Combination of Traffic-Responsive and Gating Control in Urban Networks: Effective Interactions

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Main Contributions

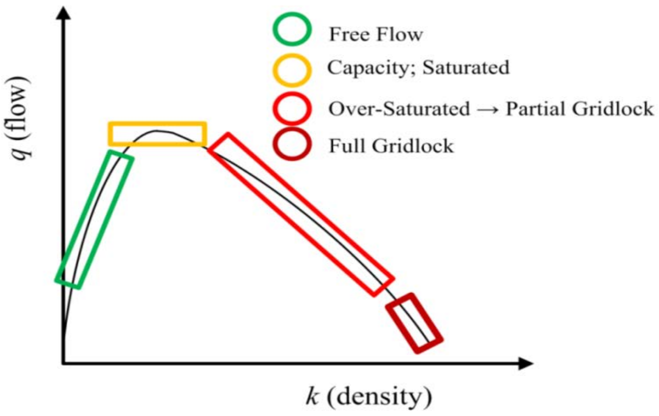
- Compared the impacts of adaptive signal control and perimeter gating (only)
- Examined the impacts of combining adaptive signal control and perimeter gating
  - The improved capacity and slightly higher critical accumulations on the MFD, as a result of traffic-responsive control, implemented for a more efficient gating
- Implemented in AIMSUN microsimulation of Chania urban network
- Impacts quantified using overall urban traffic network efficiency

Introduction

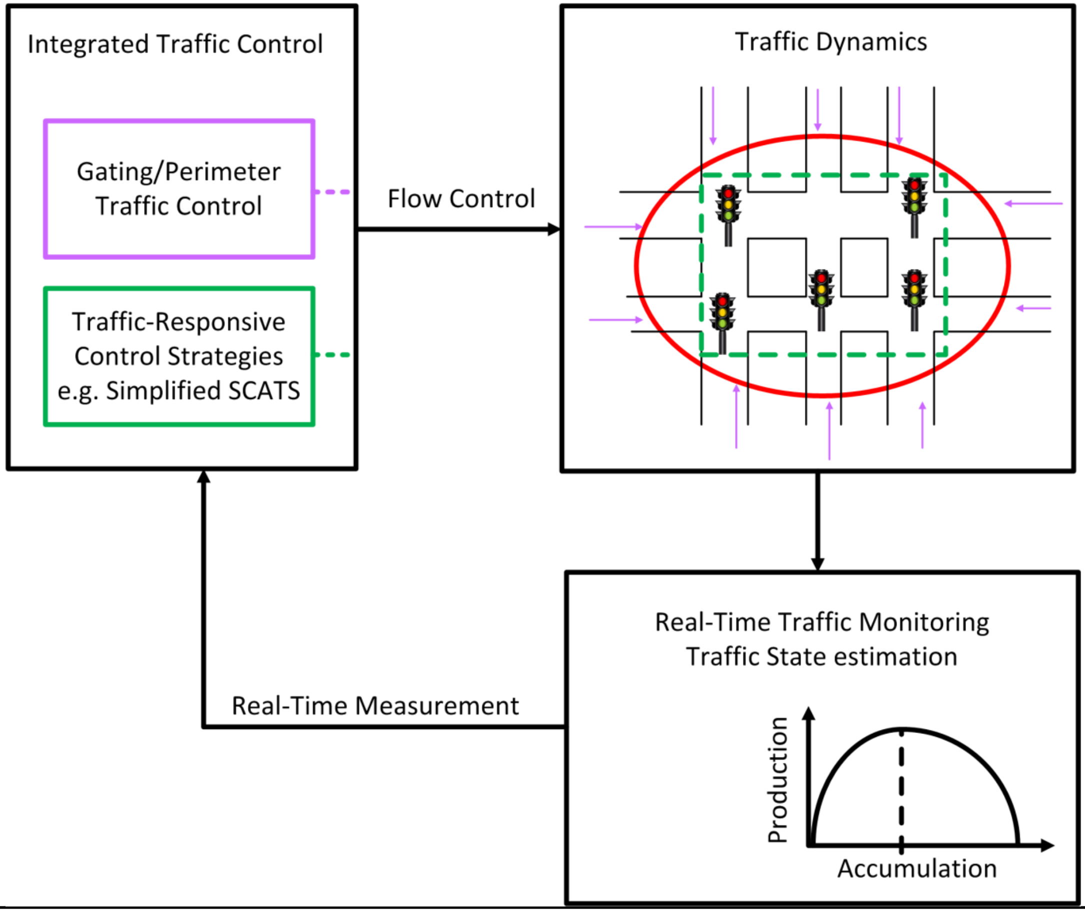
- Under over-saturated traffic conditions density-based **adaptive signal control schemes** have little to no effect on a network (Gayah et al., 2014).
- These strategies may allow too much traffic to enter from the boundary of a network, if it is less congested, which can intensify **queue spillbacks** in the congested areas.
- They also tend to act only after congestion begins to occur.
- Urban traffic networks might be better controlled by limiting the vehicle rate within the busiest parts of a network (using gating/perimeter control).
- The perimeter gating strategy relies on macroscopic relationships between traffic variables measured network-wide (network accumulation vs. production; MFD or NFD)

