Queuing under perimeter control: analysis and control strategy

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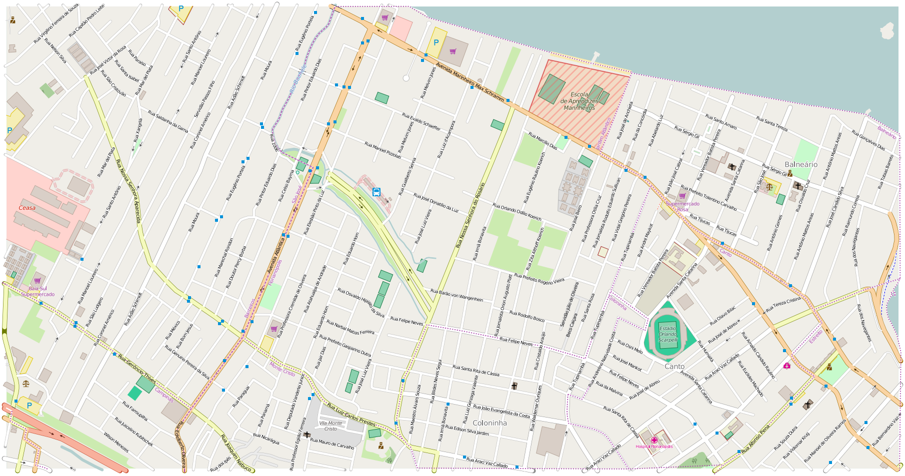
Perimeter control

What is it?



Perimeter control

What is it?

Perimeter control

What is new? What has changed?

NFD-based Perimeter Control

A new opportunity

Perimeter Control

What is wrong with that?

