D-BAUG

D-BAUG Lighthouse Project: E-Bike City Subproject D

Congestion-informed dynamic space allocation for different transport modes

Ying-Chuan Ni, Kimia Chavoshi, Michail Makridis, Anastasios Kouvelas
Traffic Engineering group, Institute for Transport Planning and Systems, ETH Zurich

Motivation

Reallocating dedicated lanes to public transport and active mode road-users, e.g., pedestrian, bike, and e-bike, promotes the development of a net-zero urban transport system, but it may potentially induce congestion in the network due to the reduced capacity for car traffic. This subproject first aims to develop a forecasting tool to explore the impact of the road space reallocation measures on the network traffic performance. The end goal of the subproject is to achieve a balance between facilitating eco-friendly transport modes and preserving network traffic efficiency by proposing a dynamic control strategy, which allocates road space to different transport modes based on the present congestion dynamics.

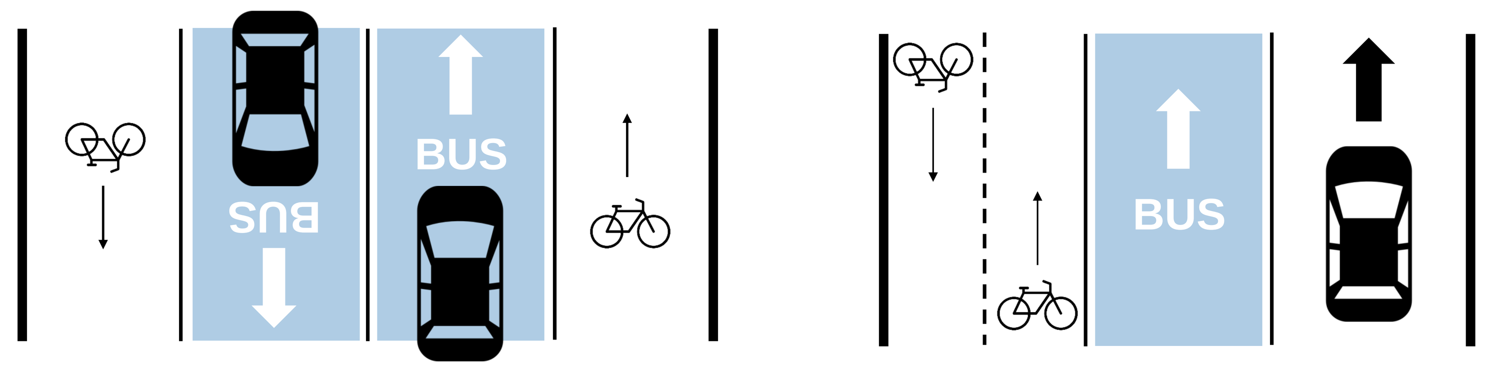

Fig. 1 Different road space allocation configurations

Deliverables

Forecasting	Multi-modal macroscopic fundamental diagram (mMFD)
Forecasting	Network traffic assignment based on the developed mMFD
Optimization	Optimal dynamic space allocation model(s)

Multi-modal Macroscopic Fundamental Diagram

In order to explore the impact of the road space reallocation strategies, the network traffic dynamics need to be described. This subproject focuses on the application of macroscopic fundamental diagrams (MFD), which can represent the relationship between vehicle accumulation and the internal flow within a network area or the outflow from the network border. The aggregated traffic dynamics of MFDs lead to low scatter on the congested branch. Its suitability for modeling traffic in large urban networks enable it to be applied for network-wide traffic management strategies.

Incorporating the characteristics of multi-modality into MFDs has become a popular research topic. Several studies proposed the 3D-MFD to describe the influence of the interaction between cars and buses on network traffic performance [1,2]. This interaction is regarded as a disturbance to the bi-model transport system. There were also studies investigating the impact of bicycle traffic on MFD [3]. How to develop a multi-modal MFD (mMFD) for the road space allocation problem would be the first research problem in this subproject.

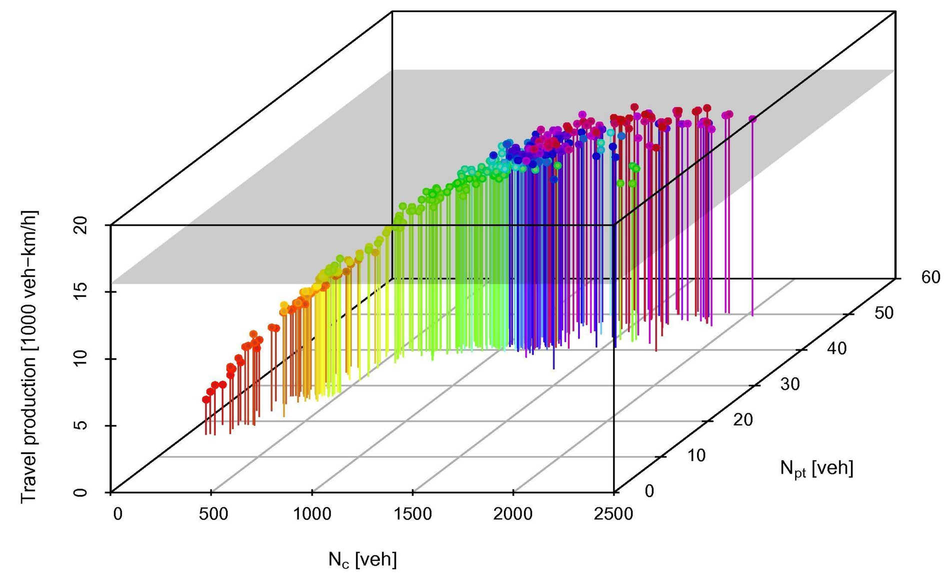

Fig. 2 3D-MFD for cars and buses in the city center of Zurich [2]

