum_{(lm, jn)} B_{ij} R_{lm, jn} x_{lm} x_{jn} - \gamma \sum_l \left( \sum_m x_{lm} - 1 \right)^2$$

## Results

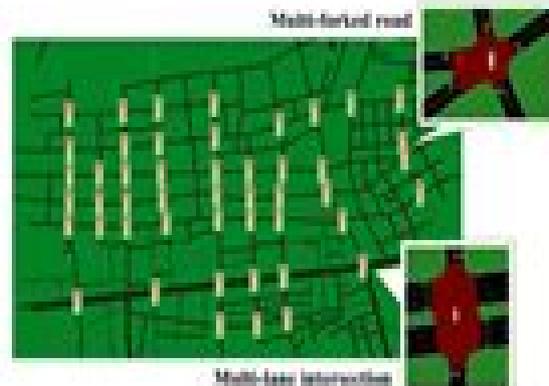
### Total Waiting Time



### Computation Time



## Real-World Map Used in Simulation



### Efficient Traffic Signal Optimization:

The QUBO model reduces vehicle waiting times at complex intersections, achieving a reduction of up to 28.9% in high-traffic scenarios.

### Quantum vs. Classical Solver Performance:

Owing to hardware limitations, D-Wave quantum annealer is currently less accurate and slower than classical solvers such as Gurobi.

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