Traffic flow optimization using D-wave quantum computer

Purpose:

The aim of the project is the optimization of the traffic flow by minimizing the time for a set of cars to travel between their individual sources and destinations by minimizing total congestion in overall road segments. To do so, we minimize traffic flow by redirecting a subset of the cars to alternative routes in a way that the amount of intersecting road segments is minimized. Thus, it is essential to optimize overall cars simultaneously. In other words, any redistribution of cars that resolves the original congestion should not cause a traffic jam in other places on the map. By using a quadratic function of the number of cars traversing it in a specific time interval, the congestion on an individual segment can be determined. We use a hybrid quantum and classical approach to solve this problem.

Workflow:

1. Classical: create a random graph with the desired size using the networkx library in python.

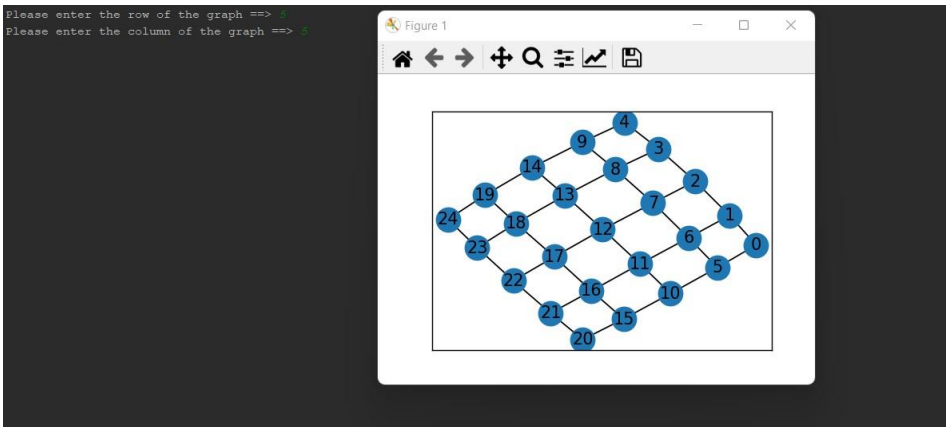

Figure 1: create a graph with the desired size (in this example is 5× 5)

2. Classical: add a weight to each edge (links) of this graph (for the instance speed limit, length of the edges, traffic weight). By having this information, we could calculate travel time on this edge.

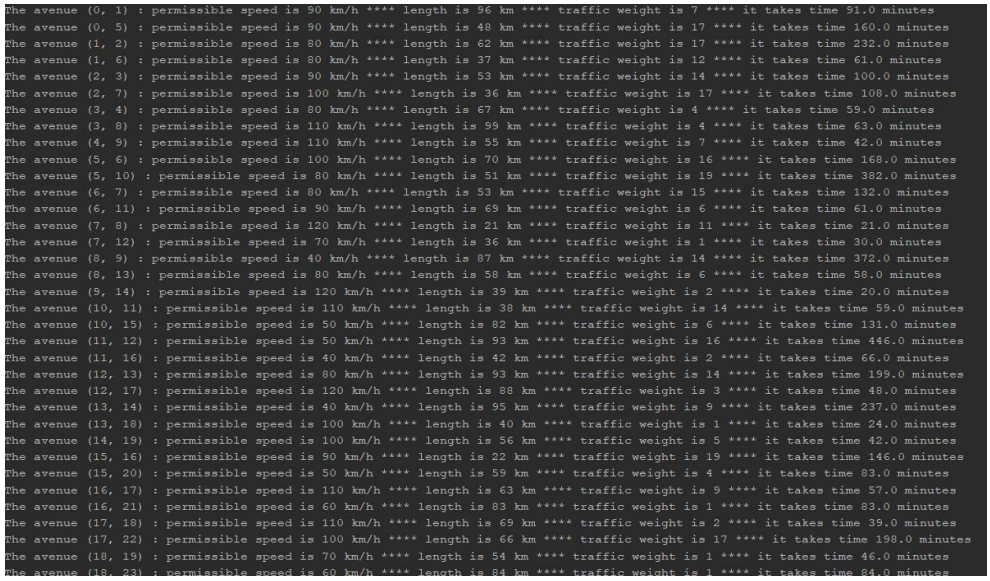

Figure 2: add a weight to each edge (links) and calculate the travel time on this edge.

