Efficient Routing Decisions for Electric Vehicles in a Congested Network

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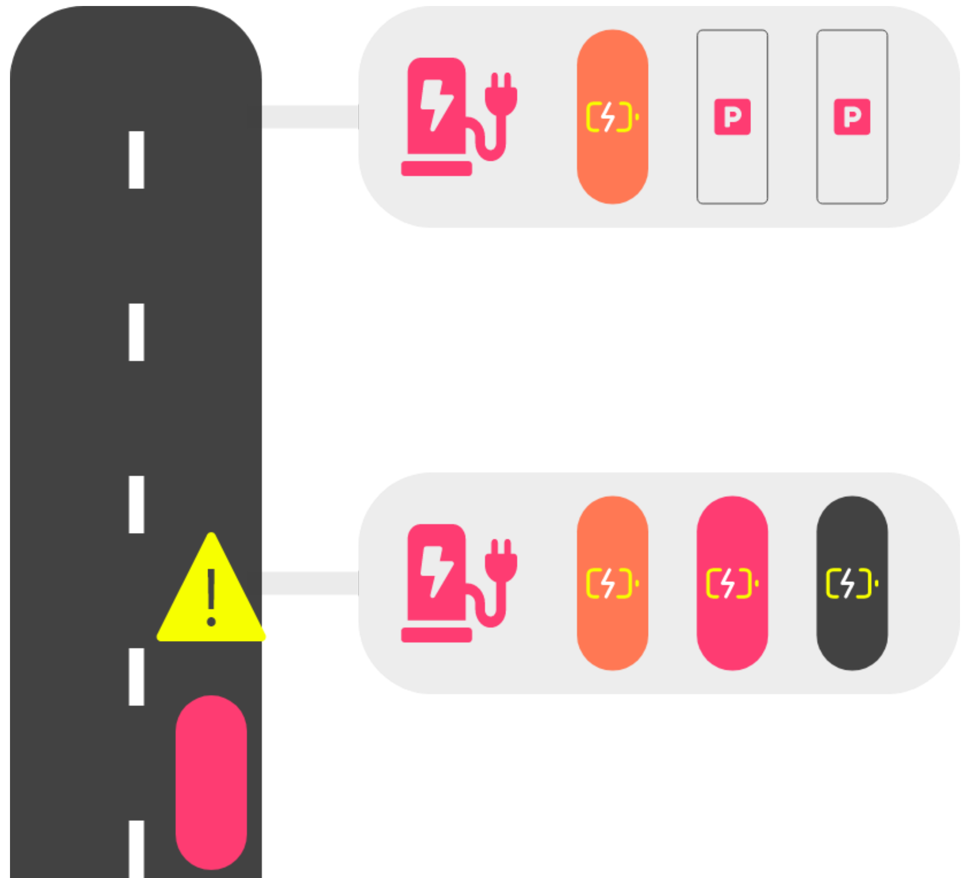
Background

The amount of needed charging stations is rising quicker when compared to the amount of charging stations.

Without a proper routing algorithm that can handle sudden surges in charging station traffic, congestions are inevitable.

Research Question

Using a road network modeled as an undirected graph, what algorithm is the most efficient to model and implement the routing decisions and travel times of electric vehicles at different charging stations to minimize the average travel time of the vehicles traversing the network?



State-of-the-art: IARS

Intention-Aware Routing System

Vehicles communicate their routing intentions while traversing the system to help others gain information about their environment.

Travel and waiting times are stochastic and time-dependent.

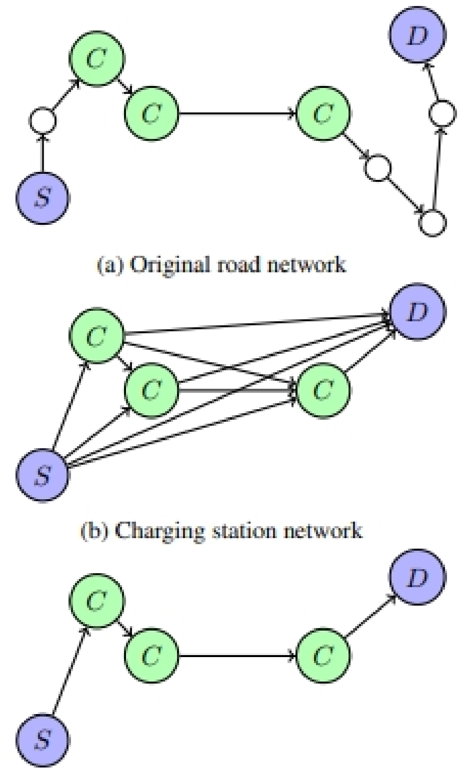
This gains over 80% improvement in terms of waiting times and more than 50% reduction in overall journey times when compared to using a shortest path algorithm.[1]

New: SEVR (+ Learning Component)

Extension upon shortest path algorithm.

