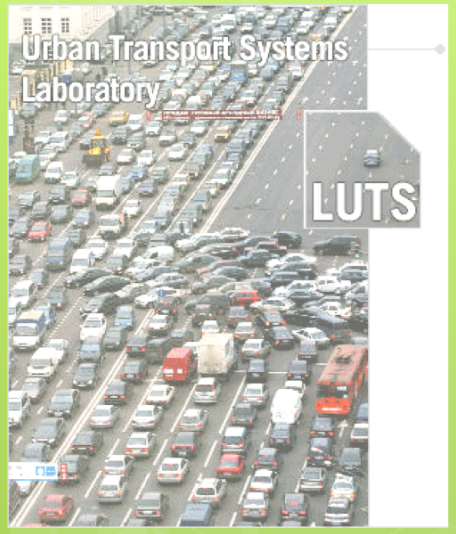

FTOC

Multimodal Traffic Management:

- Monitoring Control
- Space Allocation
- Congestion Pricing

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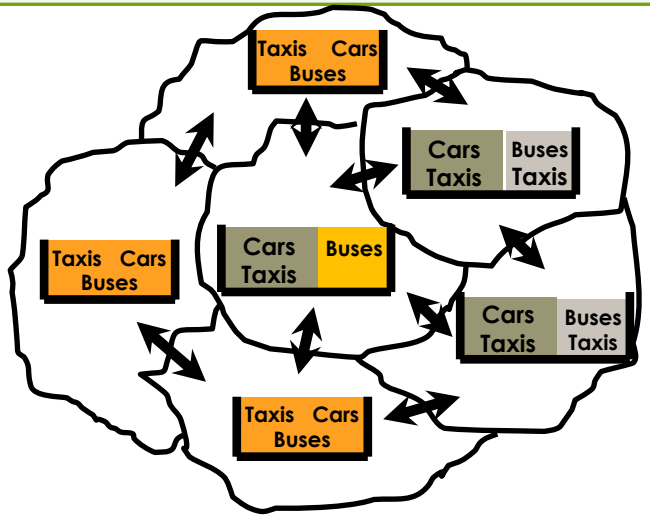
Multimodal Urban network

Modal Competition
Passenger mobility
Smart control



Space competition

Mode conflict

Smart controls

Passenger measures

Parking limitation

Multimodal networks

- Movement conflicts in multimodal urban traffic systems of shared space
- Transit stops affect the system like variable red signals in a single lane (instead of blocking all lanes)
- Increasing bus frequency decreases the flow of vehicles but can increase the flow of passengers.
- Monitoring congestion and developing more sustainable cities

•Competing modes
•Parking
•Pax vs. veh throughput

MULTIMODAL CITIES

Performance Measures

Vehicle Hours Traveled
Vehicle Kilometers Traveled

Passenger Hours Traveled
Passenger Kilometers Traveled

Mobility (Accessibility)

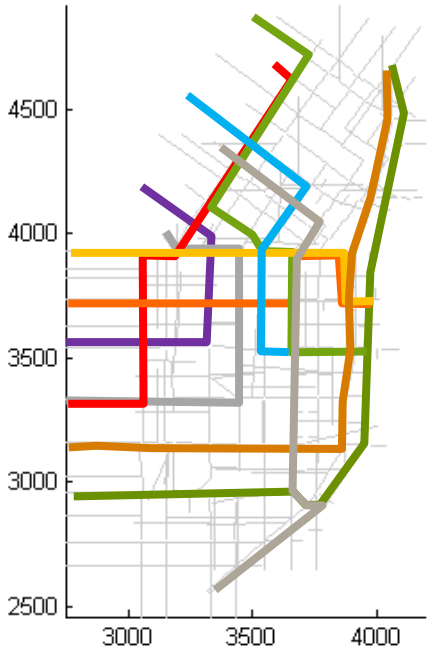
Emissions (Environ. Impacts)

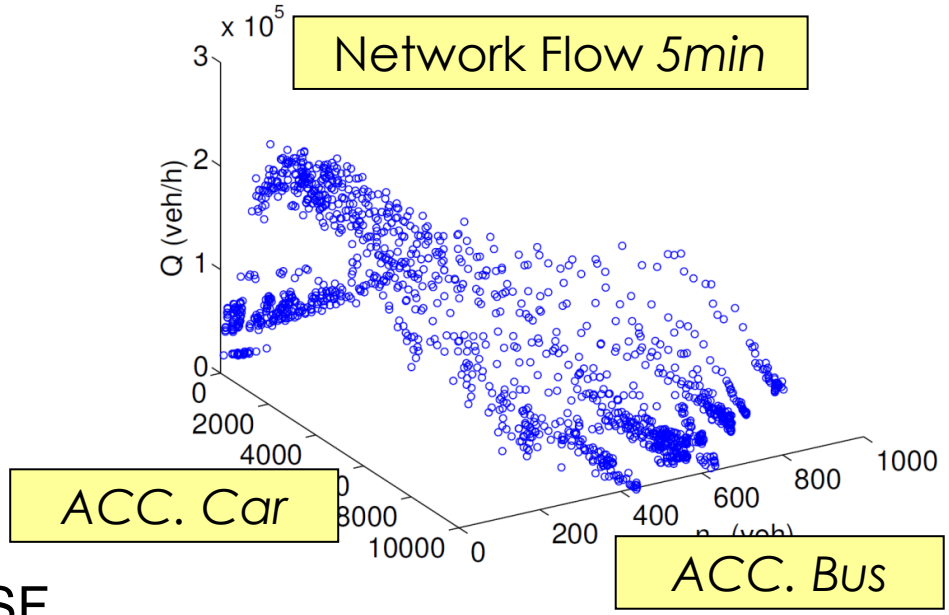
Costs (Users, Providers, etc.)