NFD and Traffic-Responsive Control Strategies

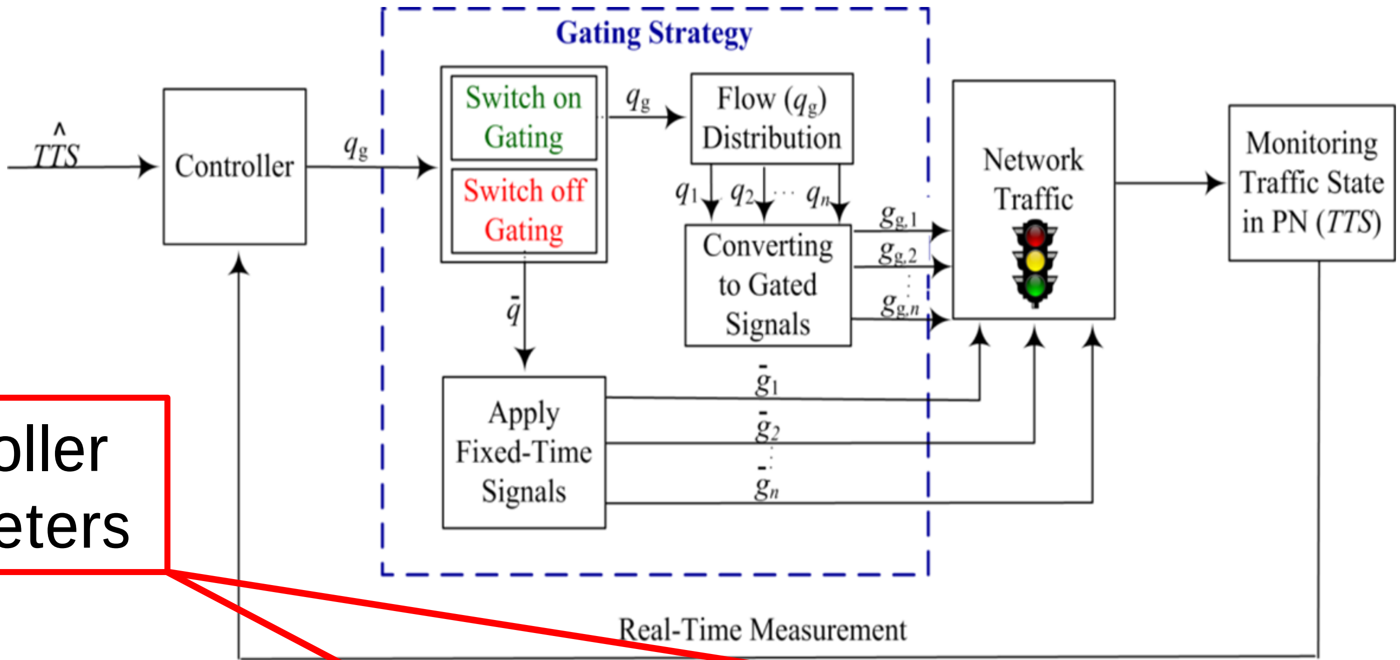
- Adaptive signal control can have positive effects on the free flow and capacity portions of the NFD
  - Improved network capacity and higher critical accumulations can be achieved on the NFD
- These improved macroscopic measures can result in more efficient gating



Combining Gating and Traffic-Responsive Strategies



Gating Control (Review)



