Comparison of On-Line Time-Delayed and Non-Time-Delayed Urban Traffic Control via Remote Gating

Mehdi Keyvan-Ekbatani
Markos Papageorgiou
Victor L. Knoop

Abstract

Recent studies demonstrated the efficiency of feedback-based gating control in mitigating congestion in urban networks by exploiting the notion of **N**etwork **F**undamental **D**iagram (NFD). In previous studies, gating was applied directly at the border of the protected network (PN), i.e. the network part to be protected from over-saturation. In this work, the recently developed feedback-based gating concept is applied at junctions located further upstream of the PN. This induces a time-delay, which corresponds to the travel time needed for gated vehicles to approach the PN. Detailed procedures regarding the appropriate design of related feedback regulators are provided. In addition, the developed feedback concept is shown to work properly with very long time-steps as well. The reported results demonstrate a stable and efficient behaviour and improved mobility of the overall network in terms of mean speed and travel time.

Introduction

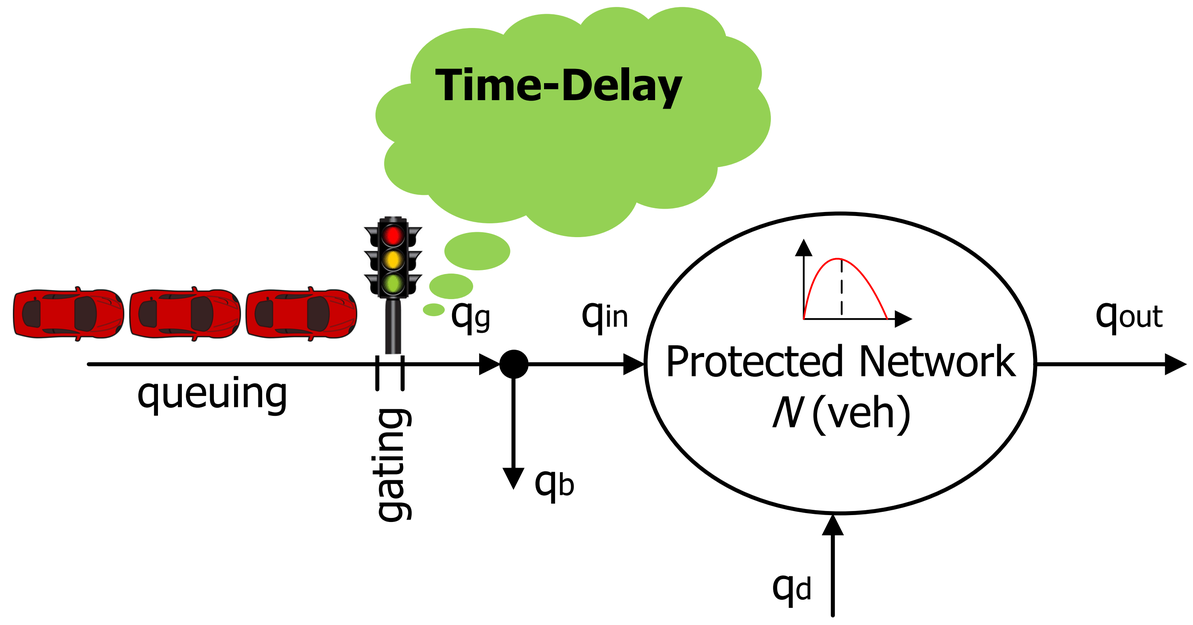
- Low efficiency of existing Urban Traffic Control Strategies in practice due to:
  1) saturated traffic conditions
  2) computationally expensive algorithms
  3) difficulties in real-time implementation

- **Gating:**
  - A practical tool, employed against over-saturation of significant links, arterials or urban network parts
  - Based on engineering judgment and manual fine-tuning
  - May lead to insufficient or unnecessarily strong gating actions

