A hybrid and multiscale approach to model and simulate mobility in the context of public event

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Support systems for urban events: Multicriterial integration for openness and safety

Butenuth et al. (2011), Integrating pedestrian simulation, tracking and event detection for crowd analysis

- Joint research project:
  Cooperation between research and practice
- Research objective:
  Research about the safety of public events
- Practical objective:
  Support for the planning of large public events

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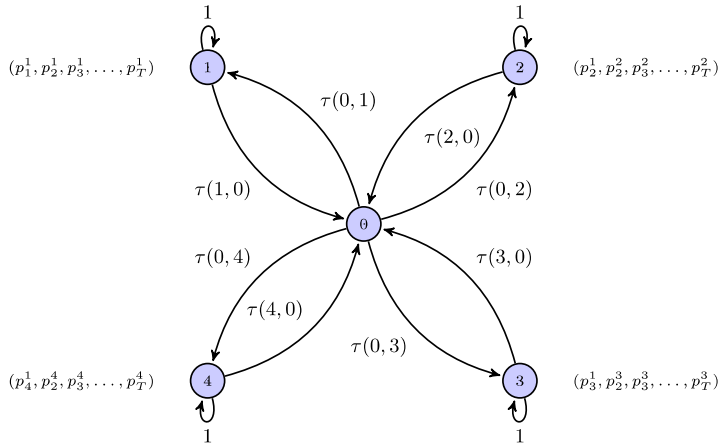
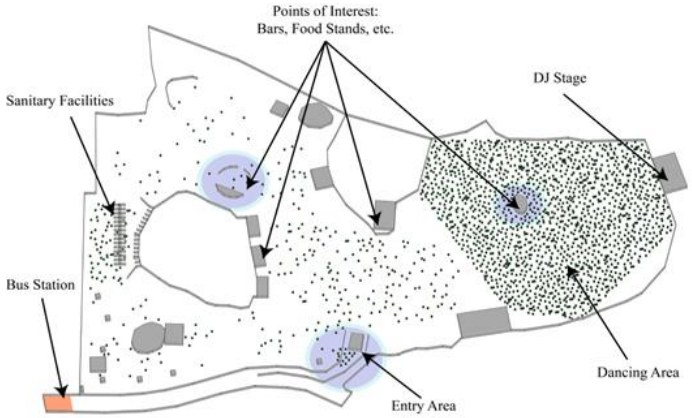
What did we do?

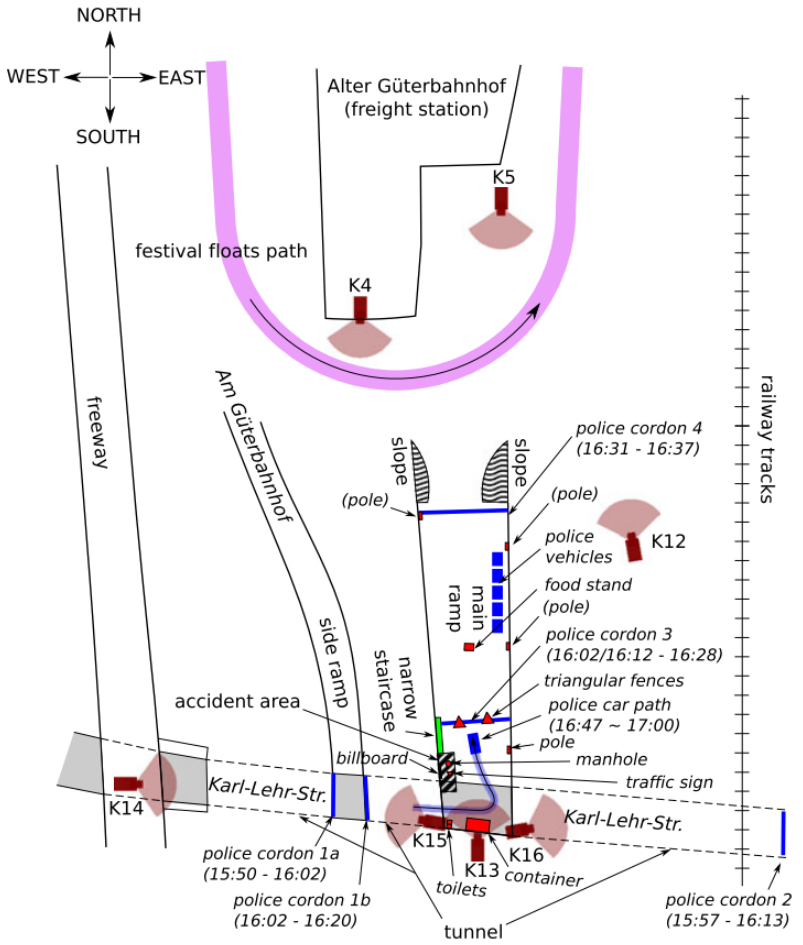
- Hybrid simulation of an event course
- Simulation models from different scales
- shuttle bus optimization-simulation
  - network flow model
- pedestrian dynamics
  - agent based models