Controller Parameters

$$q_g(k) = q_g(k-1) - K_P\left[TTS(k) - TTS(k-1)\right] + K_I\left[T\hat{T}S - TTS(k)\right]$$

TTS: Total Time Spent (Accumulation)

Volume-Based Traffic-Responsive Control

- Fixed cycle length
- Simple proportional algorithm to allocate the available green time
- Green allocation based on traffic volume measured at upstream detectors on each approach

$$g_i(t) = (C - L) \cdot \frac{v_i(t-1)}{\sum_i v_i(t-1)}$$

C: Cycle
L: lost time
i: approach
v: approach volume

Simplified SCATS

- Green time and total cycle lengths are variable
- Appropriate cycle length is first select based on the volume ratio observed during the previous cycle.

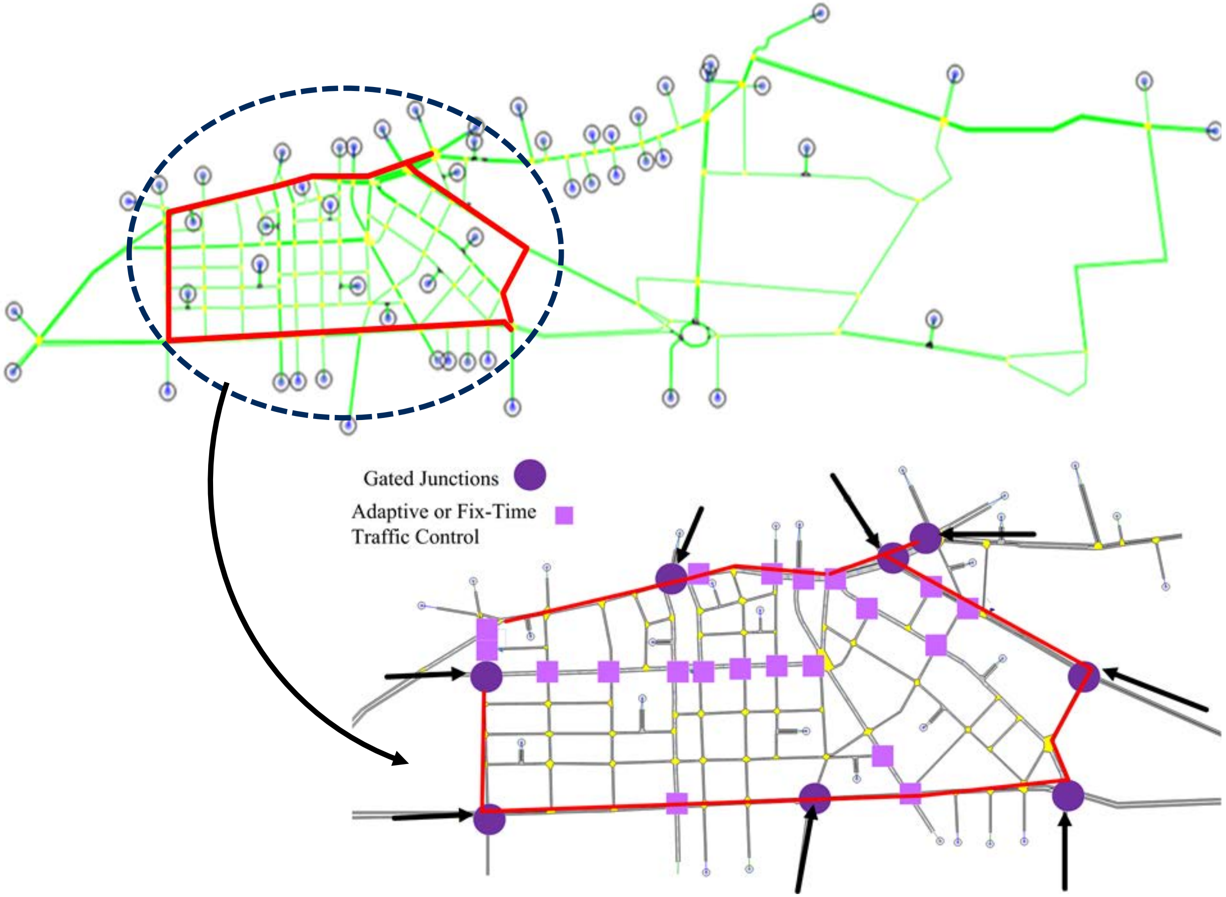
$$C(t)=\begin{cases} STOPPER & \text{if } C(t)=MIN, R(t-1)>0.4 \\ MIN & \text{if } C(t)=STOPPER \quad \text{and} \quad R(t-1)<0.2 \\ \min[C(t-1)+STEP, MAX] & \text{if } R(t-1)>0.95 \\ \max[C(t-1)-STEP, STOPPER] & \text{if } R(t-1)<0.85 \\ C(t-1) & \text{otherwise} \end{cases}$$