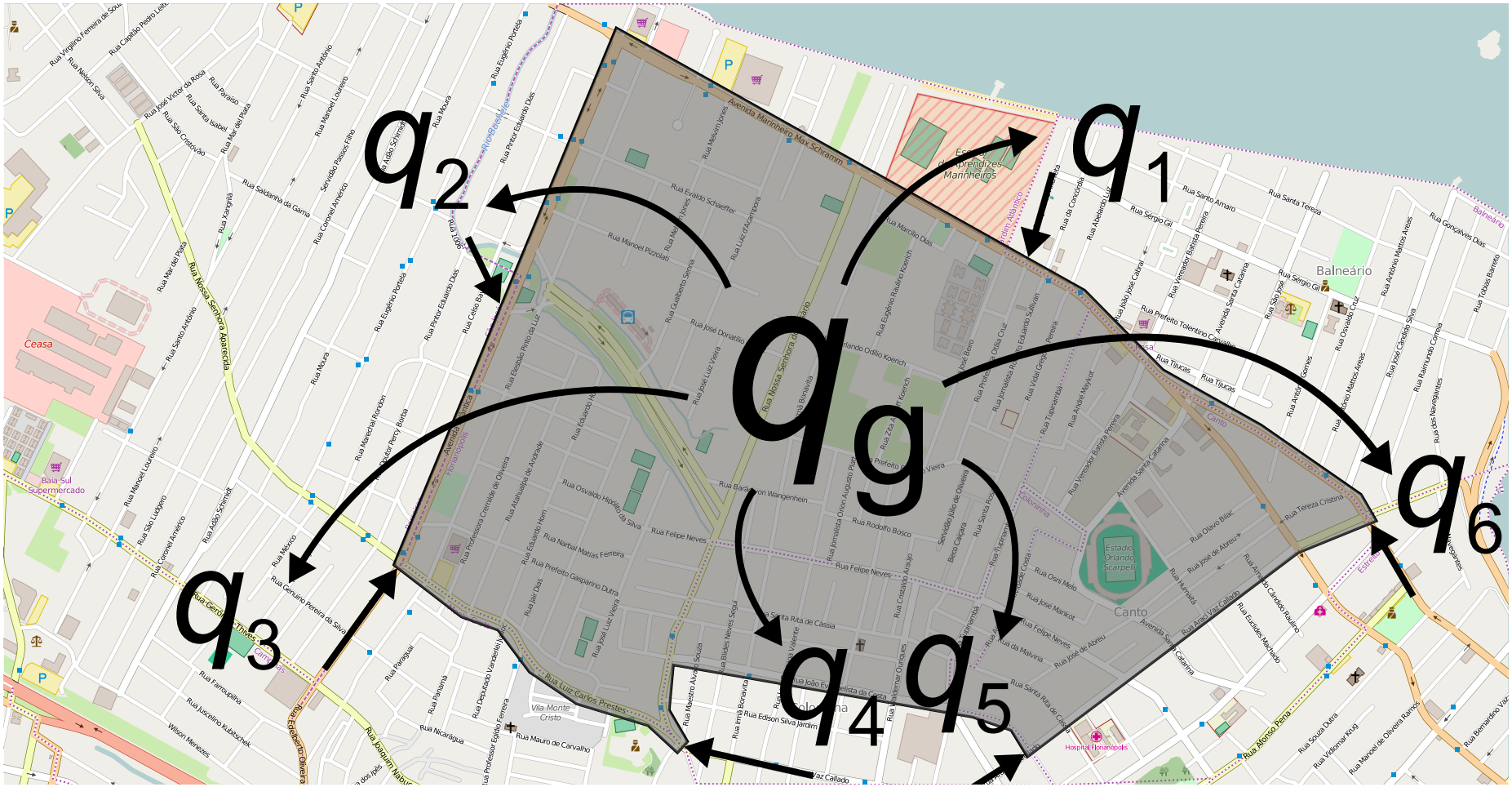
Feedback NFD-based Perimeter Control

Feedback regulator

$$q_{\mathrm{g}}(k) = q_{\mathrm{g}}(k-1) - K_{\mathrm{P}}\left[TTS(k) - TTS(k-1)\right] + K_{\mathrm{I}}\left[\hat{TTS} - TTS(k)\right]$$

Feedback NFD-based Perimeter Control

Flow distribution



$$\sum_{i=1}^{n} q_i = q_g \qquad q_{\min,i} \leq q_i \leq q_{\max,i}$$

