Feasibility of Quantum for Transport Management

How feasible are Quantum Computers for solving current optimization problems of Transport Management Systems.

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INSIDE

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Travelling Salesman Problem

Extending the problem for a simplified version of a logistic problem and how Quantum can provide us with a heuristic approach to it.

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Christofide's Algorithm

Solving the Travelling Salesman's Problem on a Quantum Computer using the Christofide's Algorithm in much better time

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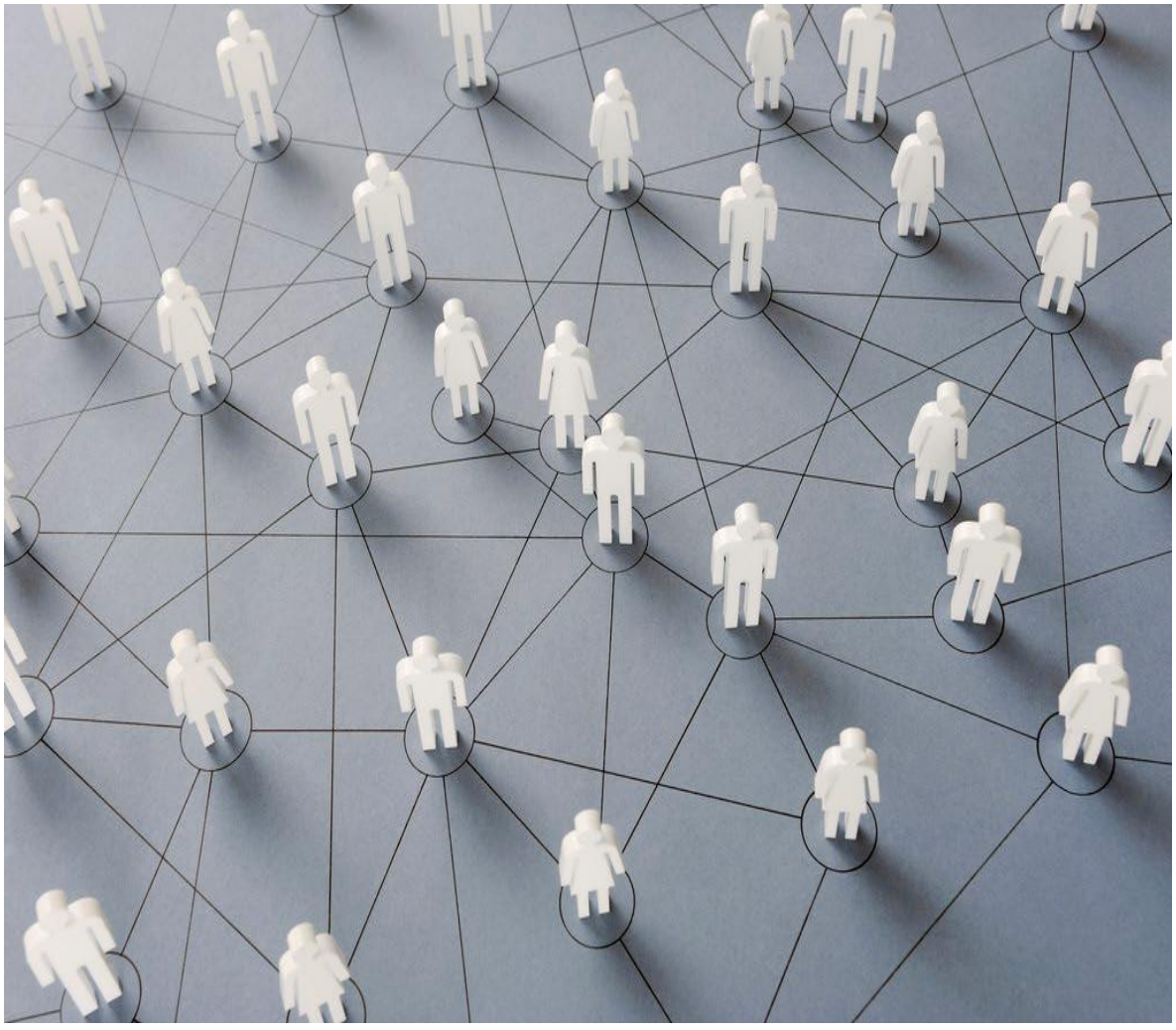
Feasibility of Quantum

Comparing the sub-optimal heuristic solutions of a Quantum Computer and a Classical Computer to understand its feasibility in the near and distant future.



