Enhancing public transportation efficiency: Evaluating a semi-flexible bus route approach in rural and suburban areas

Master‘s Thesis of Andreas Strobl

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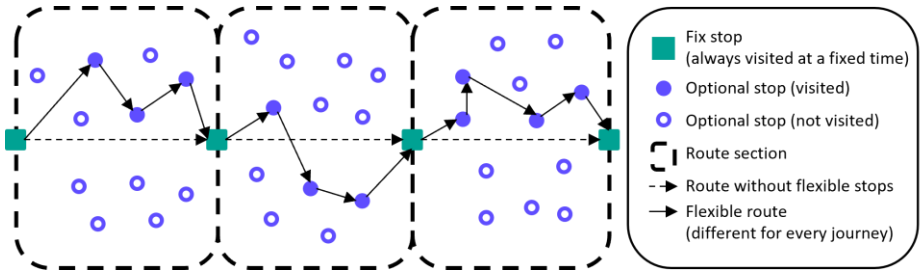

Fig. 1: Semi-flexible routing approach.

The methodology applied in this work combines the eqasim framework, which is built on the MATSim engine, with FleetPy. The dynamic scheduling algorithm developed in this thesis is integrated as a new module within FleetPy, which is connected to eqasim via a socket-based interface. While eqasim uses the MATSim engine and its DRT module to generate on-demand travel requests, FleetPy is responsible for vehicle control and routing decisions.

As illustrated in the flowchart on the right, incoming requests are processed by the dynamic scheduling algorithm, which first identifies suitable pick-up and drop-off stops within a predefined radius of 2.5 km around the agent’s origin and destination. If no feasible stop pair is found, the request is rejected. Otherwise, the expected access time is calculated and used to select an appropriate bus route from the daily schedule. The stop pair is then inserted into the vehicle plan, which is subsequently optimized to minimize additional driving distance. A feasibility check ensures that all fixed stops can still be served within their scheduled time windows. If this check fails, alternative stop pairs are evaluated, up to a maximum of three attempts. When a feasible solution is found, a travel offer is created and transmitted back to eqasim, where it is automatically accepted.

In total, five scenarios were simulated in the study area of Freising, comparing the fixed bus line 621 with a semi-flexible route. These include two door-to-door scenarios, two feeder-service scenarios, and one base simulation in eqasim without FleetPy, which serves as a reference case.

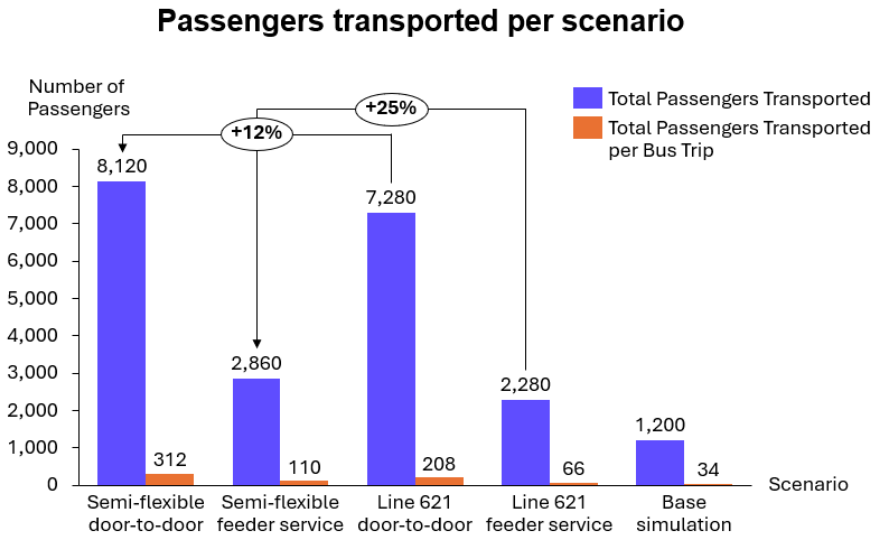

Fig. 3: Passengers transported per scenario.