Why pedestrian dynamics simulations?

- 2000 deaths[1] costs by crowd disasters
  - E.g. Loveparade 2010 in Duisburg
- Simulation of human walking behavior
  - Experiments difficult / impossible
  - Can predict dangerous situations

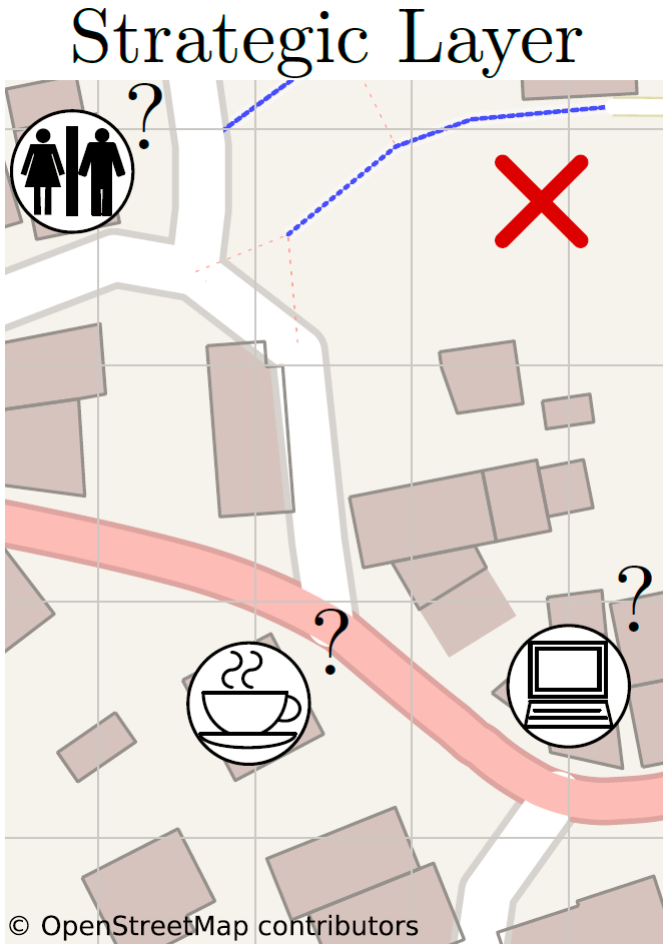


Helbing, Mukerji (2012), Crowd disasters as systemic failures: analysis of the Love Parade disaster