Road Space Used

Multimodal traffic flow characteristics and control

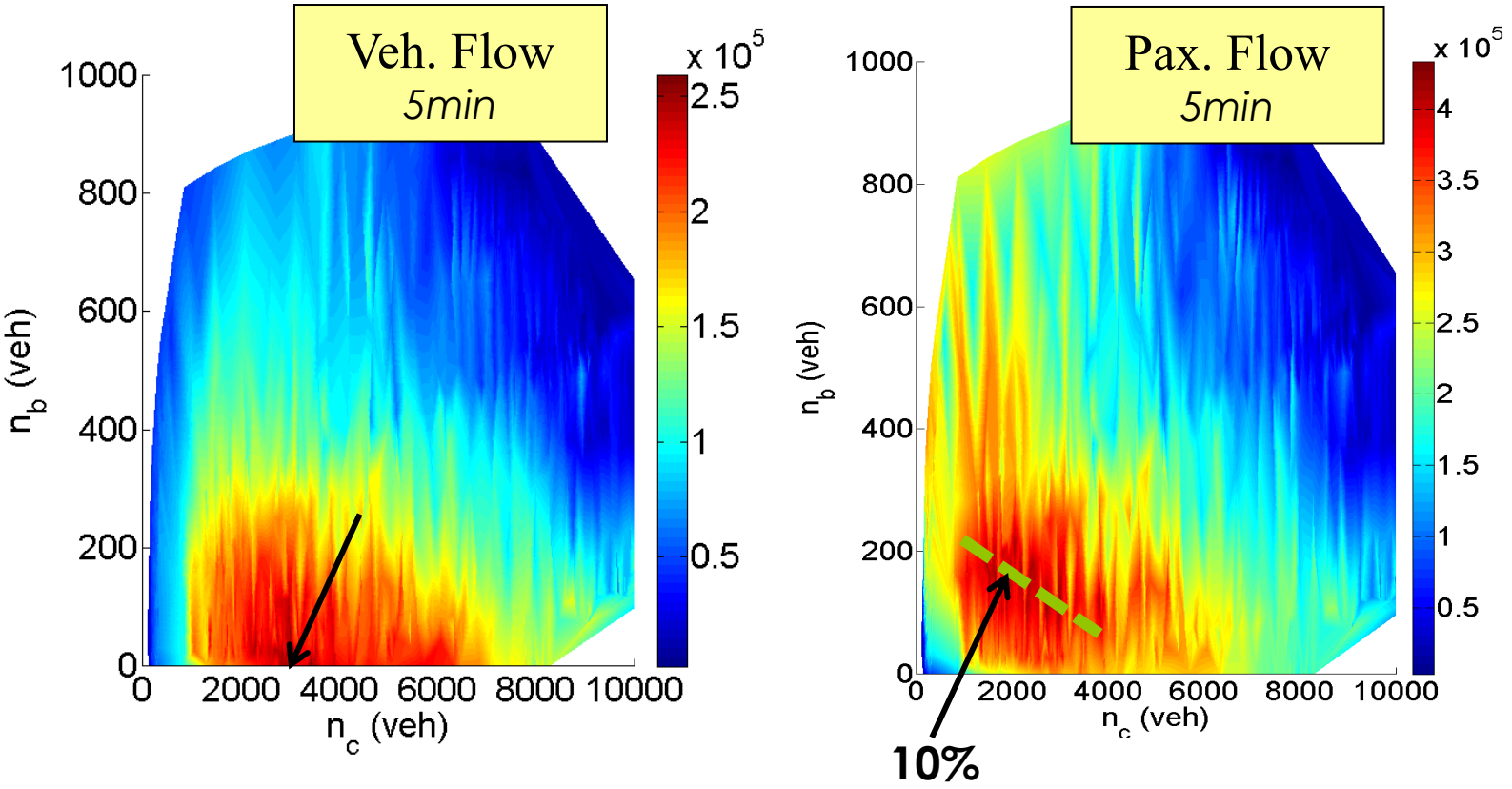
Bi-modal 3D MFD (car and bus)





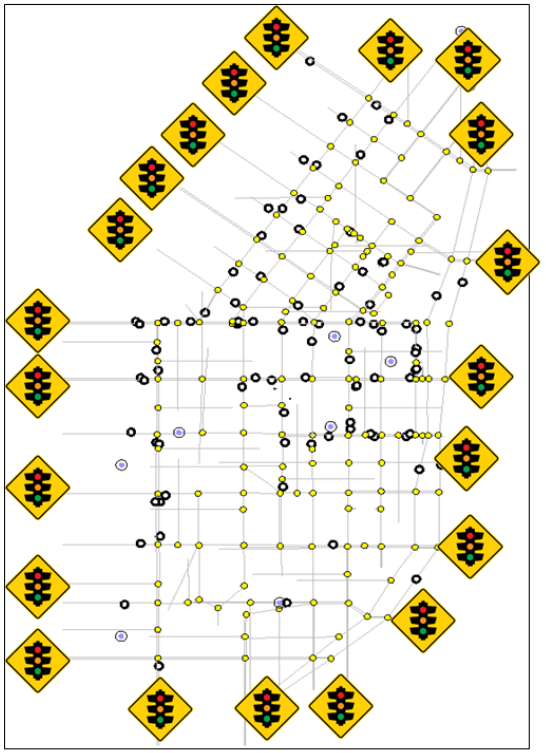
Simulated data – Downtown SF,
400 links (signalized),
30 bus lines, frequency 3-20min

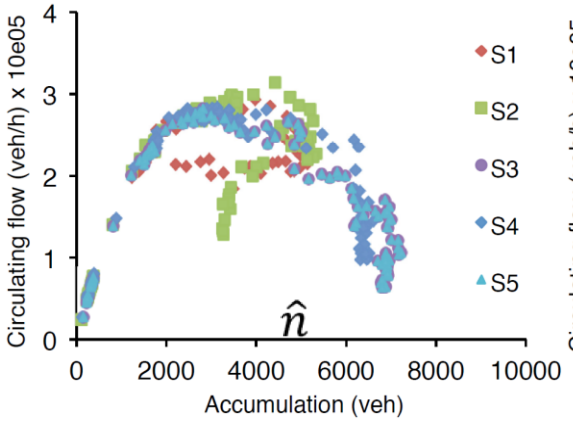
Contour plot
3D-MFDs: vehicle vs. passenger