The research question is addressed by modeling a semi-flexible bus route in an agent-based simulation framework. A dynamic scheduling algorithm implementing the semi-flexible routing logic is developed and the simulation results are compared with a conventional fixed-route bus service to evaluate potential efficiency gains in rural and suburban areas. The semi-flexible routing concept is illustrated in the figure on the left.

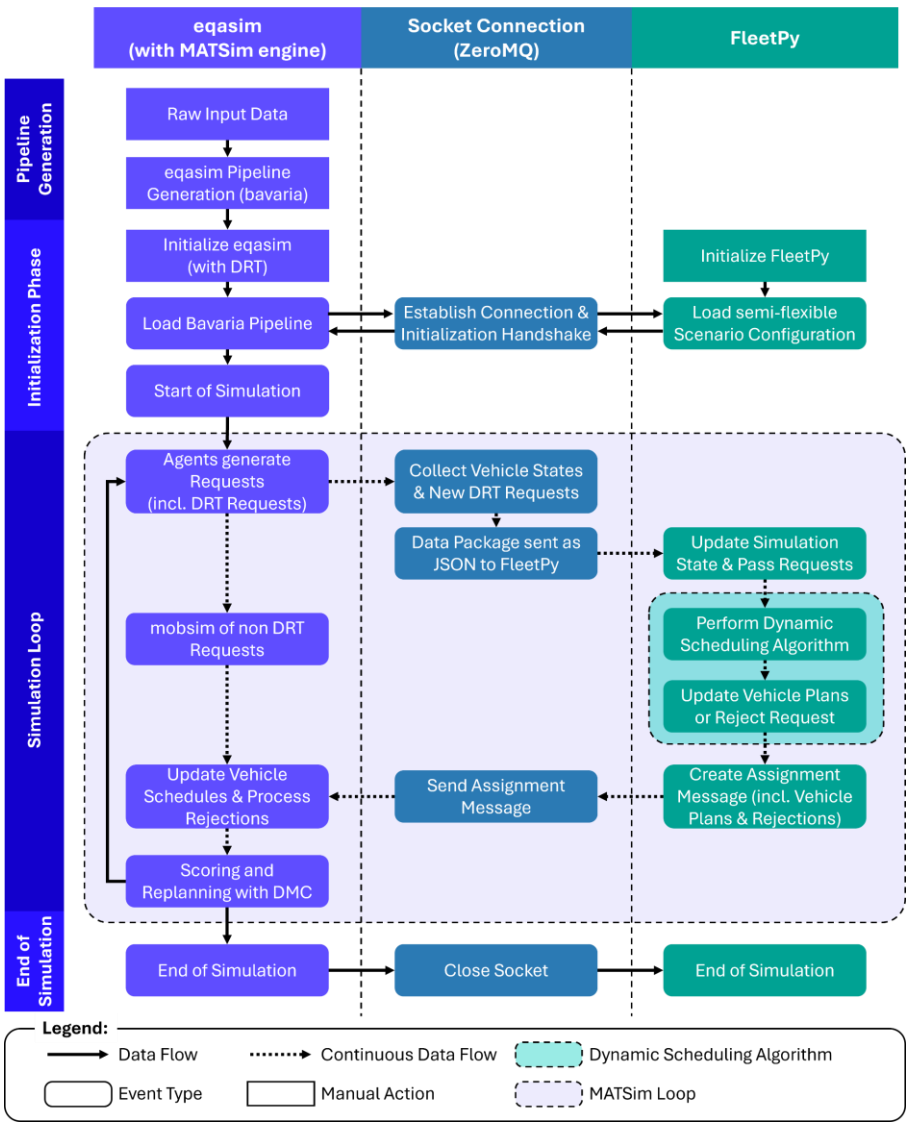

Fig. 2: Schematic representation of the data flow within the integrated eqasim-FleetPy simulation framework.

The results indicate that semi-flexible bus routes can outperform classical fixed-route services in terms of passenger demand under certain conditions. Most importantly, the effectiveness of semi-flexible systems strongly depends on a well-designed bus schedule and a carefully selected set of fixed stops. When these elements are properly configured, semi-flexible routes can enhance spatial coverage, better connect peripheral areas to public transportation, and demonstrate particular strength when operated as feeder services supporting intermodal travel.