mobil.TUM 2024 – The Future of Mobility and Urban Space, April 10-12, 2024

The Mobil-o-mat: A Simplified Assessment Approach for Early Stages of Transportation Planning

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Keywords: *Planning, Public Transportation, On-demand Service, Tool, Planning Support System*

This work addresses the following topic(s) from the Call for Contributions:
(Please check at least one box)

☐ Placemaking to integrate urban spaces and mobility
☐ Promoting sustainable mobility choices in metropolitan regions
☐ Governing responsible mobility innovations
☐ Shaping the transition towards mobility justice
☒ System analysis, design, and evaluation
☐ other: _____

Extended Abstract

Problem statement

Urban populations are increasing globally, and climate change requires changes in the infrastructure and human behavior. Municipalities and urban planners need to rethink the way people move. It should be more efficient on many levels: travel time, energy, and number of users, among others. There is no standard situation to solve and therefore no standard solution for the different levels, e.g. city district, city as a whole, or between city and suburb. Existing transport planning processes often begin with (mostly informal and cross-departmental) planning steps in which different mobility options are discussed, for instance from the County of Munich (Blum et.al., 2017). Any alternative measures resulting from such preliminary studies are often only subjectively evaluated (PTV Group et.al., 2020) due to the lack of suitable and cost-effective evaluation methods and tools. Occasionally, the number of alternative solutions is reduced using costly preliminary impact analyses (Blum et.al., 2017). An economical but evidence-based decision-making support for these very preliminary phases of planning would help eliminate unfruitful solutions and reduce the cost of further planning steps.

Planning of line-based public transport services is well documented in multiple publications such as Rüger (1986) and Vuchic (2005). As the vehicles operate on a cycle-based service, the calculation of operational and qualitative indicators is subject to deterministic formulas. However, the advent of on-demand mobility (ODM) services challenges this traditional paradigm by introducing a more flexible, demand-responsive approach. It may be inaccurate to assert that public transportation systems entirely overlook demand, as their routes and timetables are typically determined based on historical demand. This relationship between demand and supply in traditional systems is characterized by a long-term and collective planning approach, rendering it relatively predictable and deterministic (Schöbel, 2012; Iliopoulou et al., 2019). In contrast, ODM operates on a more dynamic premise where short-term, individual user requests for transportation directly influence the spatial and temporal dispatching of vehicles. A multitude of ODM systems has recently been proposed, showcasing varying levels of

responsiveness, flexibility, and optimization perspectives (Vansteenwegen et al., 2022). The short-term nature of the interaction between supply and demand in ODM systems makes them unpredictable and stochastic. Consequently, evaluating performance metrics necessitates a detailed optimization and microsimulation for performance evaluation, posing challenges in the early planning stages.

Research objectives

This work aims to develop a tool (Mobil-o-mat) to assess traditional and innovative public transport systems quantitatively in the early planning stage so that unsuitable systems for a specific study area can be identified and dismissed. It should be easily usable and understandable, so planners are enabled to use it on their own, without large prerequisites in terms of money, data, and time. To reach this objective, the following methodological approaches are used:

Methodological approach

An objective evaluation of alternative solutions must rely on a set of indicators that reflect the major fields of transport policy. The system was structured, based on the DIN EN 18316 (CEN, 2002), according to the three levels goals, criteria, and indicators. Goals being the major fields of policy interest: economy, ecology, social inclusion, operational performance, and impact on the city scape. They were operationalized by breaking them down to the indicator level: e.g. “occupancy” is turned into “occupancy in the peak hours” and “average daily occupancy”. A total of forty-four indicators were identified as useful. In the first version of the tool, twelve were implemented.

The aim of the tool is to evaluate indicators and rank transportation scenarios that are tailored as much as possible to the local conditions and allow variation of operational features. The scenarios are composed of geometrical features of the line accounting for different alignments and infrastructure quality, the mode considering operational necessities and cost, the deployed vehicle with its kinematic properties and capacities as well as the operational boundary conditions (headways, service hours, etc.). In each of these categories, the user must insert several required data points, such as vehicle properties like capacities, fuel consumption, or specific emission factors. In the initial stage, the operational indicators are calculated: number of vehicles, kilometrage, and vehicle service hours. Then, further indicators can be calculated such as cost, emissions, travel speeds, etc.