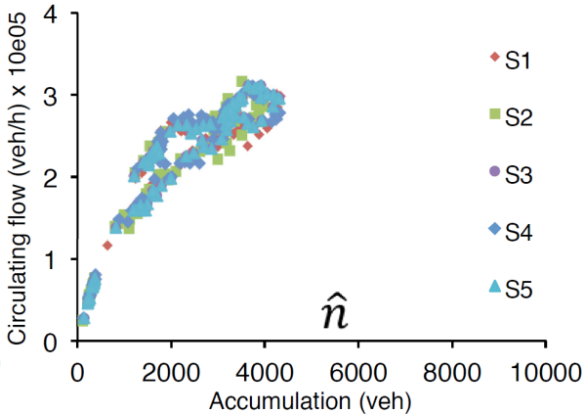


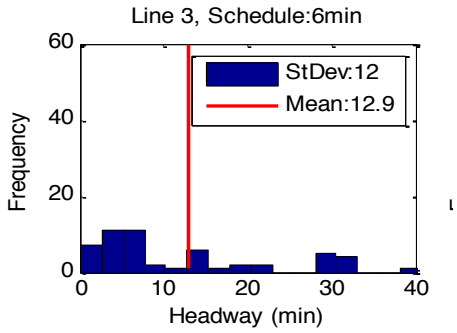
Simulated data – Downtown SF

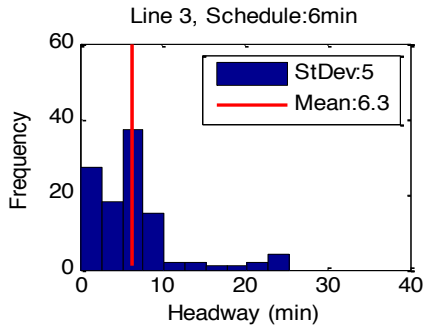
Traffic management
Perimeter flow control

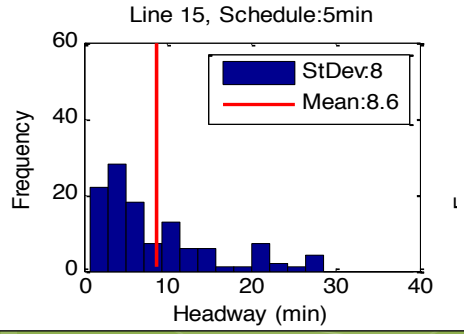


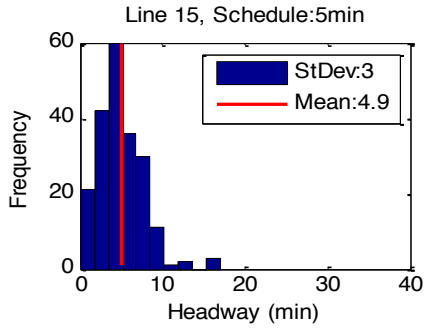












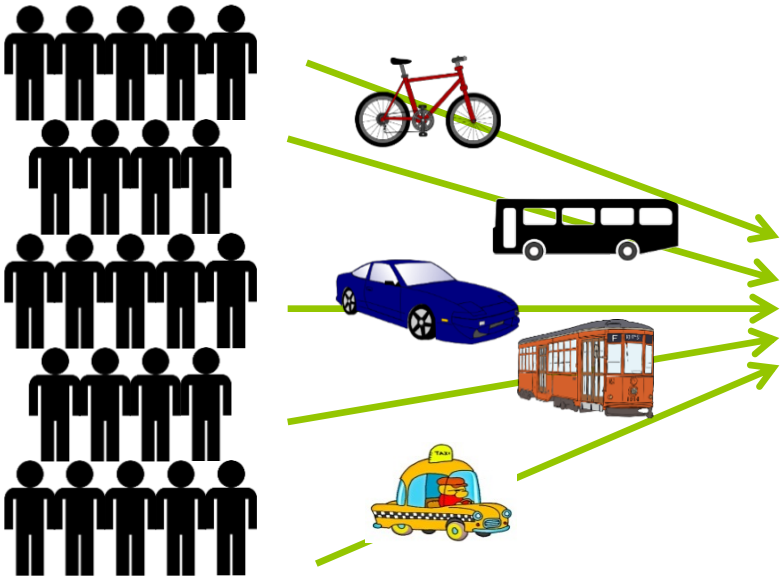
$$\beta(t) = \hat{\beta} - K[n(t) - \hat{n}]$$

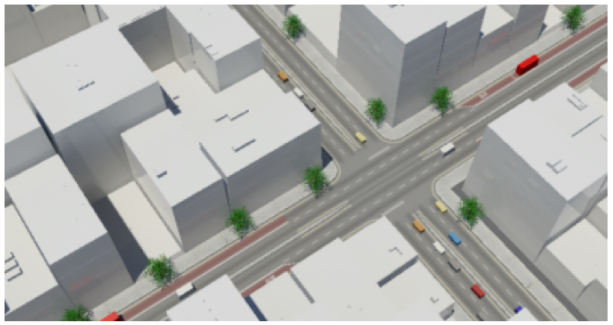
To think…

What types of traffic data do we need to monitor and control multimodal networks?

How could we obtain such data?

Space allocation policy for multimodal urban networks

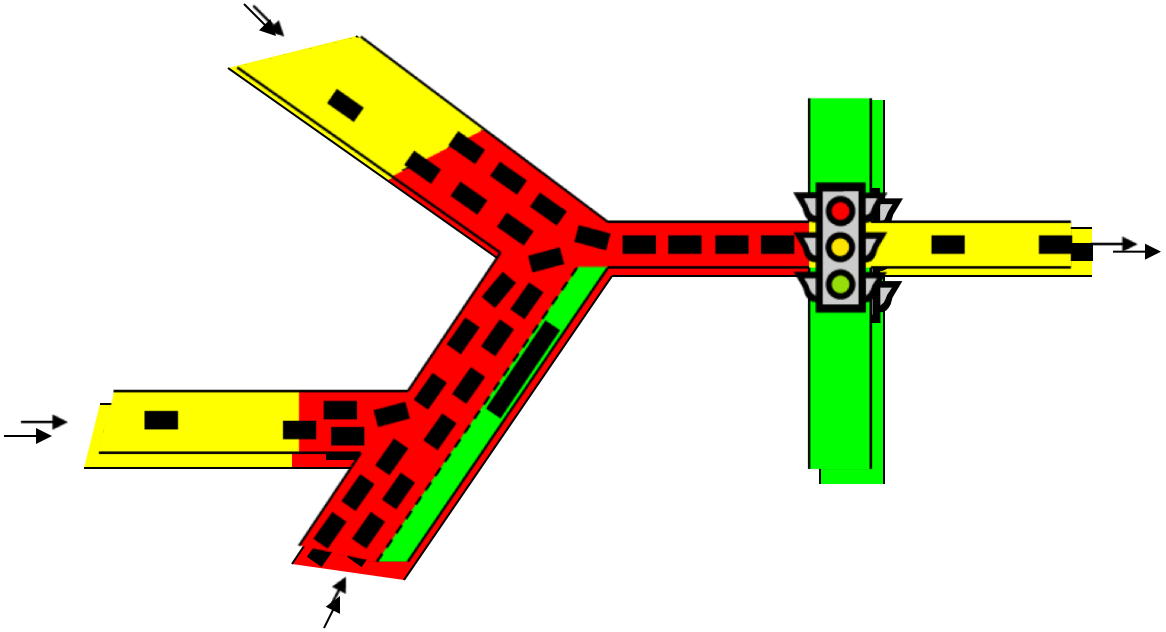




- People travel with different modes compete for limited urban space.
- We need to understand:
  - How this space is used
  - How it can be managed to improve
    - Accessibility
    - Sustainability

