Simulative Analysis of Routing Algorithms for the Operation of an Autonomous Mobility-on-Demand System

Master's Thesis of Julian Lukas Veit

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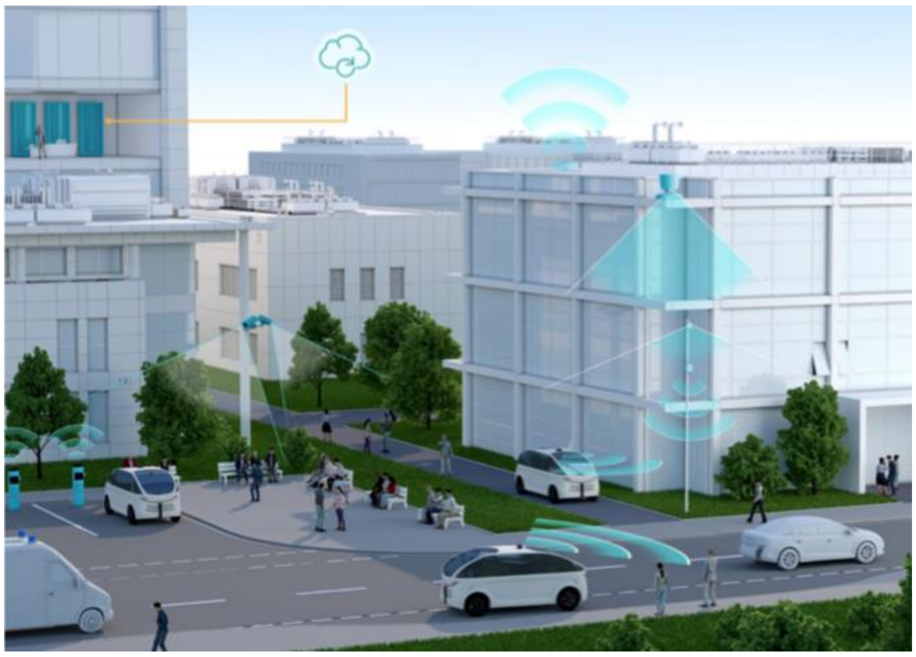
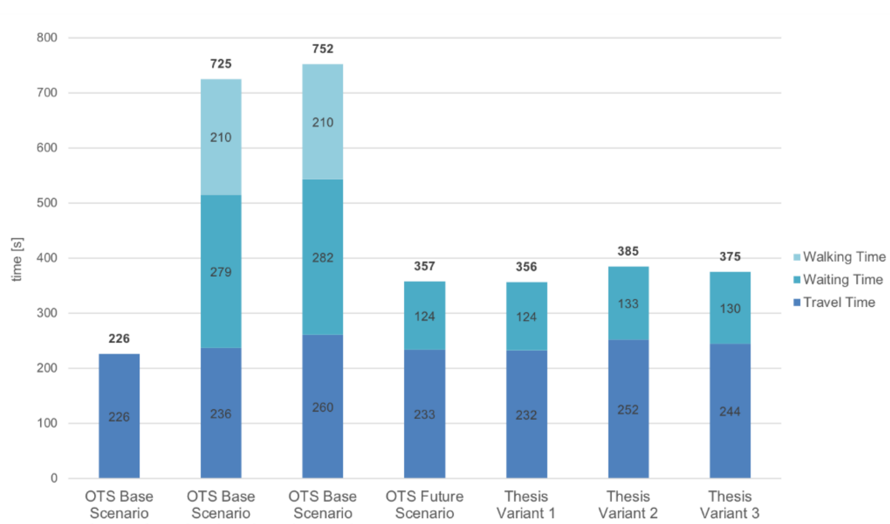


Personal mobility is recognized as a basic human need. As urbanization is accelerating and city population is continuously growing, the demand for it is rising steadily and urban traffic is increasing more and more. As a result, congestions, pollution, and a variety of other issues become more problematic each year. Private cars on the other hand are highly underused assets. They are active less than 10 % of the time and mainly during peak hours. Further, levels of occupancy are low, meaning much of their capacity is usually unused. But still, private cars are so highly valued, that households accept this inefficiency for the purpose of comfortable door-to-door mobility, without being bound to any schedule. So the question had been arising: could those benefits be maintained, or even enhanced, while reducing the inefficiencies?

This work builds on the project *OTS 1.0 - Optimized Transport System based on autonomous electric vehicles*. The thesis analyzes the impacts of a transport system with autonomous shuttle buses operating in a closed urban area without individual motor traffic, where the vehicles are functioning as a feeder to a mobility hub and offering a service for the first and the last mile. The shuttle buses operate completely on-demand, without fixed schedules or bus stops. The idea is to provide fully automated and sustainable mobility, according to a user's individual needs.

Different fleet management approaches were developed under specific constraints, such as a maximum waiting time for the users, and the routing of the vehicles was optimized based on the *Capacitated Vehicle Routing Problem with Time Windows (CVRPTW).* The objective of the route optimization was to minimize the travel costs, as well as the number of vehicles that are used to serve the demand.

	Occupancy Rate [%]	Number of Buses [-]	Number of Tours [-]
OTS Base Scenario (car & bus)	37.44	3	19
OTS Base Scenario (bus only)	83.98	3	19
OTS Future Scenario	54.47	34.35	208.40
Thesis Variant 1	55.76	33.65	203.20
Thesis Variant 2	65.02	30.80	172.25
Thesis Variant 3	63.42	31.20	178.35



In order to test the approaches, the shuttles were implemented into a microscopic traffic simulation environment with their respective routes. To assess the benefits of the system itself, and distinctly for the developed strategies, a comparative analysis was conducted based on previous results and base scenarios.

The simulation results convey that by introducing the autonomous shuttles, the average total duration of a trip could be reduced by more than 50 % compared to conventional public transportation. However, the necessary number of vehicles and the number of tours both increased by a factor of approximately ten. Compared to private car use, less than 3 % of the vehicles would be necessary to meet the same transport demand. The results further show that the developed route optimization approach, which is based on a newly implemented target function and is using a *Guided Local Search* metaheuristic, outperforms previous work, and produces favorable results for both the operator and the user.

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