Queue management

The queue model

$$N_i(k+1) = N_i(k) + T[d_i(k) - q_i(k)]$$

or

$$N_i(k+1) = A_i(k) - B_i(k)q_i(k)$$

with

$$A_i(k) = N_i(k) + Td_i(k) \text{ and } B_i(k) = T$$

Queue management

Queue balancing

$$\min \sum_{i=1}^{n} \left(\frac{A_i(k) - B_i(k) q_i(k)}{N_{\max,i}} \right)^2$$

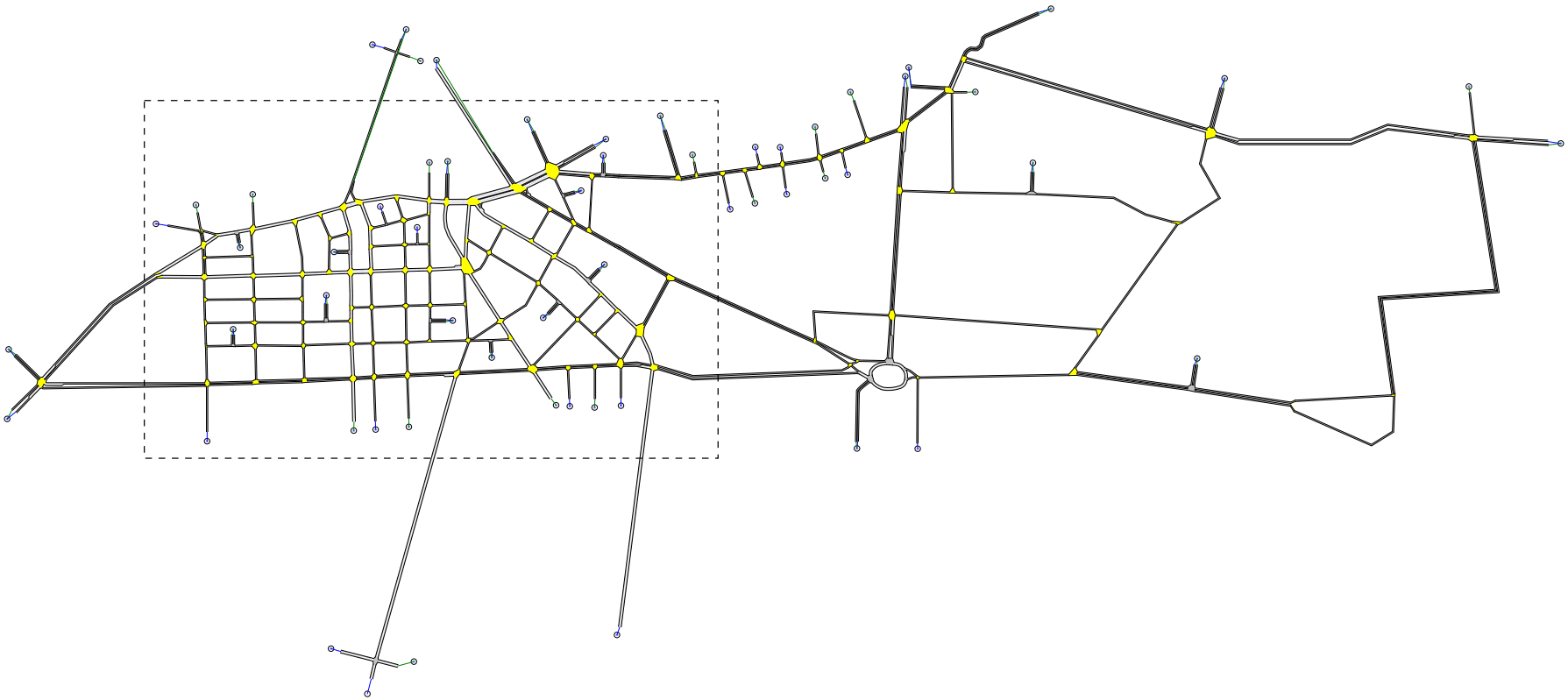
s.t.:

$$\sum_{i=1}^{n} q_i = q_{\mathrm{g}}$$

$$q_{\min,i} \leq q_i \leq q_{\max,i}$$

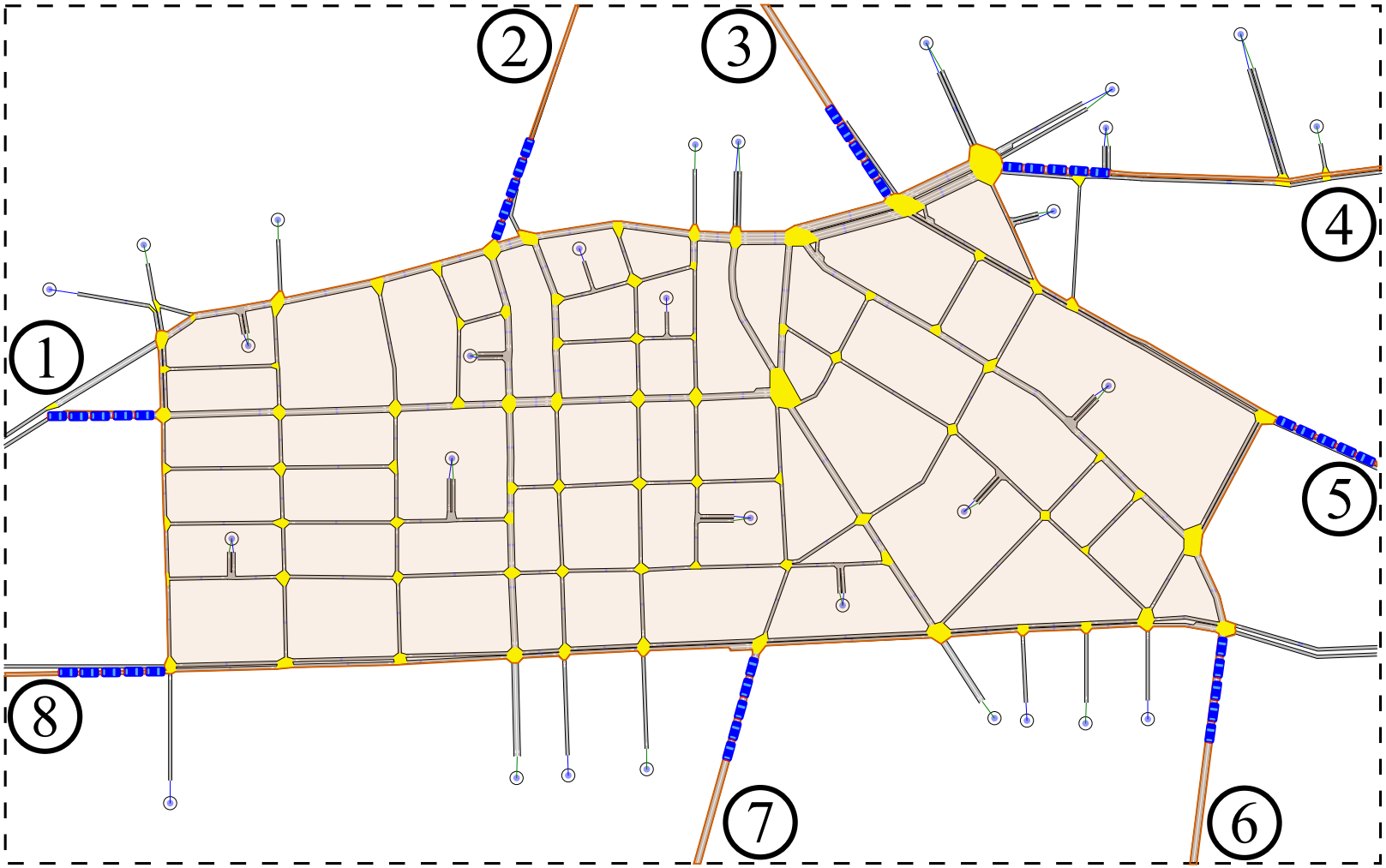
Simulation results

City center of Chania, Greece



Simulation results

Protected network and gated links



≈ 80 junctions — 27 with traffic lights and 165 links.