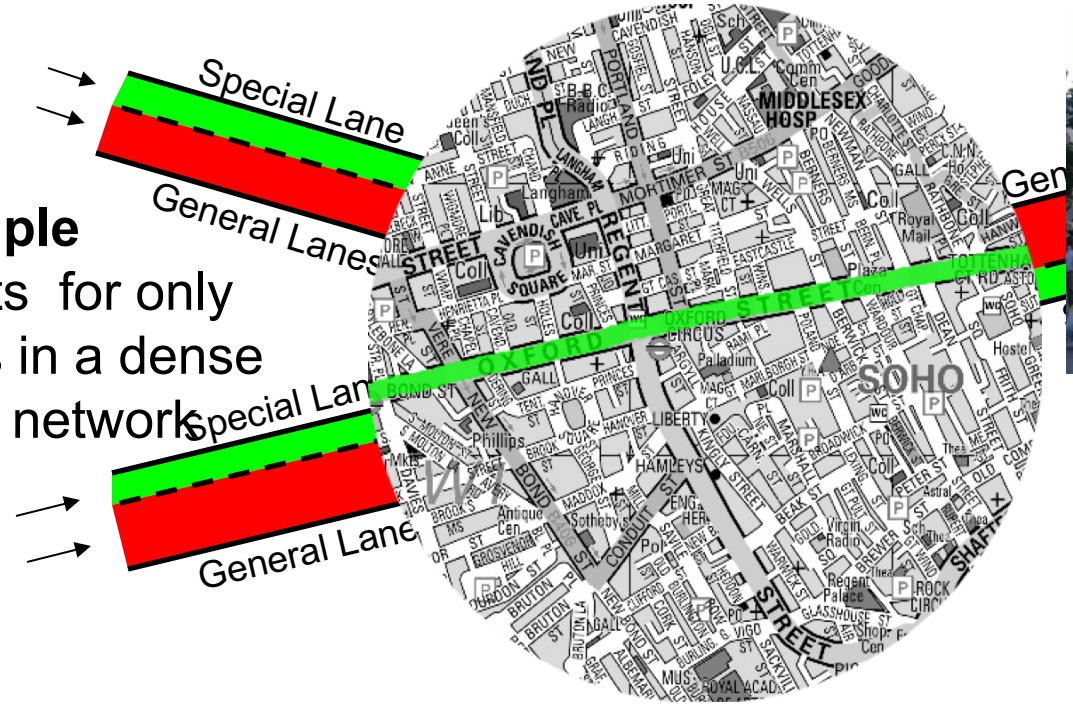
- Macroscopic methodology to model traffic with different modes
- How throughput of passengers depends on system characteristics
- How to allocate city space to different transportation modes

Infrastructure unequally available over a city



Queues form at locations with limited capacity,
but spill-over to other locations

Need not provide special lanes everywhere



Example
Streets for only buses in a dense urban network

Provide bypasses for more efficient modes around much (if not all) congestion

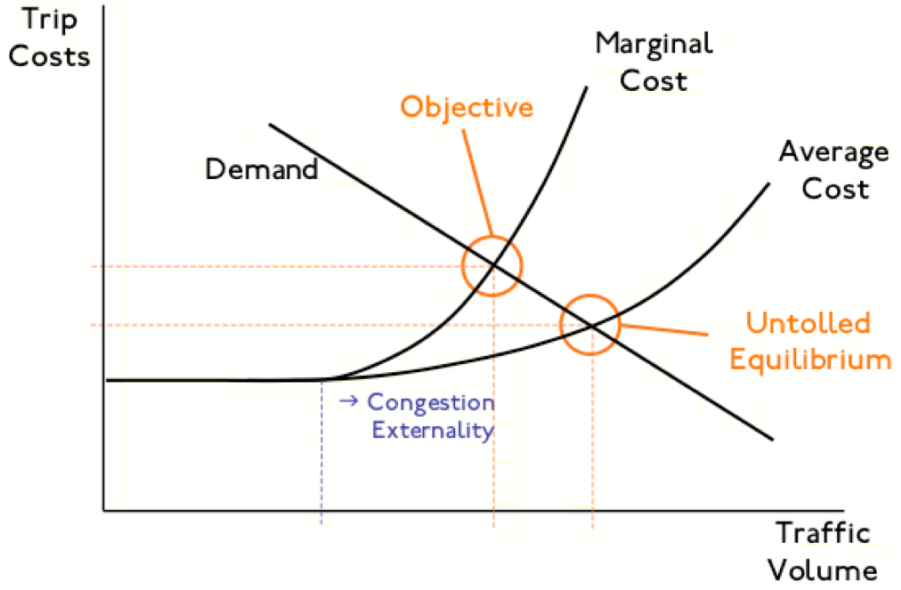
Congestion pricing schemes for urban networks

Concept

- Direct charge for road use (time, area, distance)
- Discourage use of vehicles (class, fuel, polluting)
- Revenue generation (infrastructure, public transport)
- Traffic management on externalities (travel time, emission, noise)

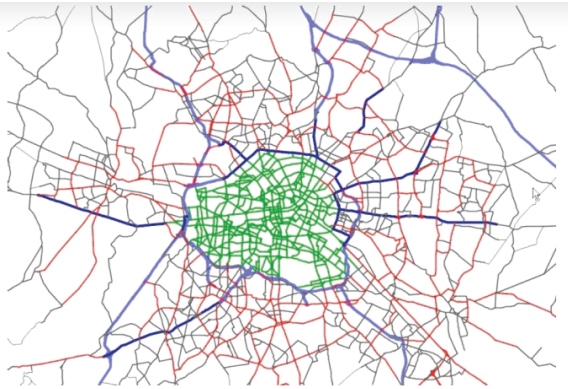
Basic principle

- Who use who pays
- Economic rationale



Types of pricing

- Variable lanes (HOV)
- Corridors/roadways
- Cordon pricing (Stockholm)
- Area pricing (London, Singapore)