[1] Hughes (2002), A continuum theory for the flow of pedestrians

Pedestrian behavioral levels[1]: strategic layer

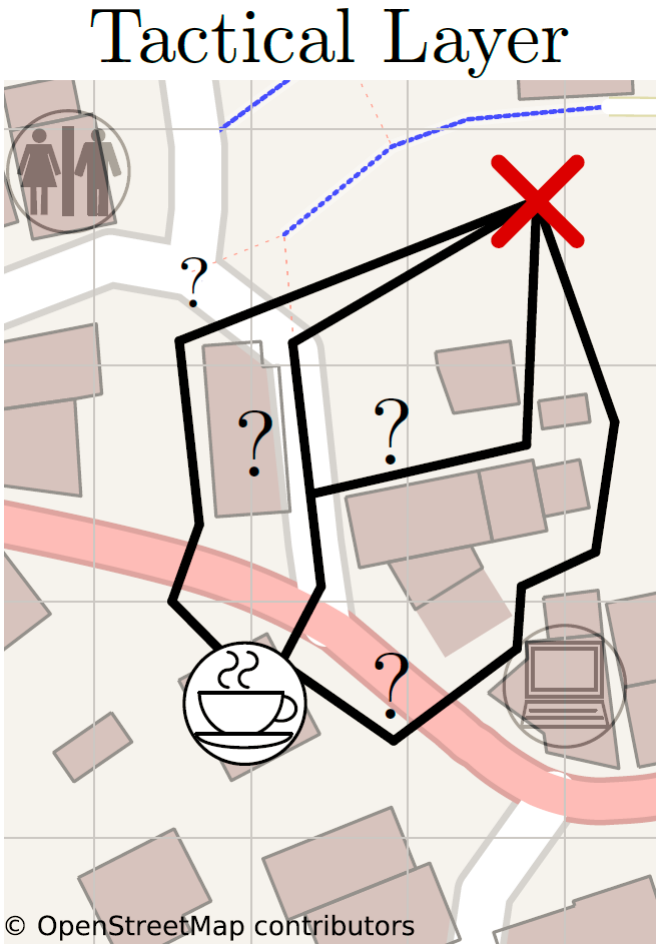
- Selection of a target
- Where do we want to go?



[1] Hoogendoorn and Bovy (2004), Pedestrian route-choice and activity scheduling theory and models

Pedestrian behavioral levels[1]: tactical layer

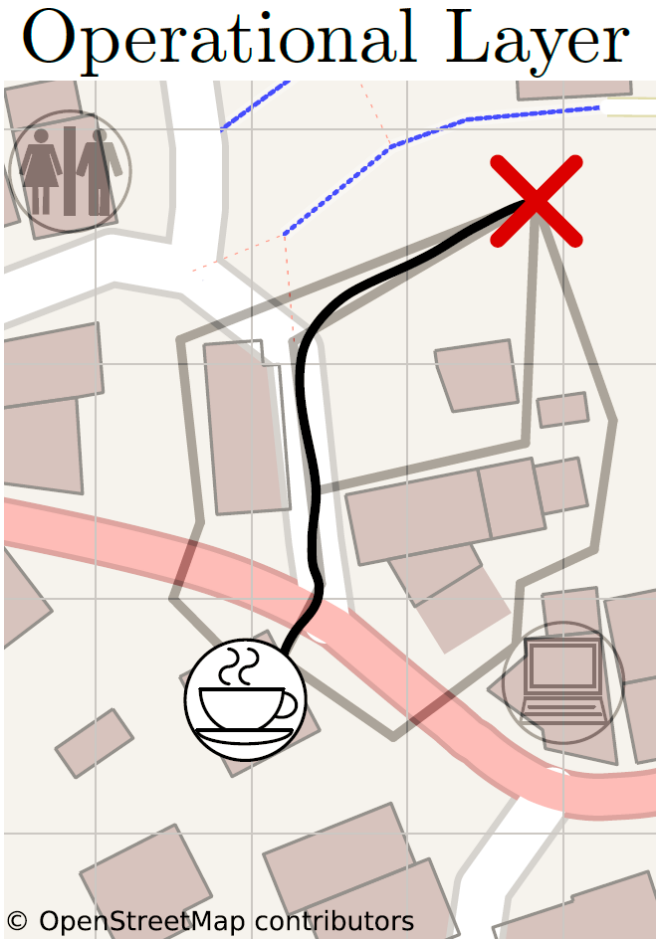
- Selection of a route
- On which way do we reach our target?