3. Classical: find 3 different routes from the origin node to the destination node with the lowest travel time

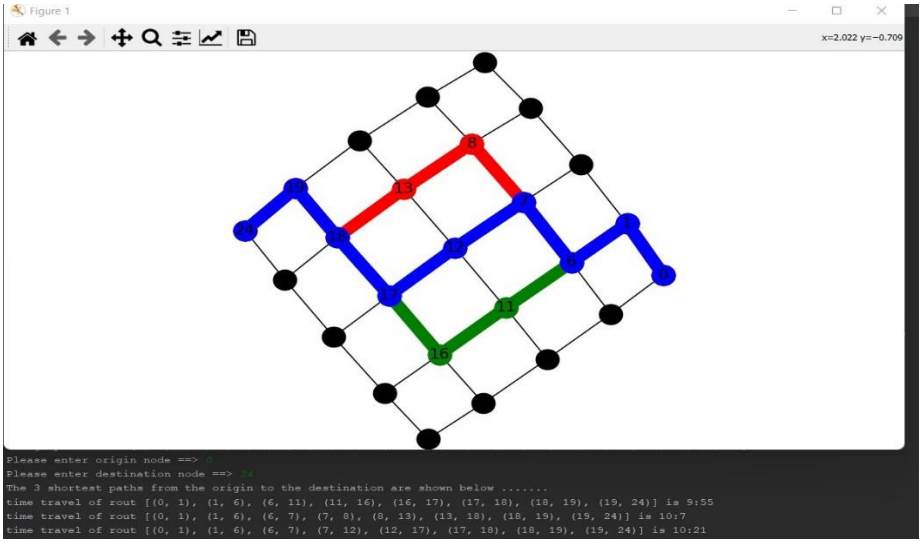

Figure 3: find 3 different routes from the origin node (0) to the destination node (24) with the lowest travel time.

4. Classical: in order to minimize congestion in road segments on overlapping routes, we formulate it as a QUBO
5. Hybrid Quantum/Classical: Find a solution that decreases congestion in three selected routes.
6. Classical: the cars are distributed based on the results in these 3 routes

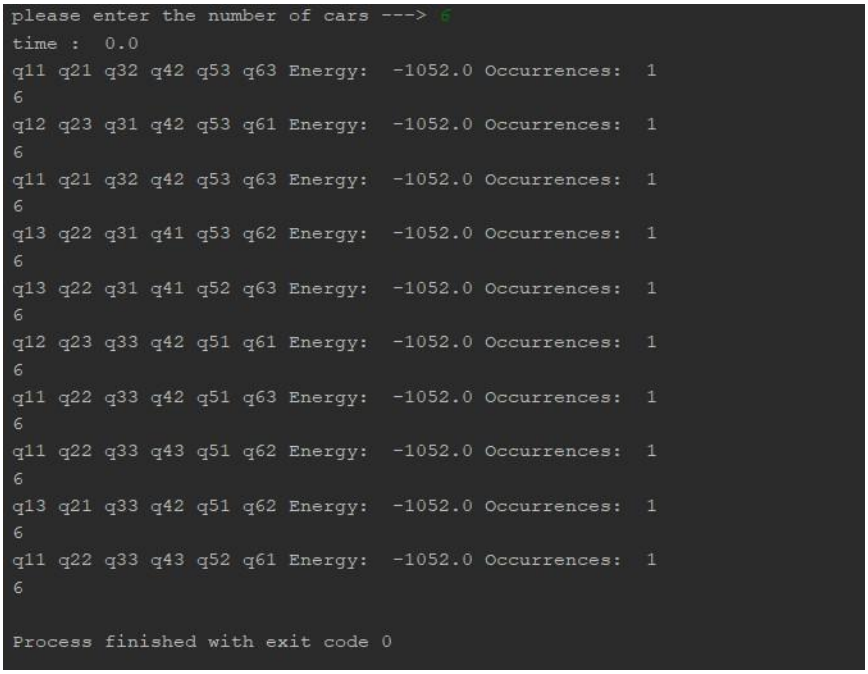

Figure 4: Distribute cars (in this example number of cars is equal to 6) that want to travel from node 0 to node 24 based on the results in these 3 routes. In such a way that they create the least traffic for each other, in this case, we found10 different scenarios. q11 means car number one takes route number one, q21 means car number two takes route number one, and so on.

Advantages of solving the traffic problem by using quantum computers compared to the current navigator applications:

As we know, a group of these applications uses mean-field theory to solve the traffic problem, but they do not deal with the issue precisely. Assume that some travel requests are sent to the application, simultaneously. In order to propose the best route for all the requests, they use only the traffic information by having this big data and engineering it with machine learning method, they are able to optimize the travel time. However, they do not take into account the probable traffic that each car could create for each other after navigating; due to similar routes which the algorithm may provide for some requests.

The D-Wave Systems use Quantum annealing technologies like the quantum processing units (QPUs) to solve complex combinatorial optimization problems. We can demonstrate that the continuous redistribution of position data for cars in crowded road graphs as an example of the time-critical optimization tasks are suitable candidates for quantum computing.
It is necessary to mention that this project was done by Volkswagen and D-Wave Systems[1] and we only did a simple primary model of that. The source code of this project will be sent as a separate python file.

References

1. Neukart, F.; Compostella, G.; Seidel, C.; Von Dollen, D.; Yarkoni, S.; Parney, B., Traffic flow optimization using a quantum annealer. *Frontiers in ICT* **2017,** *4*, 29.