Travelling Salesman Problem(TSP)

This NP-Hard problem consists of a salesman who is required to travel n cities, only once, and return to the origin while covering the shortest distance possible.

This problem can used to simulate a highly simplified version of a logistic problem wherein the nodes mimic the pick-up points or depots, the edges represent the road network interconnecting them and the salesman is replaced by the carrier. Hence finding the optimal solution for this gives the cheapest way to transport the carrier from the carrier depot to all the subsidiary depots or warehouses and back to the carrier depot.

Given below is the non-deterministic, sub-optimal solution to solve the TSP on a Classical Computer and a heuristic version of the same on a Quantum Computer.

You can find the code on my GitHub Link.

Given below is a comparison of how many nodes can be processed on a Quantum Computer v/s that on a Classical Computer as well as the time taken to do the same based on the benchmarking results of the above code.

Execution Time Comparison

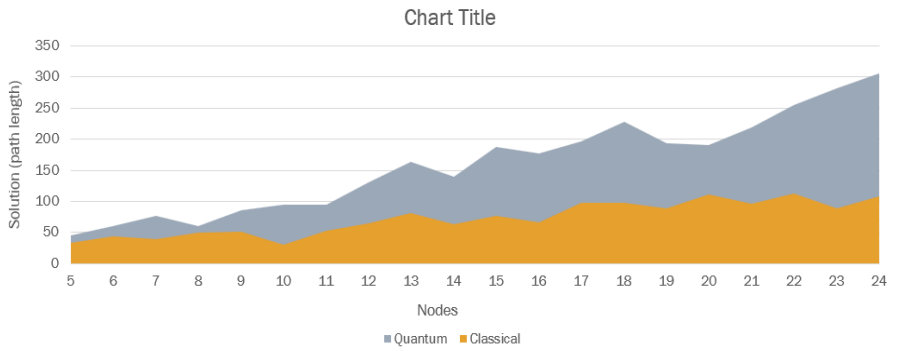
QUANTUM COMPUTER

Number of nodes	Time Taken
10	1 ms
20	0.92 s
30	22.76 s
35	148.02 s
40	Over 20 mins

CLASSICAL COMPUTER

Nodes	Edges	Time Taken
5	8	Less than 1ms
10	25	0.3s
12	40	38.4s
13	75	437.8s
14	100	Over 1hr

Comparing sub-optimal solutions



Feasibility of Quantum

Although Quantum Computers provide us with a way to process higher number of nodes in a much shorter duration as compared to a classical computer, the prime agenda of a TMS is not fully met.

A Transport Management System (TMS) primarily creates route plans for carriers with an aim to minimize cost in terms of fuel and time. A Quantum Computer provides a sub-optimal solution with an approximation factor of 2 due to which the average cost of transportation doubles. On top of that Quantum Computers are very expensive to make, run and maintain and due to lack of technical advancements in the field, the number of qubits (quantum bits) which is the number of bits of data the Quantum Computers can process, is limited, limiting its computational power by hardware. Cost of adding any additional qubit does not justify the increment in the computability of the same.

The distant future might however give us Quantum Computers with much better hardware, with Quantum Computers running on 128 qubits already being launched. Better accessibility to Quantum Computers and cheaper acquisition costs should help in giving Quantum Computers a boost, especially in the logistics market.

Christofides Algorithm

This algorithm is a heuristic approach to solve the Travelling Salesman Problem in the order of O(nmlog(n)) while a classical approach solves the same problem in the order of O(n!). Using a quantum computer to solve the algorithm makes it much more efficient that running the algorithm on a classical computer.

However, the algorithm provides a solution with an approximation factor of 1.5, i.e., the sub-optimal solution provided by the same will 1.5 times worse than the optimal solution. Since a Quantum Computer provides a non-deterministic answer with an average success rate of 0.7, the sub-optimal solution's approximation factor further worsens to almost 2.

References:
qiskit.org, geeksforgeeks.com, ibm.com