Revisiting Mesoscopic Traffic Flow Simulation in SUMO: Limitations, Analysis, and an Alternative

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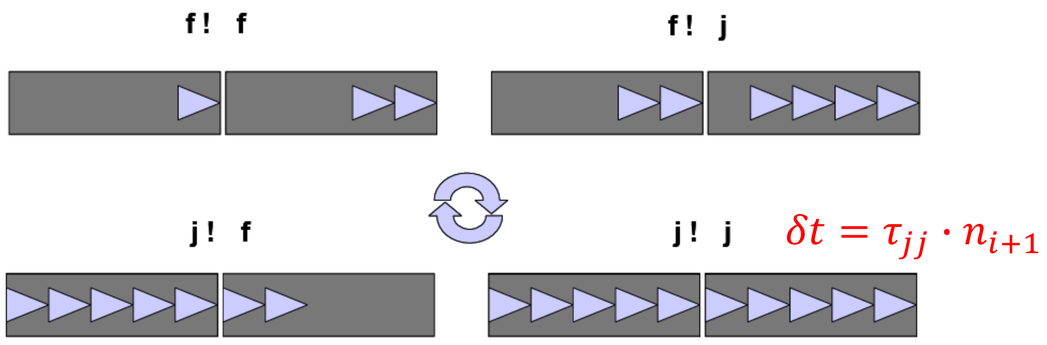
Abstract

Mesoscopic traffic models track individual vehicles while preserving key properties of macroscopic traffic flow. Compared with microscopic simulation, they require substantially lower computational effort because detailed vehicle-to-vehicle interactions are not explicitly modeled. At the time of this study, the mesoscopic model proposed by Eissfeldt (2004) is implemented in SUMO as the MESO function. The movement of vehicles is governed by dynamic headways between edges. However, MESO does not fully comply with the principle in the Lighthill–Whitham–Richards (LWR) model. Several problems are identified when simulating interrupted traffic flow in urban road networks.

*Eissfeldt, N. G. (2004). *Vehicle-based modelling of traffic. Theory and application to environmental impact modelling*. Doctoral dissertation, Universität zu Köln.

MESO queue dynamics

Sequence of possible traffic states that develops starting from free-free to a jamming situation at the downstream, causing an upstream propagation. Finally, the downstream jam dissolves.



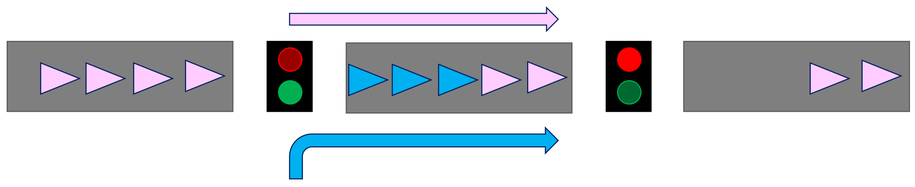
*Eissfeldt, N., Krajzewicz, D., Nagel, K., & Wagner, P. (2006). Simulating traffic flow with queues.

Problems

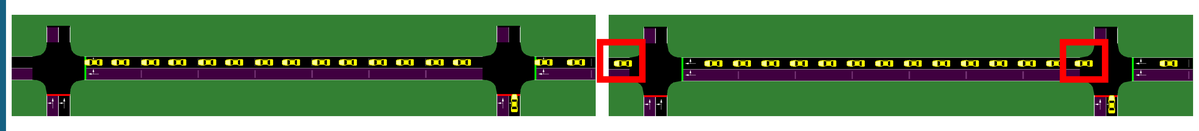
1. Incomplete consideration of queue dynamics due to varying vehicle distribution within a link