Simulation results

Scenarios

NPC - *no-perimeter-control*

Fixed-time traffic control

PC - *perimeter control without queue balancing*

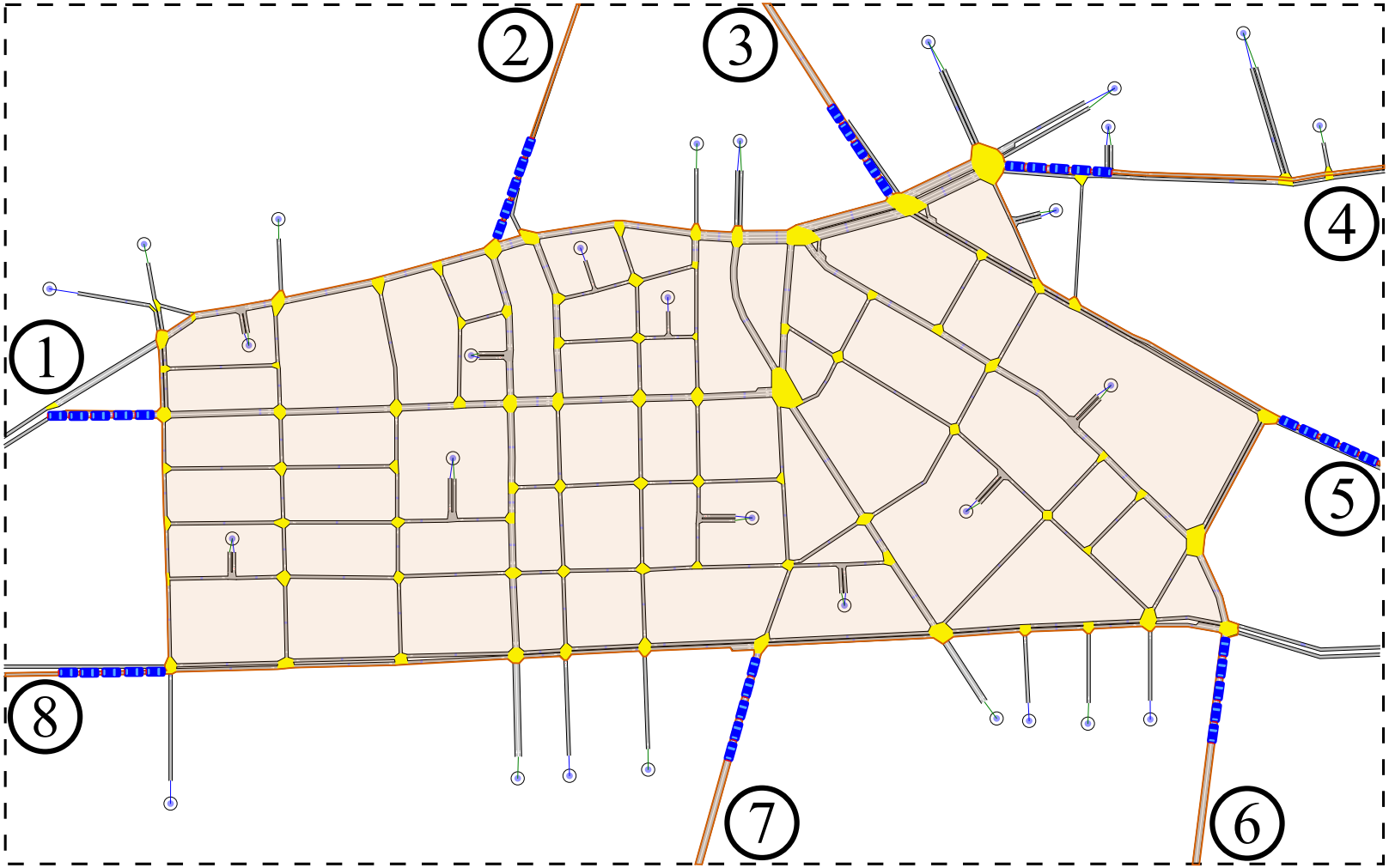
Feedback perimeter traffic flow control with the flow distribution based on links' saturation flows