To think…

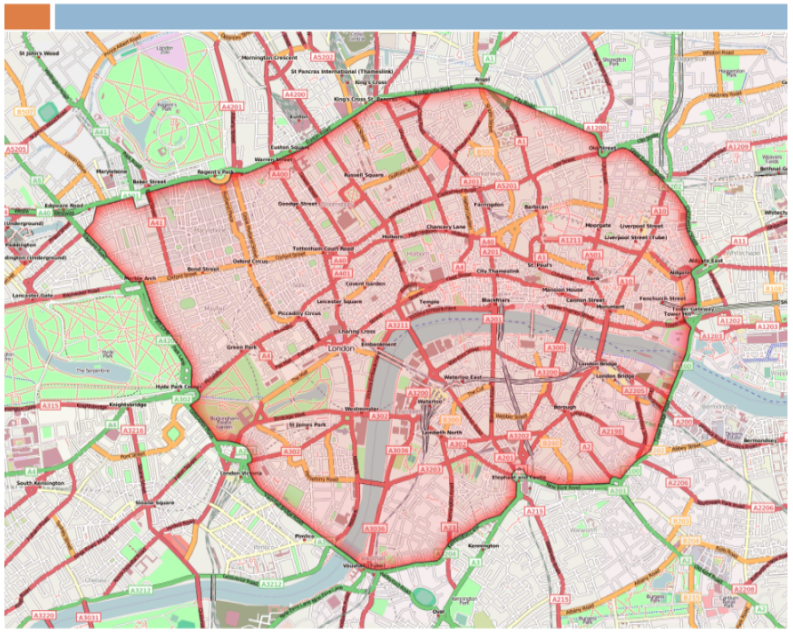
Which type of pricing works better under each of the goals below?

- To reduce congestion in the CBD region?
- To reduce general congestion with fairer toll?
- To encourage high-occupancy pooling travel?

Real life case - London

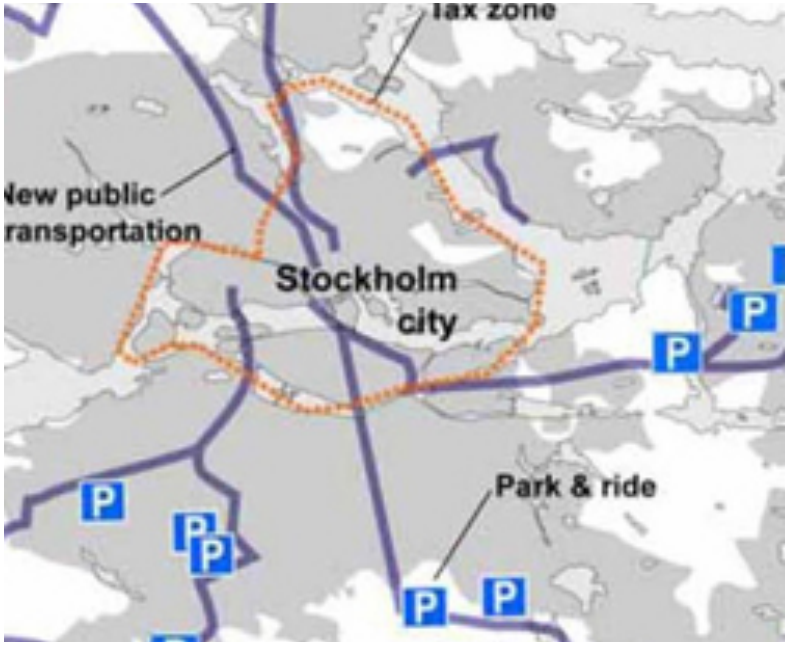
- Area pricing
- Powerful transit system
- Congestion no better…

(Bad space reallocation)



Real life case - Stockholm

- Cordon pricing
- Wide acceptance
- Traffic reduction
- Reasonable prices



Real life case - Singapore

- Dynamic pricing
- Regular adjustment (v~[30 40km/h])
- High operation cost

Limited field implementation (low acceptance)

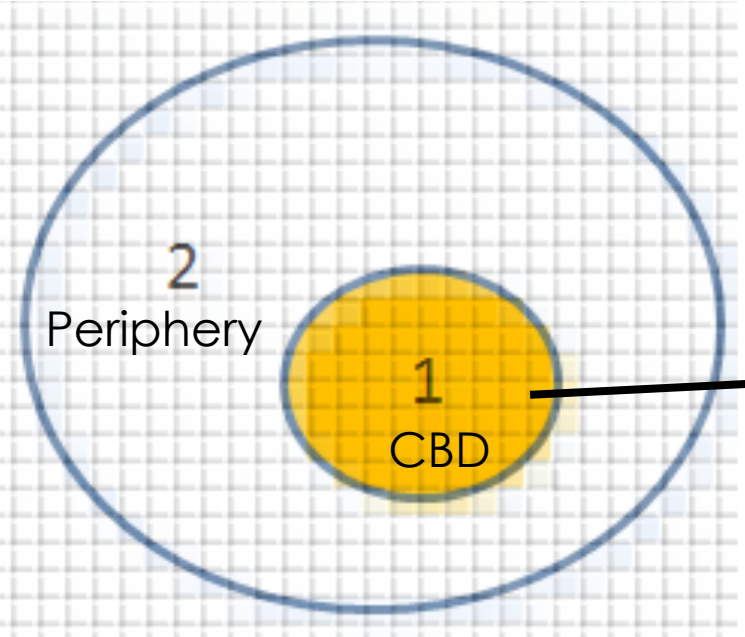
- Insufficient traffic reduction
- Costly to apply (operation, data)
- Insufficient effort on public transport
- Non-equitable policies and incentives