mMFD-based Network Traffic Assignment

Dynamic traffic assignment (DTA) can be used to reproduce or predict the propagation of congestion dynamics within the urban network. To consider multi-modality, travelers' mode choice behaviors will be included in this framework. At an even more advanced level traffic modeling, departure time choice can also be taken into account.

Instead of a link-level model, the traffic assignment will be carried out based on the developed mMFDs. In this kind of approach, the entire network is partitioned into multiple homogeneous subregions. Traffic flows are modeled between adjacent subregions. Different from link-based assignment methods, this kind of zone-based assignment approach reduces the computational requirements and increases its real-time applicability in such a large-scale traffic management problem [4]. Different scenarios can be tested to evaluate the potential impact of the pre-determined road space reallocation strategies.

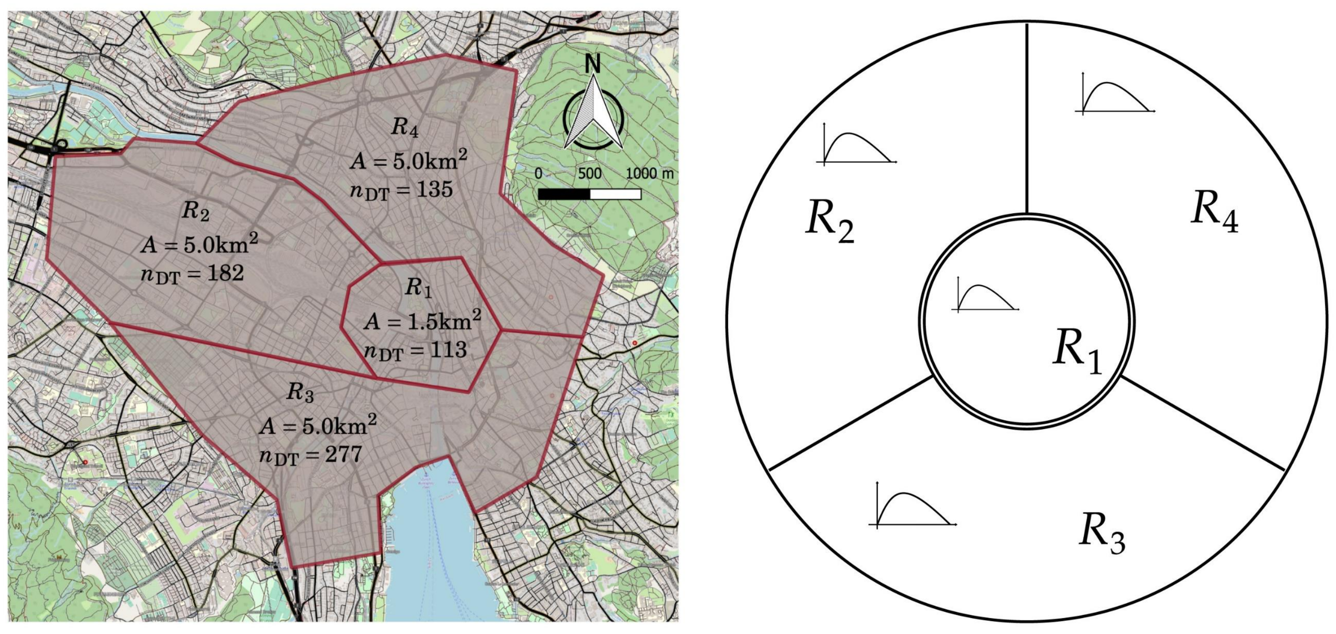

Fig. 3 Subregions design and network model for traffic assignment based on MFDs in the city of Zurich [5]

Dynamic Space Allocation Model(s)

The spatial-temporal variation of traffic demand within the urban network highlights the importance of a dynamic management strategy. There were several research works which utilized the concept of mMFD-based traffic modeling to design novel control strategies, including cordon pricing schemes [5], urban space allocation [6], and perimeter control [7,8].

In this subproject, after being able to forecast the traffic dynamics in various scenarios, dynamic control strategies can be applied to optimally allocate the road space between different modes over different time periods and maximize the throughput to ensure an efficient utilization of network road capacity.

Various control methods can be applied for this problem. Several studies have applied model predictive control [7] and deep reinforcement learning [8] for network-wide traffic management strategies based on MFDs. The last deliverable is hence to develop a decision tool which determines the road configurations within the subregions by handling the DTA problem and the optimal road space allocation problem in the meantime.

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Institut für Verkehrsplanung und Transportsysteme
Institute for Transport Planning and Systems

+41 44 633 3105
info@ivt.baug.ethz.ch
www.ivt.ethz.ch