$$g_i(t)=\left(C(t)-L-G_{min}\right).\frac{d_i(t-1)}{\sum_i d_i(t-1)}+g_{i,min}$$

G_{min}: sum of minimum greens
d: approach demand

- $MIN = 42$ s
- $MAX = 132$ s
- $STOPPER = 66$ s
- $STEP = 6$ s
- $g_{i,min} = 6$ s

Test-Bed (Chania Network)



Simulation Setup

- The protected network includes 28 signalized junctions and consists of 165 links.

- measurements are collected every 90 seconds for the gating control

- 4-hour trapezoidal demand profile
- Realistic O-D flows applied.

- 15 simulation runs carried out.

- (1) Overall mean speed and (2) delay; (3) Maximum queue length applied as performance indexes

Simulation Scenarios

- Scenario 1: (no-gating) the traffic lights in the PN are controlled applying fix-time control signal plan.

- Scenario 2: (no-gating) “volume-based” traffic responsive control strategy is implemented to control all the traffic lights within PN.

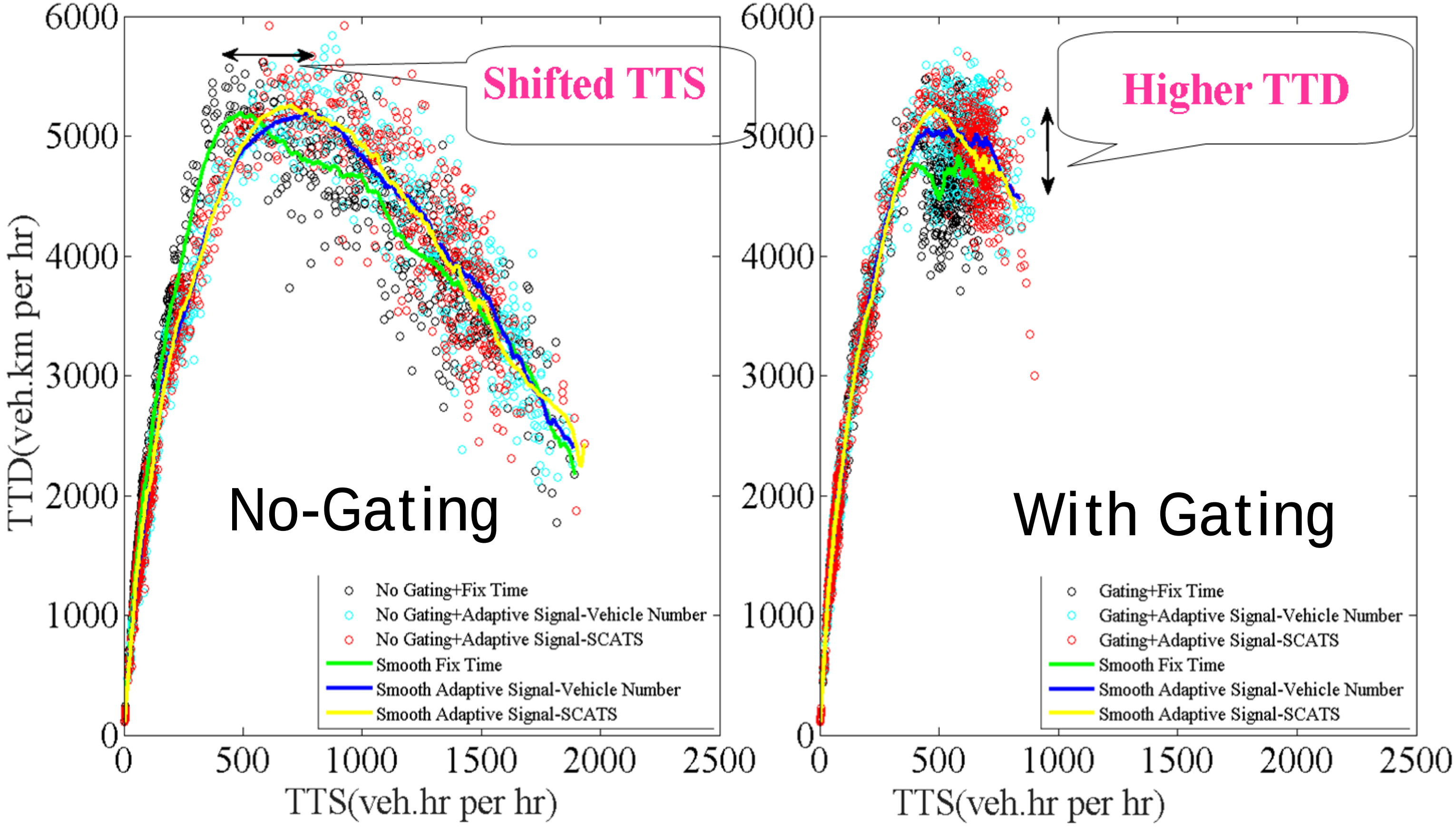
- Scenario 3: (no-gating) adaptive traffic control strategy “modified SCATS” is used for controlling the signalized junctions within PN.