PCQ - *perimeter control with queue balancing*

Feedback perimeter traffic flow control with the flow distribution from the solution of the relative queue balancing problem

Simulation results

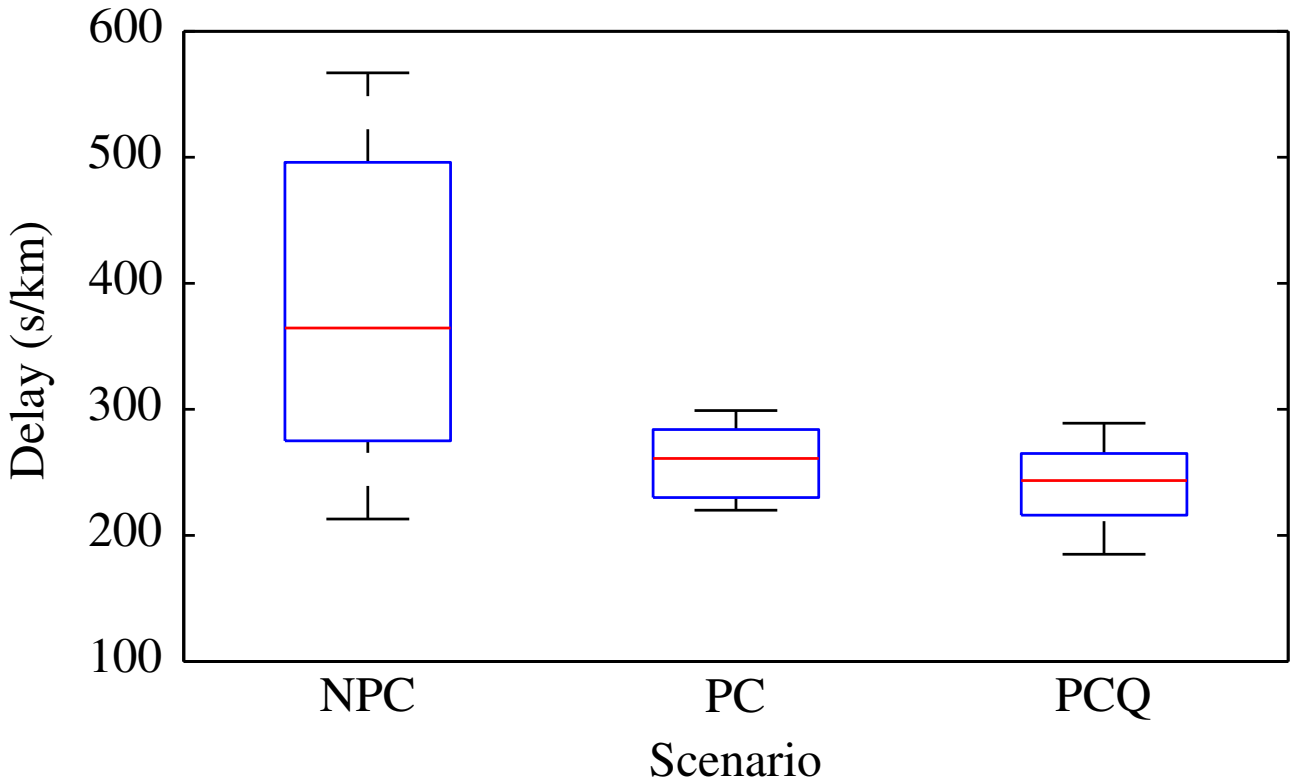
Simulation and control setup



$T\hat{T}S = 600$ veh·h/h, $K_\mathrm{P} = 20$ h^{-1} and $K_\mathrm{I} = 5$ h^{-1}, $T = 90$ s