Addition of a Greedy Geometric Spanner to make the network sparser.

Uses historical arrivals to estimate waiting times.



(a) Original road network

(b) Charging station network

(c) Sparse charging station network

Results

3-Grid Routing Graph

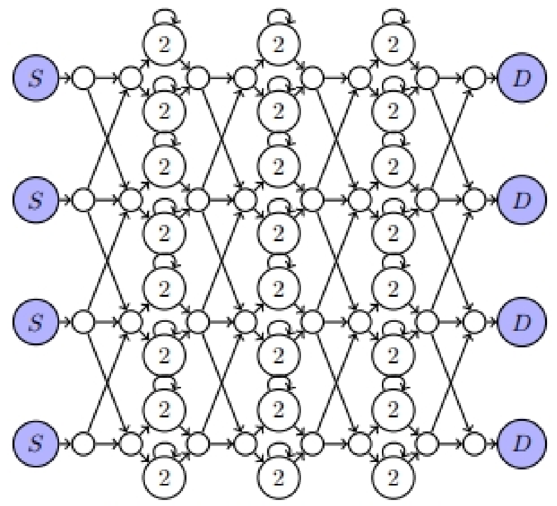


Figure 6: The *3-Grid* Routing Graph

Performance

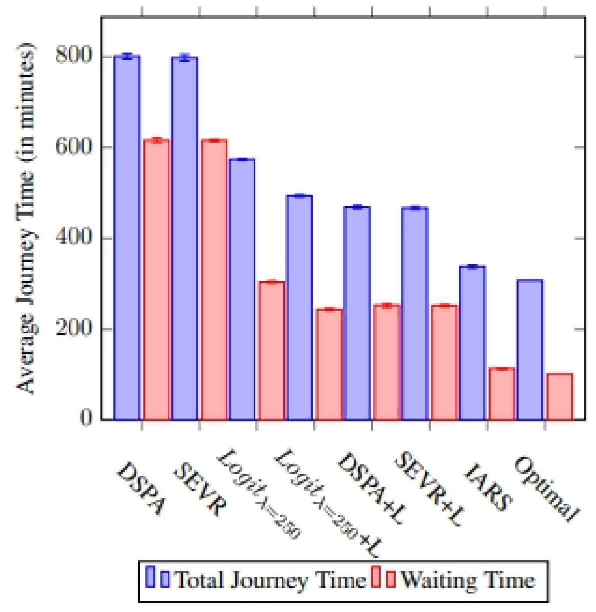


Figure 7: Average journey- and waiting times for different algorithms in the *3-Grid* Routing Graph.

Time Efficiency

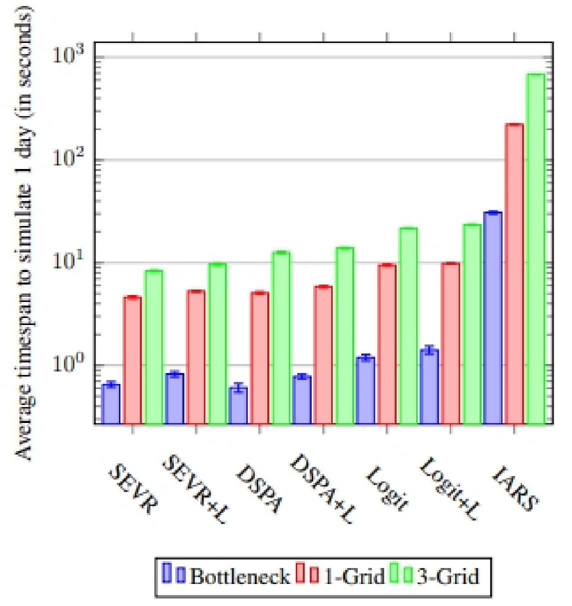


Figure 8: Average timespan to simulate 1 day for different algorithms in a specific Routing Graph.

Conclusions

IARS[1] comes closest to the optimal bound and reliably gives the best performance of the tested algorithms.

SEVR runs up to 34% faster than its shortest path algorithm counterpart because of its spanner.

Since IARS gives the best performance, but lacks in time efficiency, we should add the spanner to IARS.

Further work

The addition of other subproblems to E-VRP like nonlinear charging times, partial recharging or time windows.

The addition of a greedy geometric spanner to IARS to make the network sparser there to further improve upon the time efficiency of IARS.

The implementation of other algorithms like a Particle Swarm Optimalization (PSO) to see how that performs when compared to the other algorithms.

[1] de Weerdt, M., Gerding, E., Stein, S., Robu, V., & Jennings, N. (2013). Intention-aware routing to minimise delays at electric vehicle charging stations. In F. Rossi (Ed.), Proceedings 23rd international joint conference on artificial intelligence (pp. 83–89). United States: American Institute of Aeronautics and Astronautics Inc. (AIAA). (NEO; IJCAI 2013 ; Conference date: 03-08-2013 Through 09-08-2013)

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