- Scenario 4: Gating at the perimeter and fix-time control inside PN.

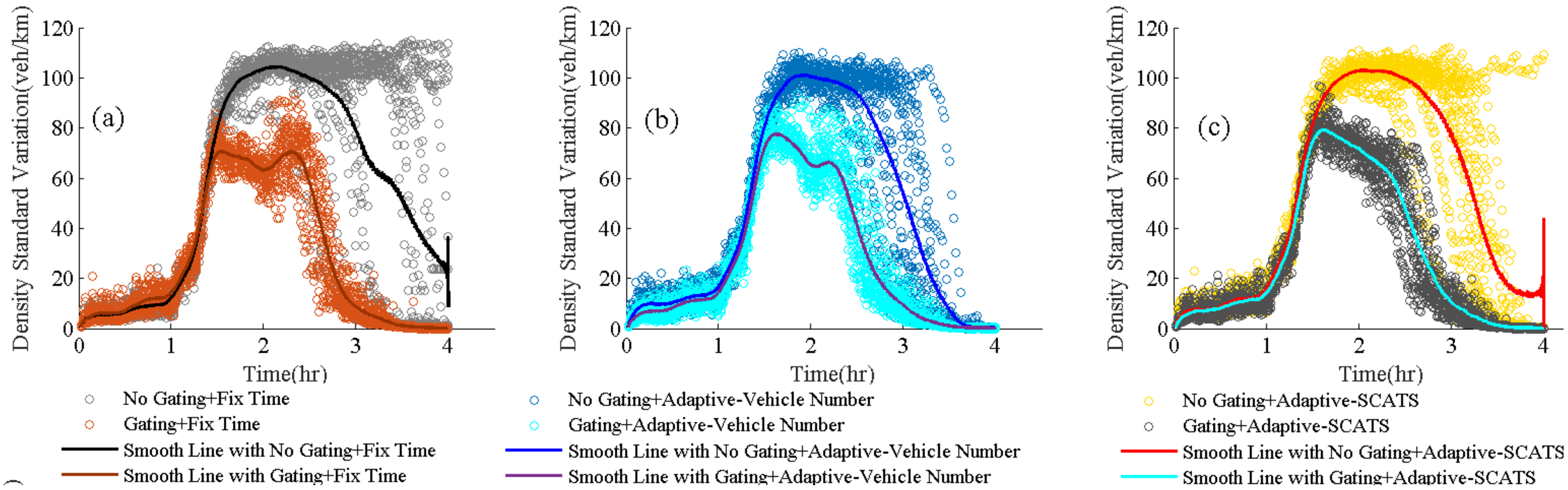
- Scenario 5: Gating at the border and “volume-based” for the rest of the traffic lights in the PN.