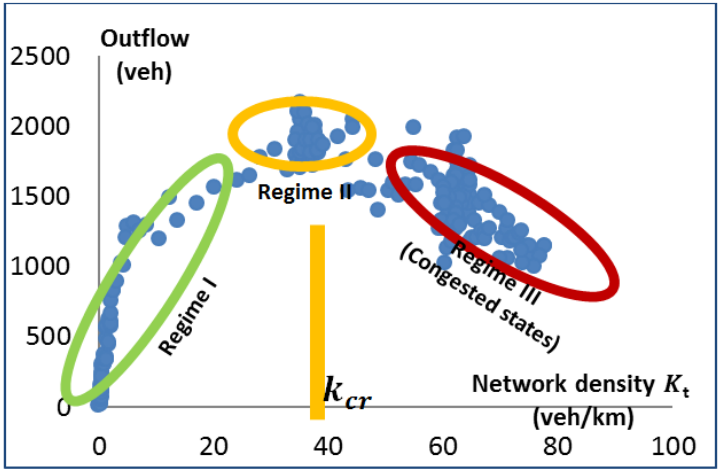
Sustainable pricing

- Applicable at city-level
- Capture congestion dynamics
- Control congestion efficiently
- Incentivize public transport

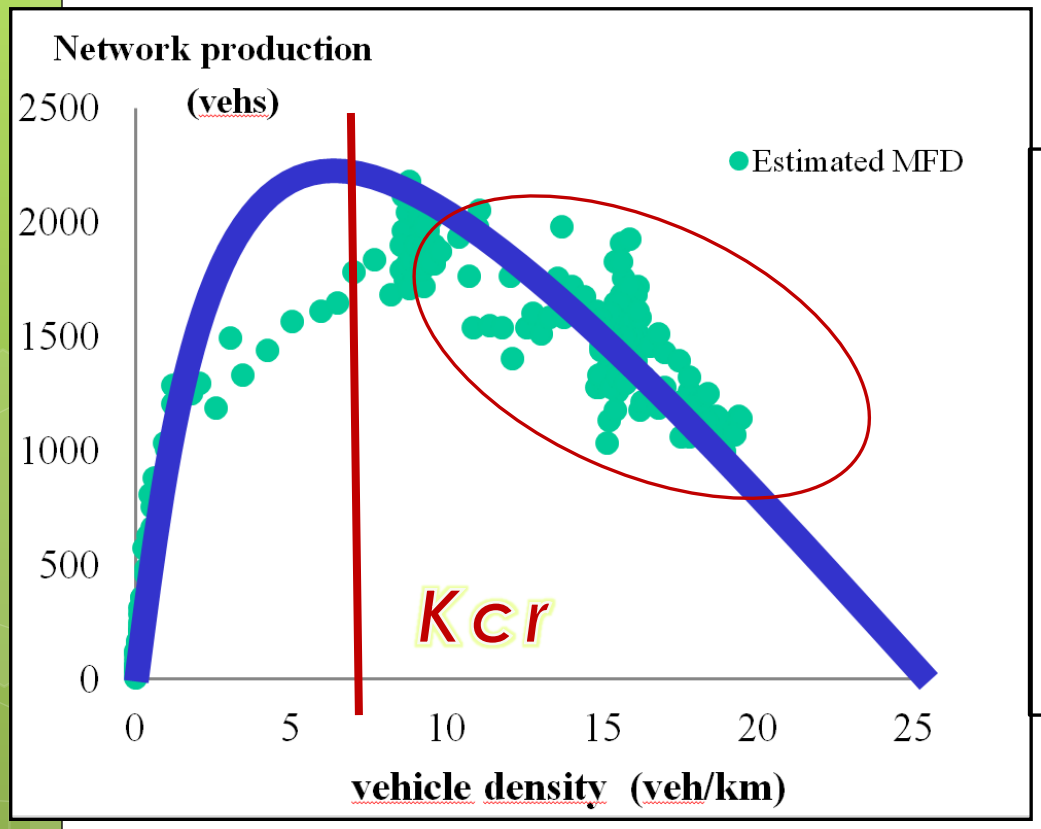
- MFD-based pricing
- Incentivize public transport