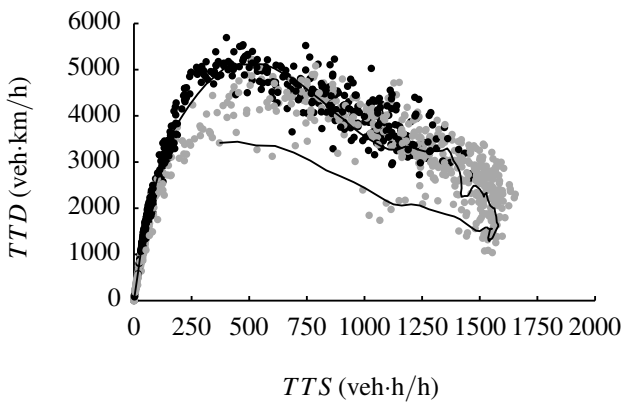
Simulation results

Network performance

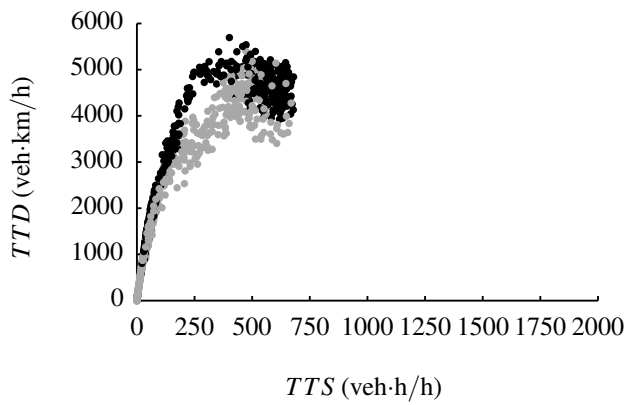


Simulation results

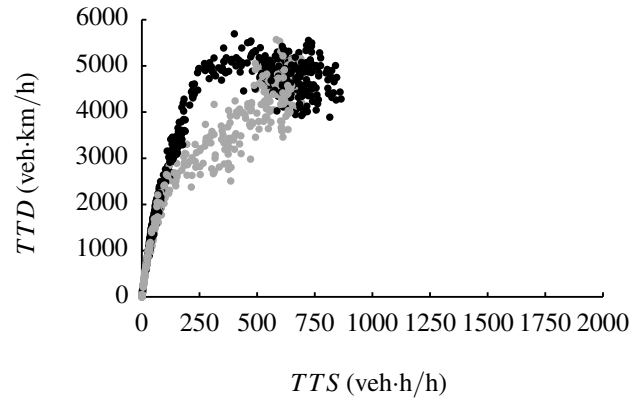
Analysis of the NFDs



NPC



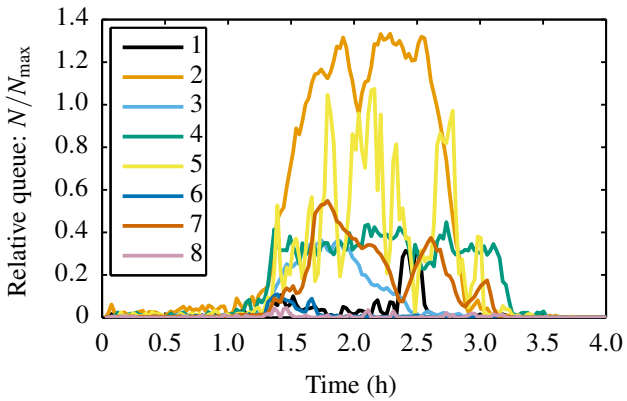
PC



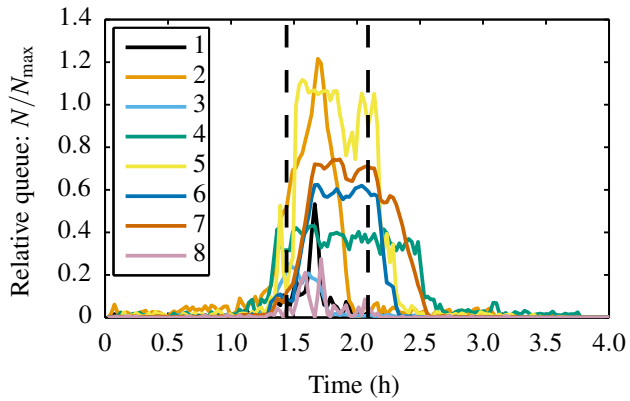
PCQ

Simulation results

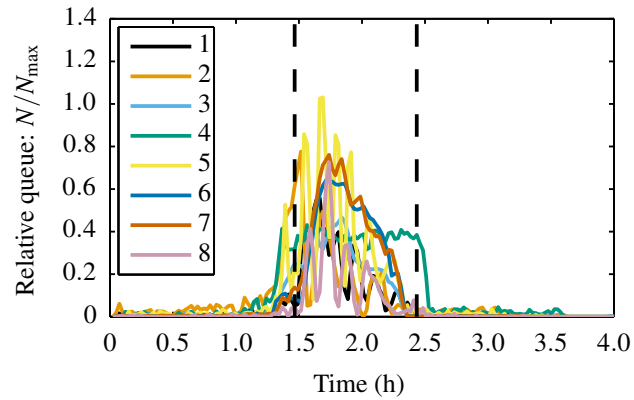
Analysis of relative queues



NPC



PC

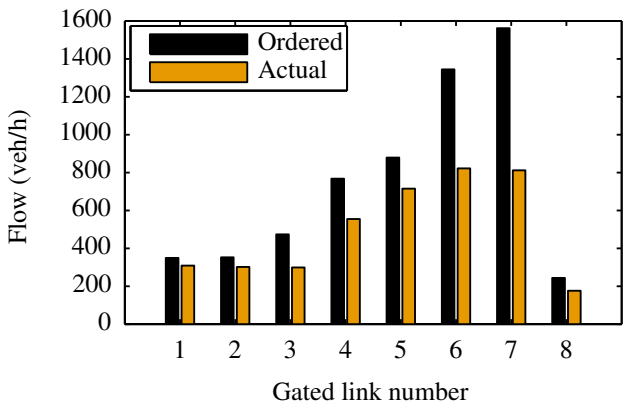


PCQ

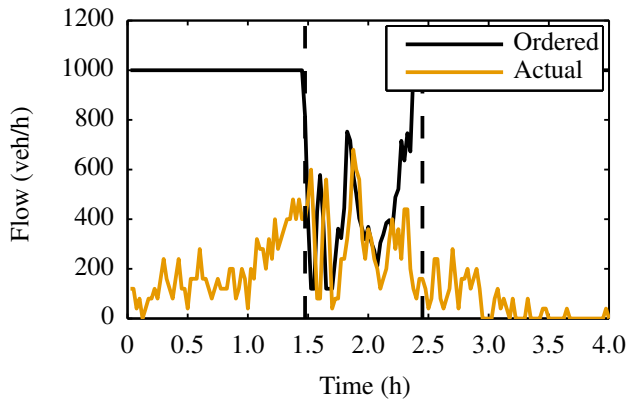
- PC does not necessarily lead to larger queues than in the NPC case
- Throughput is higher with PC!