[1] Hoogendoorn and Bovy (2004), Pedestrian route-choice and activity scheduling theory and models

Pedestrian behavioral levels[1]: operational layer

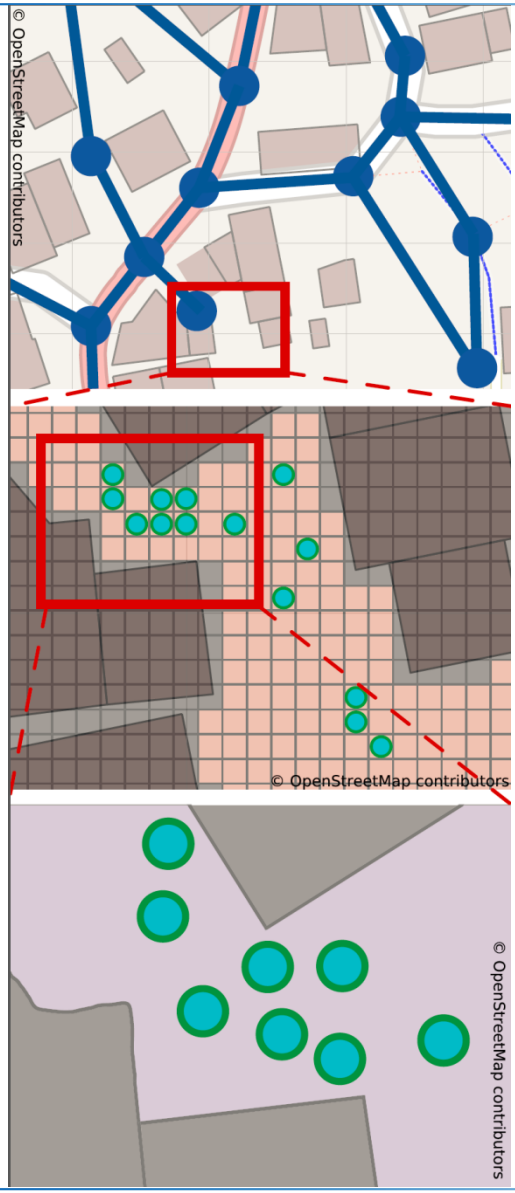
- Motion of the pedestrian along the selected route
- How do we walk on our route?



[1] Hoogendoorn and Bovy (2004), Pedestrian route-choice and activity scheduling theory and models

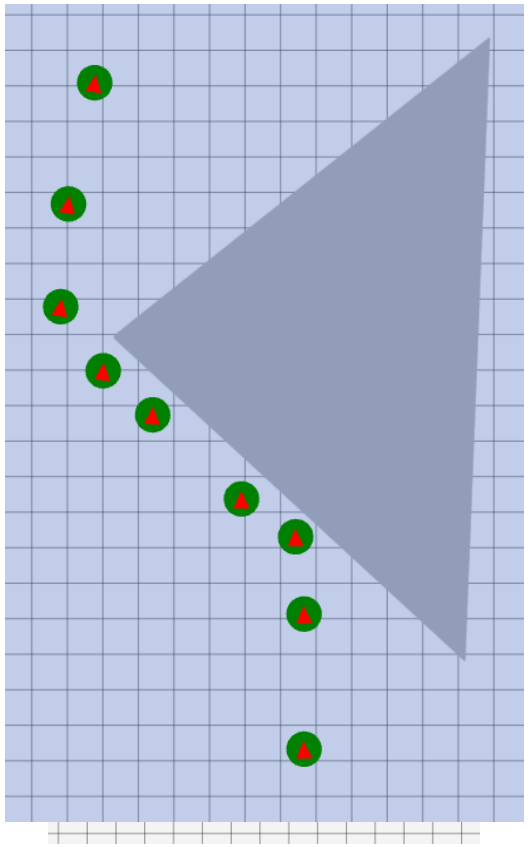
Hybrid modeling

- Macroscopic Scale
  - network, aggregated parameters
  - low spatial resolution & computational effort
- Mesoscopic Scale
  - grid, discrete pedestrian
  - medium spatial resolution & computational effort
- Microscopic Scale
  - continuous system, discrete pedestrian
  - high spatial resolution & computational effort