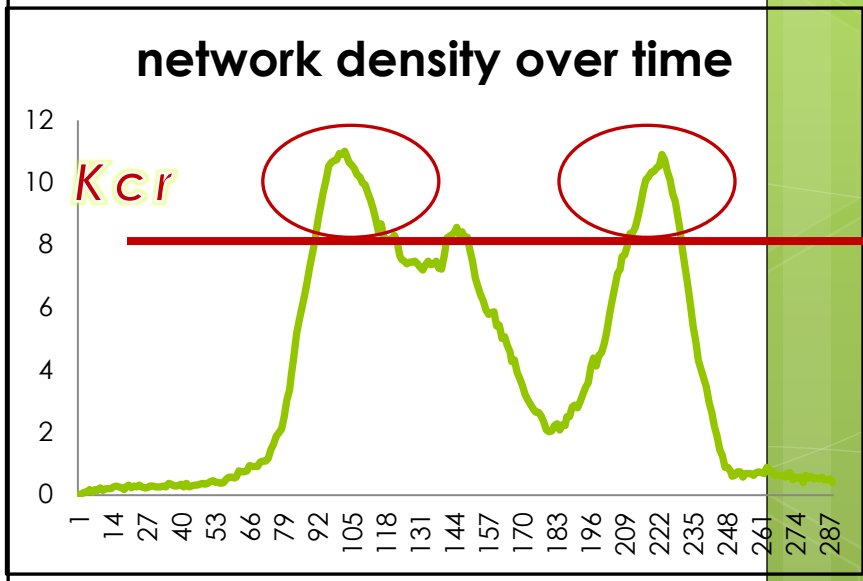
MFD-based pricing scheme



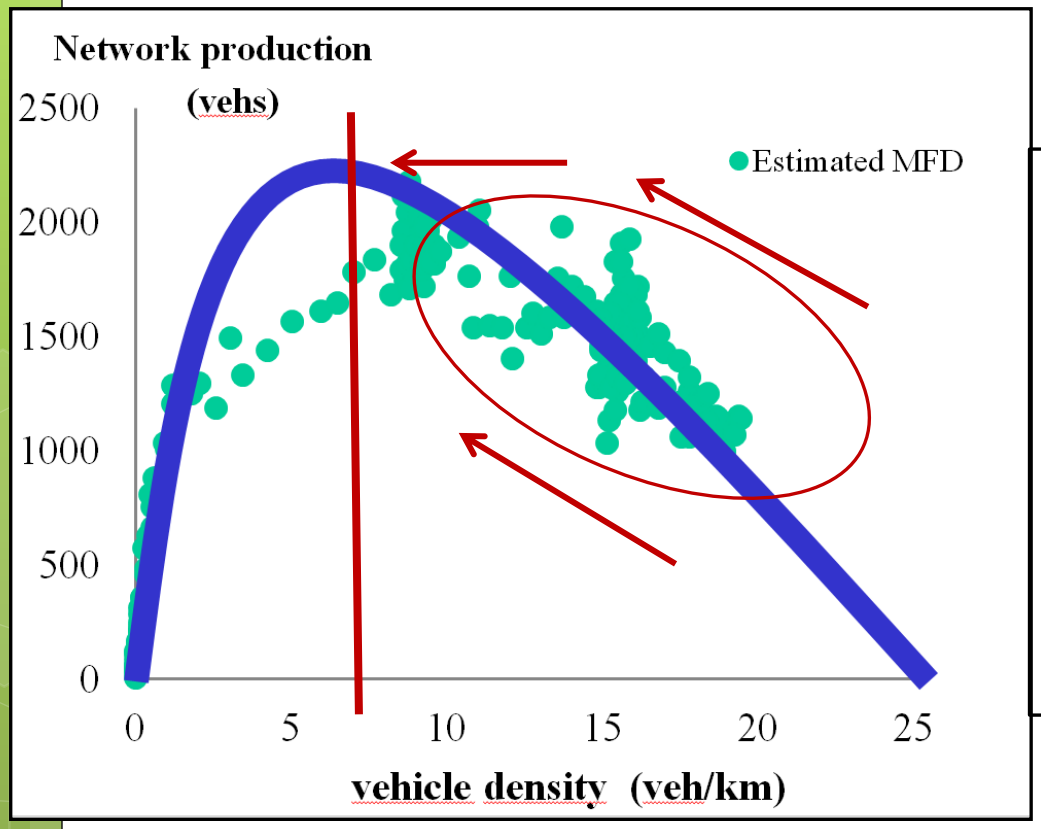


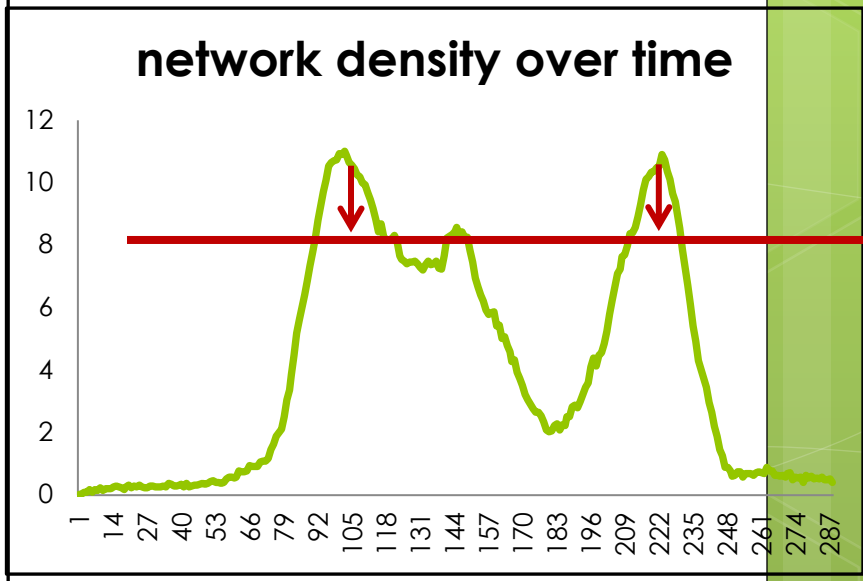
MFD-based pricing scheme





MFD-based pricing scheme





MFD-based pricing control

- Drivers adaptation
- Monitor ***Kt***, Set ***Tollt***, Monitor, Adjust price ……

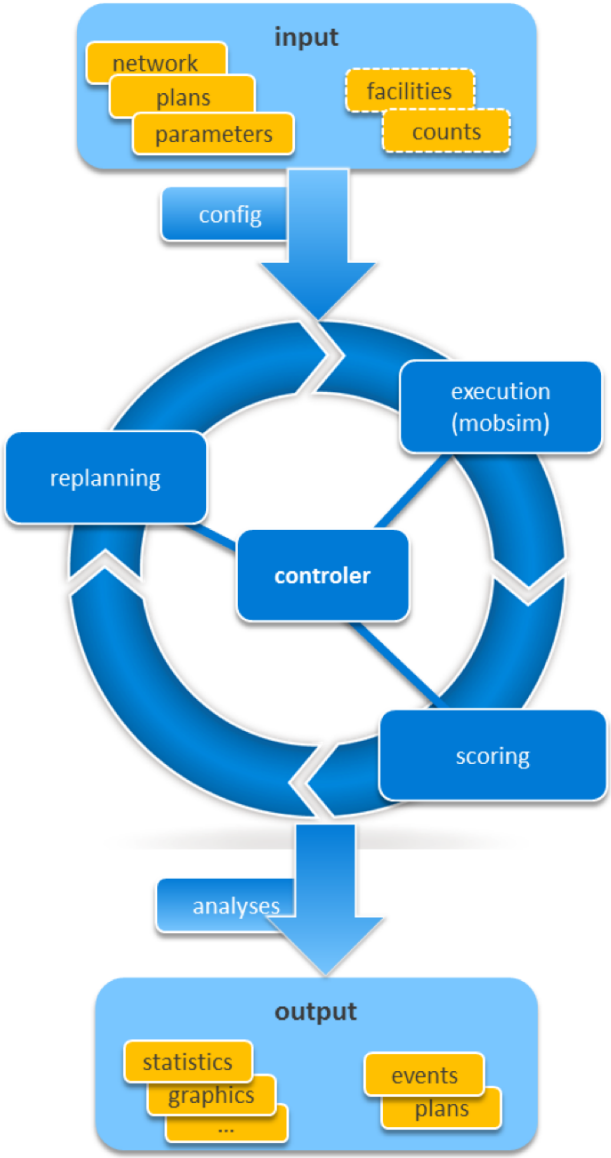
- Feedback-controlled dynamic pricing scheme

$$Toll_t(n+1) = Toll_t(n) + c(K_t(n) - K_{cr})$$

- n : the n-th price adjustment (e.g. every month)
- K_{cr} : control objective
- c : control gain parameter

