Project title: Scheduling and Routing of Electric Cars

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Function: Assistant Professor

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Proposal (250 words):

Introduction: The research project studies fundamental scheduling and routing problems arising when driving electric cars with or without a range extender.

Range Extender. Range extender is a small and weak combustion engine that is solely used to charge the battery of an electric car. An electric car cannot operate (move) just by running the range extender; it is used to extend the capacity of the battery. The range-extender cannot simply be switched on, when the battery is empty. Sometimes, it is necessary to switch on the range extender early enough, e.g., well before a very steep (energy demanding) part of the road, so that the battery is pre-charged to a sufficiently high level.

Routing and Scheduling. Electric car can also recharge its battery by going downhill, and in this case, the range extender may not be needed and should be switched off to save the fuel, even if a moderate uphill road appears afterwards. This project studies the arising fundamental questions of which route is economic to drive (taking the battery-charging effects of driving downhill and uphill into account) and when to use the range-extender in a possibly efficient way. There are various objectives to consider, such as the energy-efficiency, or the length of the path, or both.

Objectives: Study the algorithmic problems of efficiently routing an electric car, scheduling of the range-extender, and of the charging policies. Analyze the impact of self-interest on the performance of the society.

Setting and Methods: The project aims to characterize the complexity of the arising optimization problems, and to provide efficient algorithmic solutions, in the form of exact, approximation, and fixed-parameter algorithms. Additionally, for selected application areas, practical algorithms will be engineered to provide near-to-optimal results for real-time needs. For problems arising from the game-theoretic considerations, algorithms for an efficient computation of equilibrium states will be developed. Furthermore, the impact of self-interest of the drivers on the well-being of the society will be analysed using game-theoretical approach.

Impact: The project will provide basic understanding of how optimization can help in the usage of electric cars, and how self-interest of car users affects the performance of the system. Some of the results, e.g., the developed and engineered routing algorithms, have a possible impact on real-world implementations.

Requirements candidate: Highly motivated and proactive student with good English communication skills, that has interest in algorithm design, and theory of computer science.

Keywords: Algorithms, approximation, optimization, computational complexity, electric cars, range extender, road network, graphs, scheduling, routing, implementation.

Top 5 most-related publications (the list of other publications can be seen at Google Scholar, or at DBLP):

1. S. Feuz, M. Mihalák, P. Widmayer. *Bi-criteria optimization for energy-efficient routing of electric cars.* Unpublished manuscript.
2. K. Böhmová, M. Mihalák, P. Neubert, T. Pröger, P. Widmayer. *Robust Routing in Urban Public Transportation: Evaluating Strategies that Learn From the Past.* ATMOS 2015: 68-81
3. A. Mamageishvili, M. Mihalák, S. Montemezzani. *An H(n/2) Upper Bound on the Price of Stability of Undirected Network Design Games.* MFCS (2) 2014: 541-552
4. M. Mihalák, S. Montanari. *Bi-directional Search for Robust Routes in Time-dependent Bi-criteria Road Networks.* ATMOS 2015: 82-94

5. A.Bärtschi, J. Chalopin, S. Das, Y. Disser, B. Geissmann, D. Graf, A. Labourel, M. Mihalák. *Collaborative Delivery with Energy-Constrained Mobile Robots.* SIROCCO 2016: 258-274