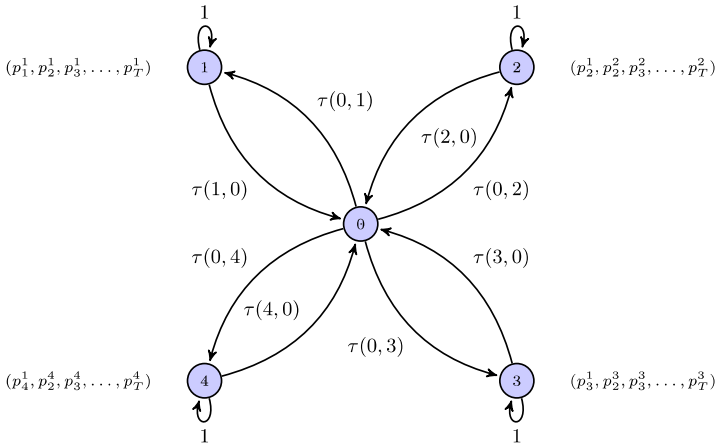
Multiscale approach to combine all three scales

- Overall simulation of a public event
- Arrival to the event (macroscopic)
  - simulation of shuttle buses
- Event process (mesoscopic)
  - pedestrian dynamics with cellular automaton
- Critical situations (microscopic)
  - continuous simulation of pedestrian dynamics

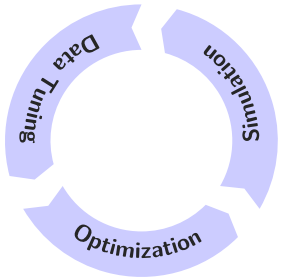


The shuttle bus simulation (macroscopic)

- Dynamic network flow model
  - optimized schedule fur shuttle buses

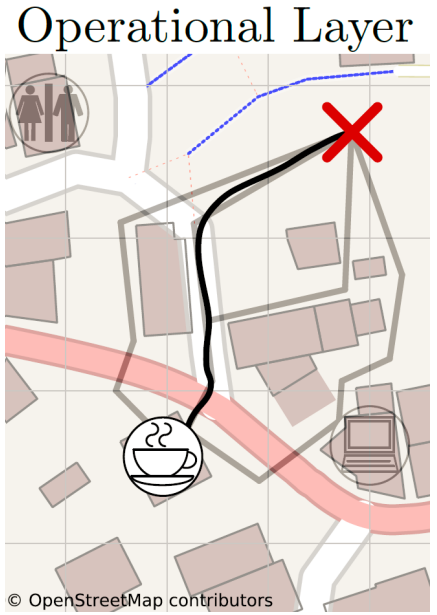


- Shuttle bus simulation
  - based on optimized schedule
  - optimized according to total waiting time
  - error-prone schedules are discarded



Pedestrian dynamics simulations (micro- & mesoscopic)

- Strategic layer
  - Destination Choice Model[1]
    - cognitive modeling
- Tactical layer
  - Unified Routing Model[2]
    - combines routing approaches
- Operational layer (meso)
  - Cellular Stock Model
    - stock based movement