Simulation results

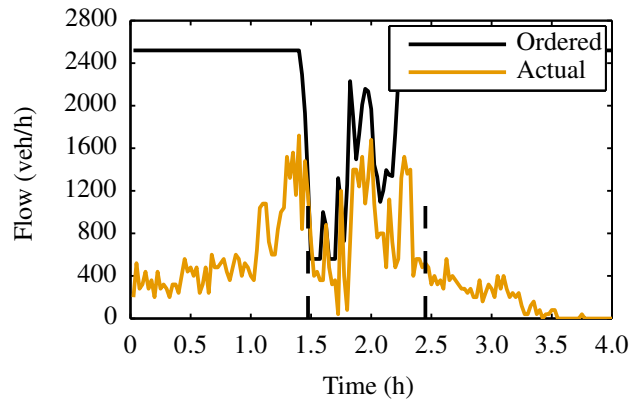
Analysis of relative queues (PCQ)



All links



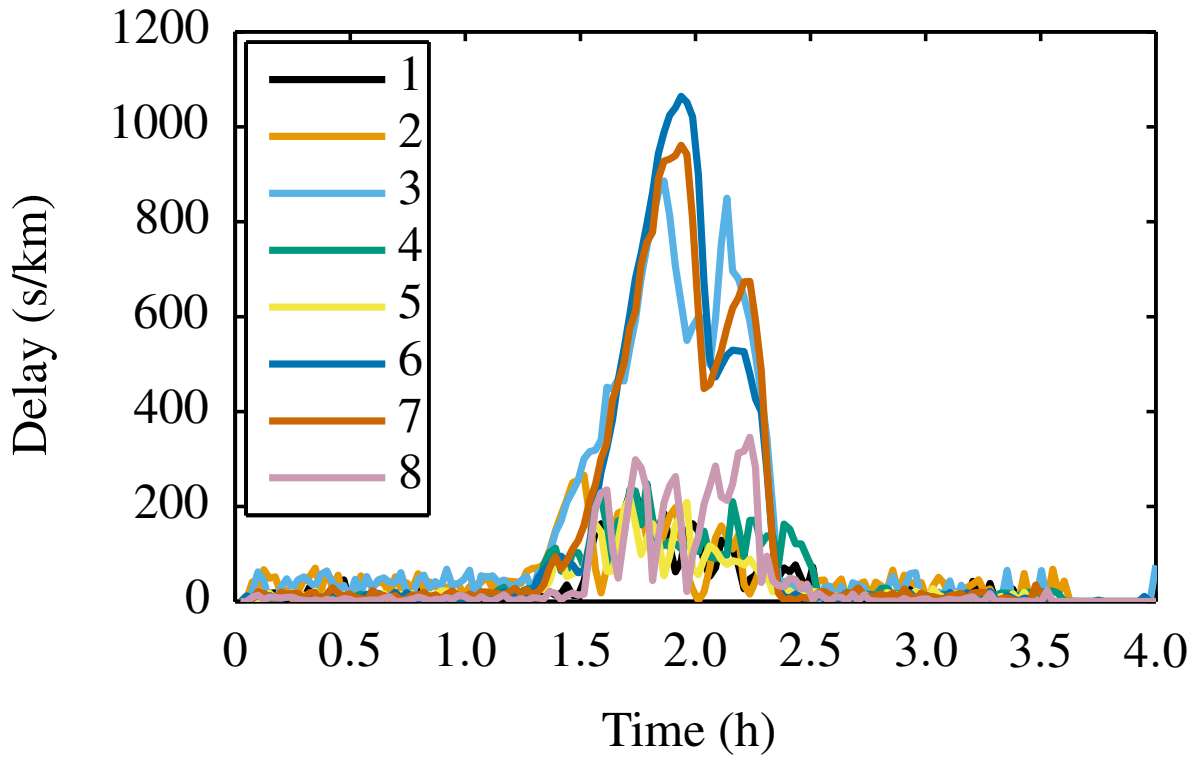
Gated link 3



Gated link 7

Simulation results

Analysis of delays



PCQ

Final remarks

- Higher throughput with PC and PCQ: smaller queues than with NPC
  - Less interference at upstream junctions
- Unbalanced queues caused by localized congestion
  - Avoid localized congestion within the PN by the use of traffic control
  - PCQ + adaptive traffic control!
- Unbalanced delays (fairness)
  - Delay balancing

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THANK YOU!

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