The Mobil-o-mat is developed to facilitate the comparative analysis of diverse mobility solutions, including On-Demand Mobility (ODM), during the initial phases of decision-making in urban planning. Therefore, it needs to address the challenge posed by the deterministic nature of conventional line-based public transport and the stochastic nature of on-demand mobility services. This entails the construction of a regression model designed explicitly for on-demand mobility. To inform the model's development, synthetic on-demand services scenarios with varying parameters such as grid network size, block size, number of stops, number of users, and fleet sizes were explored to capture the dynamic interplay of supply and demand. These scenarios were simulated using the simulation framework, "FleetPy" (Engelhardt et al., 2022). The results were used as input for a linear regression model that seeks to calculate key metrics, including the mean trips' bee-line speed, mileage, and occupancy. Subsequently, the mileage data is employed to compute environmental indicators by applying emissions-specific values (HBEFA, 2023) as multipliers. This comprehensive methodology allows Mobil-o-mat users to compare transparently and systematically line-based and ODM services, employing the same input and output parameters, thereby overcoming the inherent disparities between both mobility paradigms.

Expected results

Two fictive case studies were conducted to test the current Mobil-o-mat version. First, two city districts should be connected with a line-based public transportation system. Second, a new city district should be connected with conventional line-based public transport or ODM (Figure 1). The case studies showed that the calculated indicators can be used for a realistic comparison between different mobility solutions (figure 2). To further validate this, we plan to compare our preliminary results with simulation studies and the scientific literature until the conference. With this, the tool addresses the need for a first quick and accurate assessment of potential public transport solutions. Further plans involve including all the identified indicators in the tool to provide a multidimensional assessment.

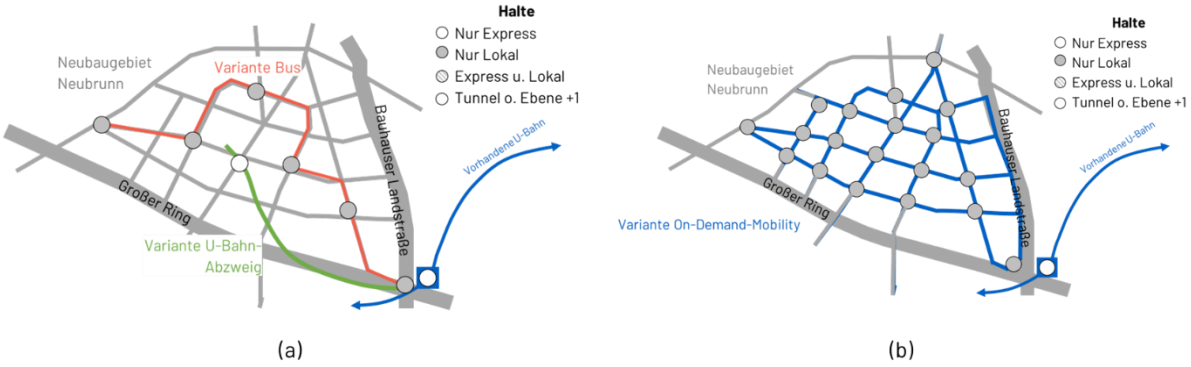

Figure 1: Conducted Scenarios: (a) public transportation scenario (b) ODM scenario

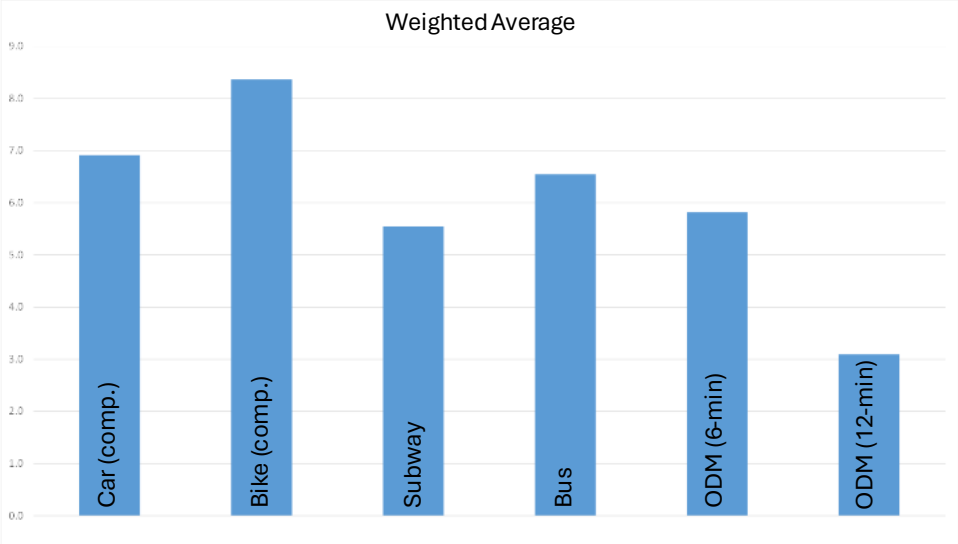

Figure 2: Exemplary Results of scenarios' evaluation

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