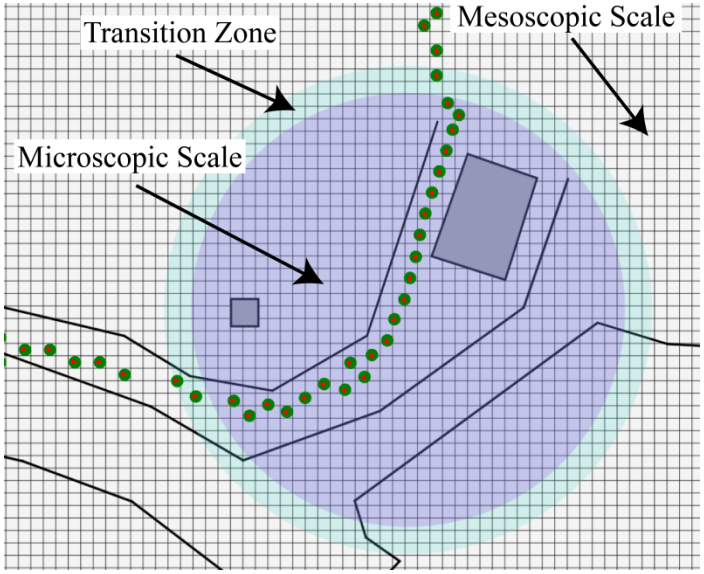


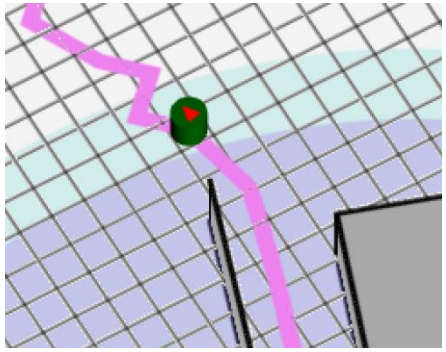
- Operational layer (micro)
  - Social Force Model[3]
    - potential-field based

[1] Based on Kielar, P. M., Borrmann A. 2016. Modeling pedestrians' interest in locations: A concept to improve simulations of pedestrian destination choice and Kielar, P. M.; Handel, O.; Biedermann, D. H.; Borrmann, A.: Concurrent Hierarchical Finite State Machines for Modeling Pedestrian Behavioral Tendencies
[2] Kielar, P. M., Biedermann, D. H., Kneidl, A., Borrmann A. 2016. A Unified Pedestrian Routing Model Combining Multiple Graph-Based Navigation Methods
[3] Helbing, D., Farkas, I. J., Molnar, P., Vicsek, T. 2002. Simulation of pedestrian crowds in normal and evacuation situations

Coupling of the microscopic and mesoscopic scale

- TransiTUM Model[1]
  - combines arbitrary models
  - based on transition zones



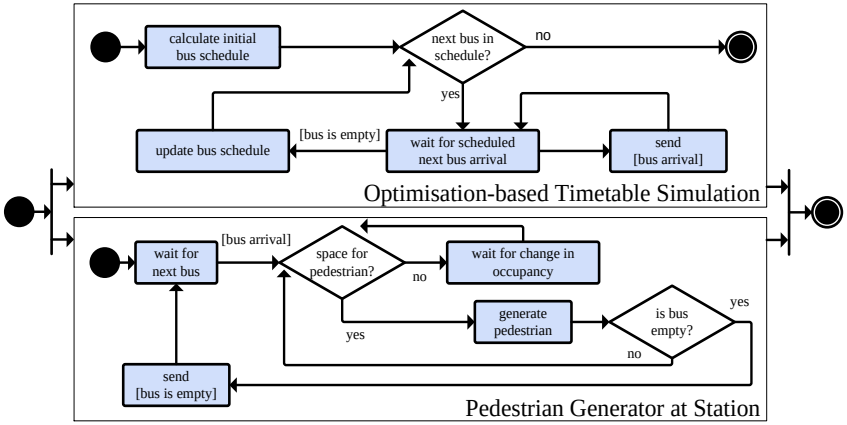


[1] Biedermann, D. H., Kielar P. M., Handel, O., Borrmann, A. 2014. Towards TransiTUM: A generic framework for multiscale coupling of pedestrian simulation models based on transition zones

Coupling of the mesoscopic and macroscopic scale

- Shuttle buses as arrival traffic
  - determines pedestrian inflow
- Pedestrians influence shuttle buses
  - time delay by exiting passengers
  - more realistic simulation
- Data exchange necessary
  - Communication Protocol

Torchiani, C. et al. (2015), Fahrgastwechselzeiten von Shuttlebussen



Case Study: Back to the Woods music festival

Case Study: Back to the Woods music festival

- Back to the Woods
  - 5000 visitors
  - Campus Garching
- Arrival Traffic
  - depends mainly on subway
- Simulation scenario:
  - subway breakdown
  - shuttle buses have to substitute

