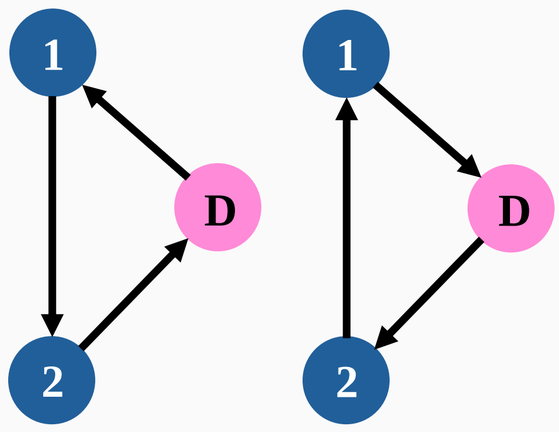
Quantum vs Classical in Solving the Vehicle Routing Problem

A comparative analysis of classical and quantum techniques in solving the Vehicle Routing Problem (VRP), a well-known *NP*-hard problem.

What is the VRP?

The goal is to find the route with the lowest cost to serve all customers with a given number of vehicles.



Algorithms

Classical Methods

- Branch and Bound (B&B)
- Simulated Annealing (SA)

Quantum Methods

- Quantum Approximate Optimisation Algorithm (QAOA)
- Variational Quantum Eigensolver (VQE)

Research Aims

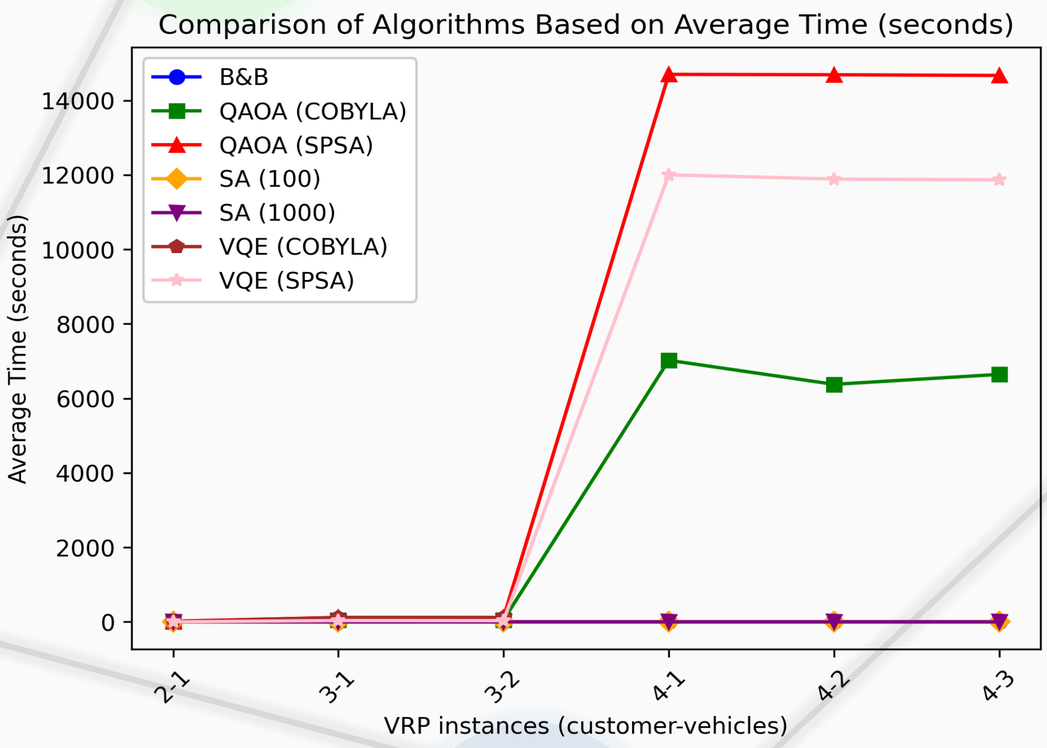
- Determine how the performance of QAOA and VQE differ from that of B&B and SA as the complexity of VRP instances increases.
- Analyse the potential impact on performance of optimiser choice for quantum methods.