- Scenario 6: Gating at the boundary and “modified SCATS” within PN

Traffic-Responsive Control Benefits on NFD



Density Standard Deviation in all Scenarios

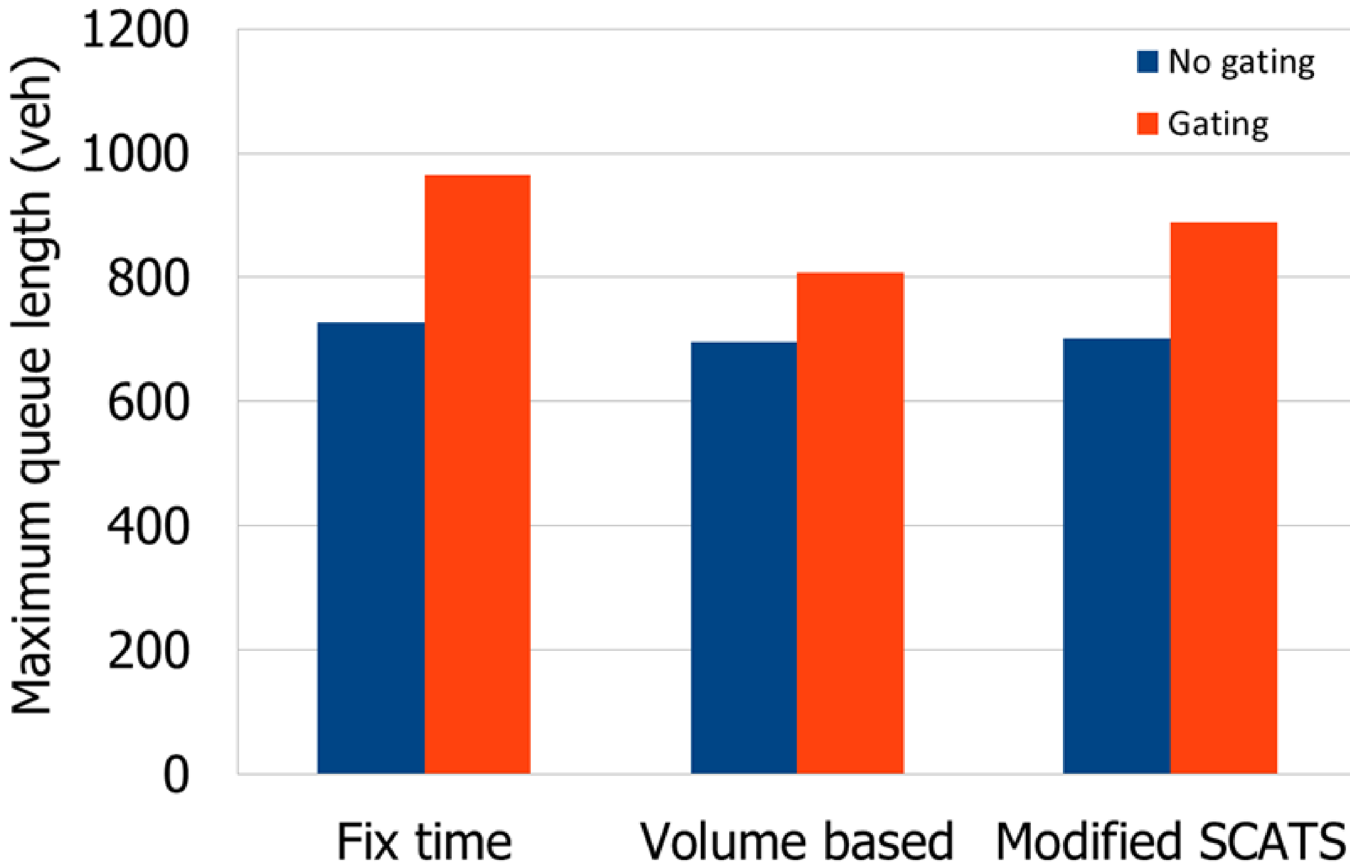


Overalll Network Performance

Performance Index	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario5	Scenario 6
delay (sec/km)	389	294	351	203	193	203
speed(Km/h)	8	10	9	13	14	13
vehicle out	12675	12913	12801	12924	12912	12923

Gating Scenarios

Maximum Queue Length



Conclusions

- The joint implementation of perimeter gating control and adaptive traffic signal control examined.
- **Gating provides higher speeds and lower delays than adaptive signal control alone.**
- Adaptive traffic control increases the critical accumulation → **less car metered, shorter gating queues.**
- The combination offers advantages in case of multi-zone gating **(less negative impact on vicinity traffic).**

Thanks for listening!

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