f→j but τ logic for j→j should apply. Also j → f, but a different τ

2. Unlike motorways, congestion propagates on urban roads not because the headway τ becomes smaller when j → f.



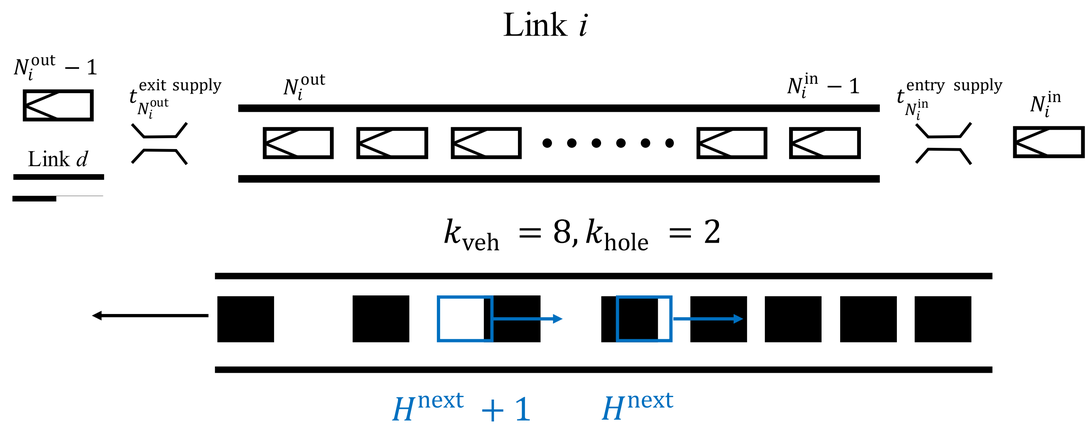
3. Limited (memory-less) consideration of backward traveling spaces causing unrealistically fast congestion dissipation



Time = 2067.00 s Time = 2067.25 s

Mesoscopic link transmission model

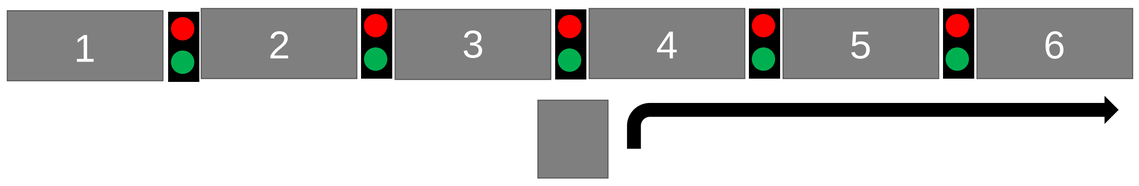
LIFT, an event-based mesoscopic model, follows the same theoretical foundation as the link transmission model (Ni et al., 2026). By explicitly simulating backward traveling spaces to capture queue spillback phenomena, LIFT provides a more accurate representation of queue dynamics on a link.



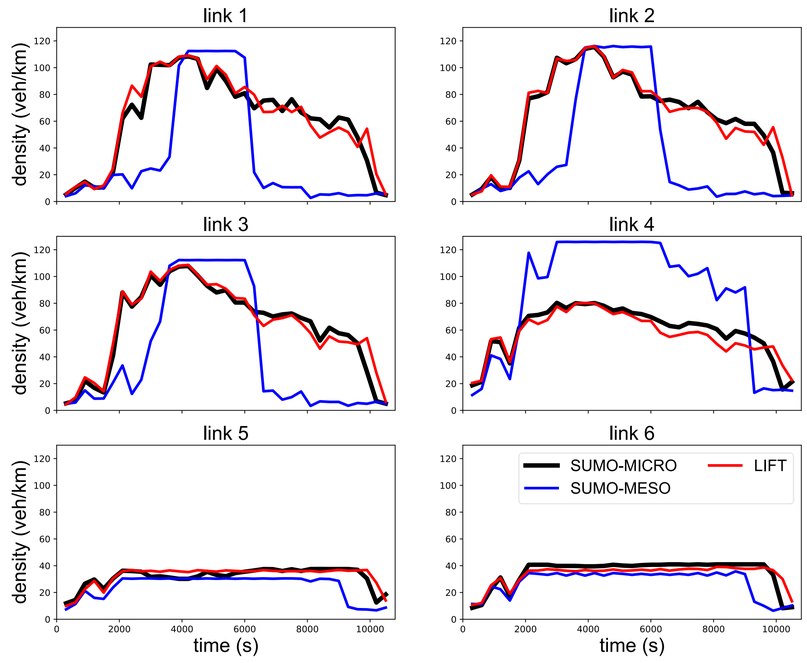
*Ni, Y.-C., Kouvelas, A., & Makridis, M. A. (2026). Simulating link-level interrupted flow traffic dynamics and the comparison between different models for urban road networks. *Simulation Modelling Practice and Theory, 147*, 103252.

Case study demonstration

The problems are particularly pronounced in the simulation of interrupted traffic flow in urban road networks due to the frequent stop-and-go movements. A case study on a signalized corridor is designed.



The link density outputs produced by SUMO-MESO show long duration of overestimated density at the bottleneck (link 4), while congestion occurred later and dissipated earlier on those upstream links.



The results produced by LIFT are consistent with SUMO-MICRO. Ongoing work implements a discrete-time version and hopes to integrate it into SUMO in the future.

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