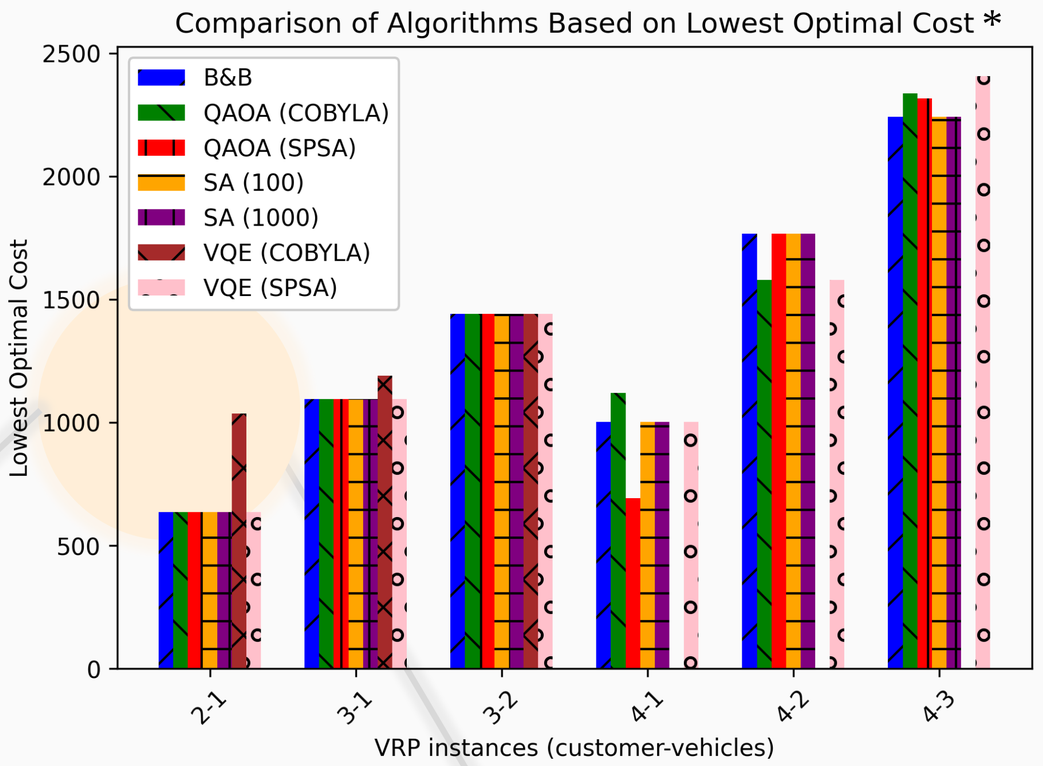
Performance Metrics

- **Solution quality**: the total cost of the optimal route identified
- **CPU time**: duration each algorithm takes to solve
- **Scalability**: maximum problem size able to be solved
- **Feasibility**: proportion of problem instances that meet all problem constraints
- **Success rate**: how often solutions within certain thresholds of the best solution are produced

Summary of Results

Experimental results reveal that SA excels in computational time and scalability, while maintaining a high Success Rate (SR). B&B consistently achieves the lowest optimal costs, creating a benchmark for the other algorithms. Both classical algorithms produce 100% valid solutions, while QAOA and VQE produced some infeasible routes. Quantum algorithms are less scalable than their classical counterparts. The different optimisers affect the quantum algorithms' performance across all metrics, but not enough to compete against classical algorithms.





* All costs produced by algorithms that seem to be below the cost produced by B&B are infeasible

University of Cape Town
Department of Computer Science
www.sit.uct.ac.za

Ben Cleveland: BNJCLE001@myuct.ac.za
Tayla Rogers: RGRTAY001@myuct.ac.za
Supervised by **Krupa Prag**: krupa.prag@uct.ac.za