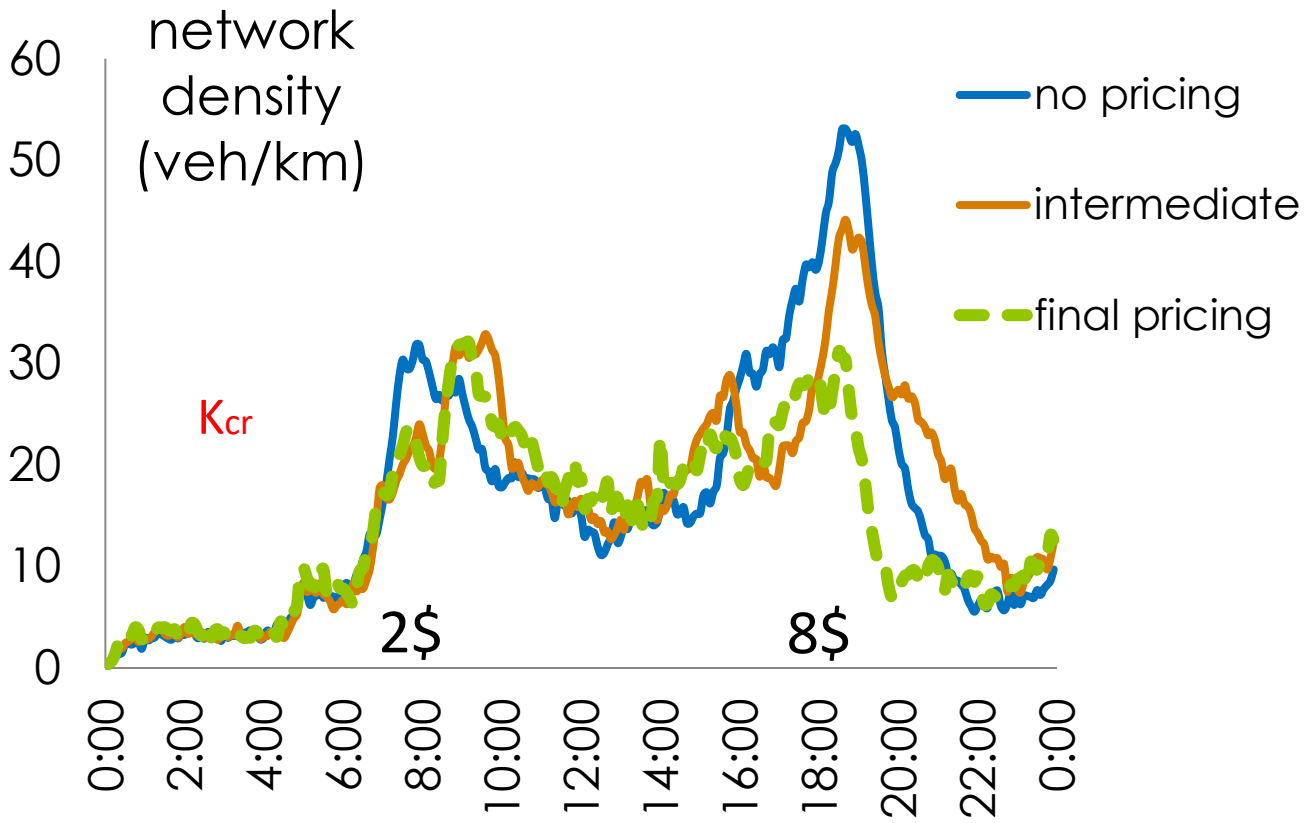
Test environment: agent-based simulator MATSim

- Activity-based plan
- Complex utility
- User heterogeneity
- Behavioral adaptivity
- Made in Suisse

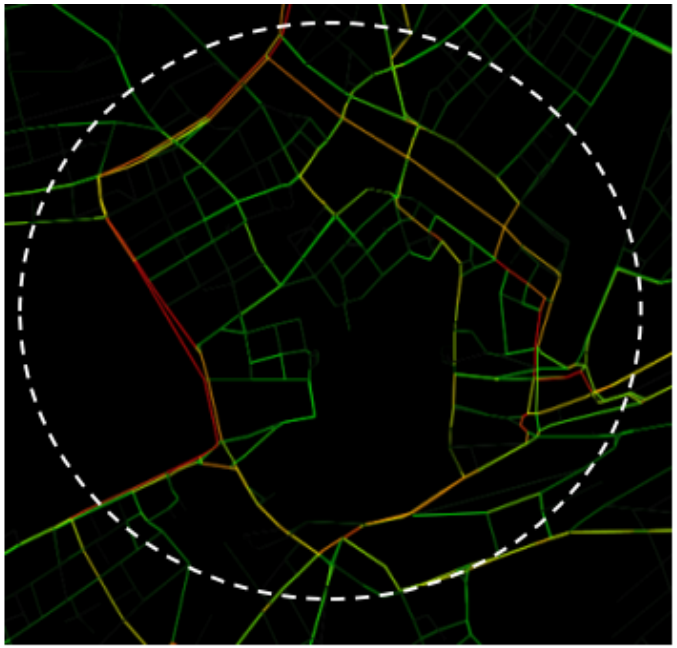


Case study 1:
Cordon Pricing in Zurich

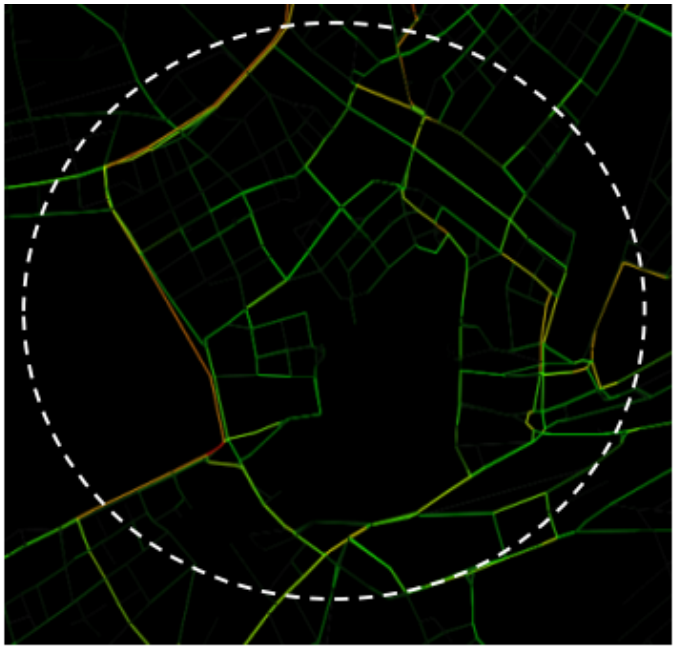
Density reduction over toll adjusts



Comparison of speed at 19pm



Before Pricing



After Pricing

Questions and discussions