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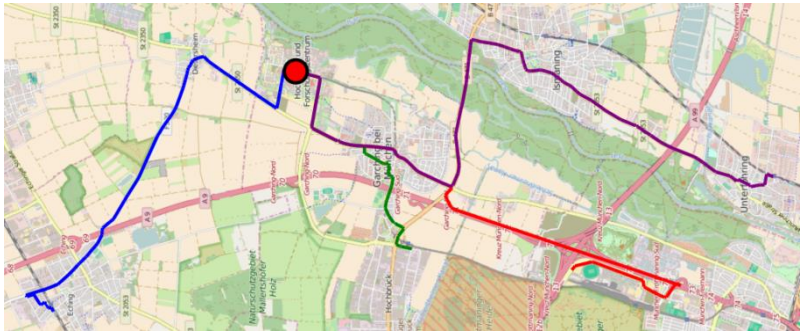
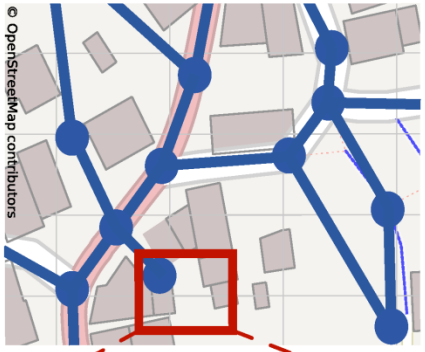
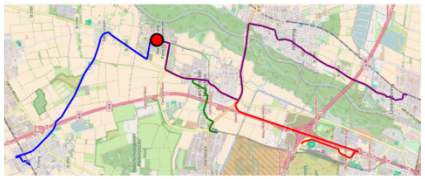
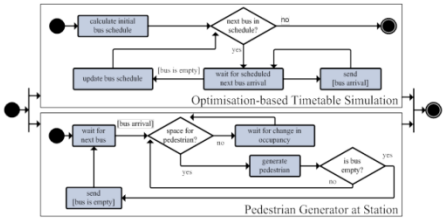
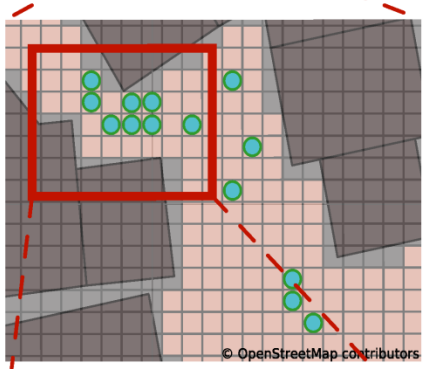


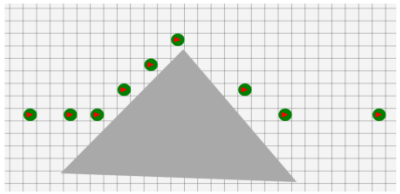
Spatial Scale	Simulation Models	Transition Models
Macroscopic Scale	Shuttle Bus Simulation	Communication Protocol
Mesoscopic Scale	Cellular Stock Model	TransiTUM Model
Microscopic Scale	Social Force Model	

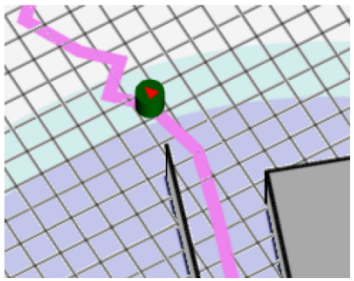


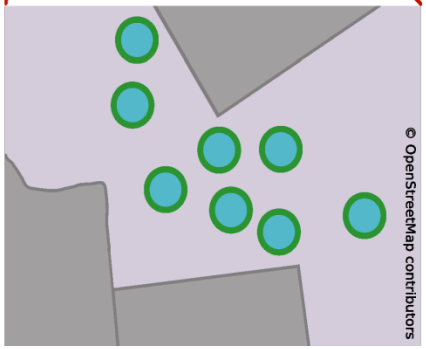


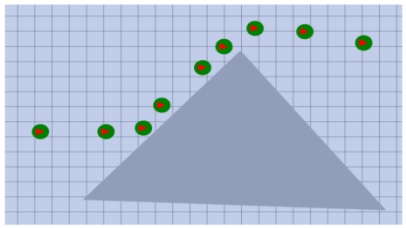












Thank you for your Attention!

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