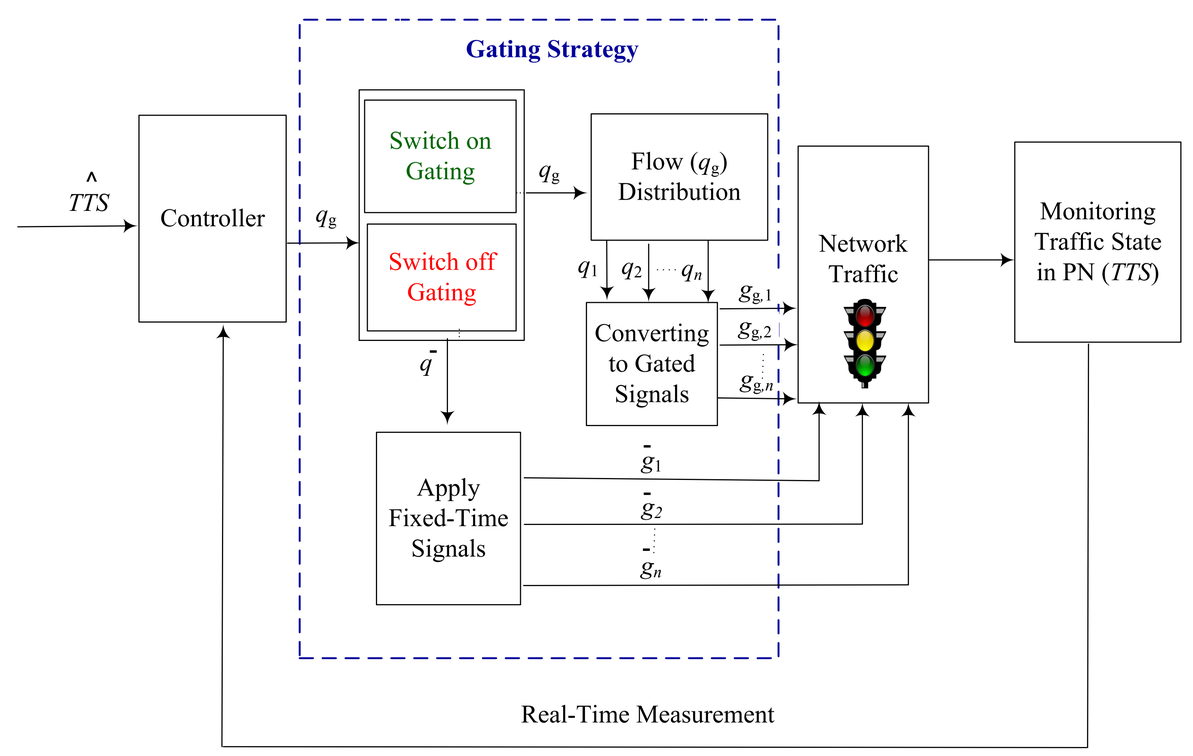
- **NFD (Network Fundamental Diagram)**
  - Network total weighted flow vs. average density
  - Recently, NFD exploited for traffic control strategies (e.g. gating or perimeter control, routing, congestion pricing)
  - In this study, NFD (*TTD* vs. *TTS*):
    TTS =Total Time Spent; *TTD*=Total Traveled Distance
  - Employed feedback regulator of proportional-integral (PI)-type targets an operating NFD point of maximum throughput $\hat{TTS}$

In this study: Remote Gating

- Feedback gating strategy **further upstream** of the PN
- Model Identification
- **Design** a robust feedback controller by considering a **time-delay** term
- Gating control **with bigger control steps** (non-time-delayed)



Remote gating scheme



General gating procedure of a gated junction

Model and Controller

- **Model (considering the time-delay term (*m*)):**

$$\Delta TTS(k+1) = \mu \times \Delta TTS(k) + \zeta \times \Delta q_g(k-m)$$

- **Model identification**: least-squares parameter estimation conducted for μ, ζ using time-series of (q_g, *TTS*)-measurements within and around the critical *TTS*-range

- **PI Controller**:

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

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Project: there is plenty of room in the other lane

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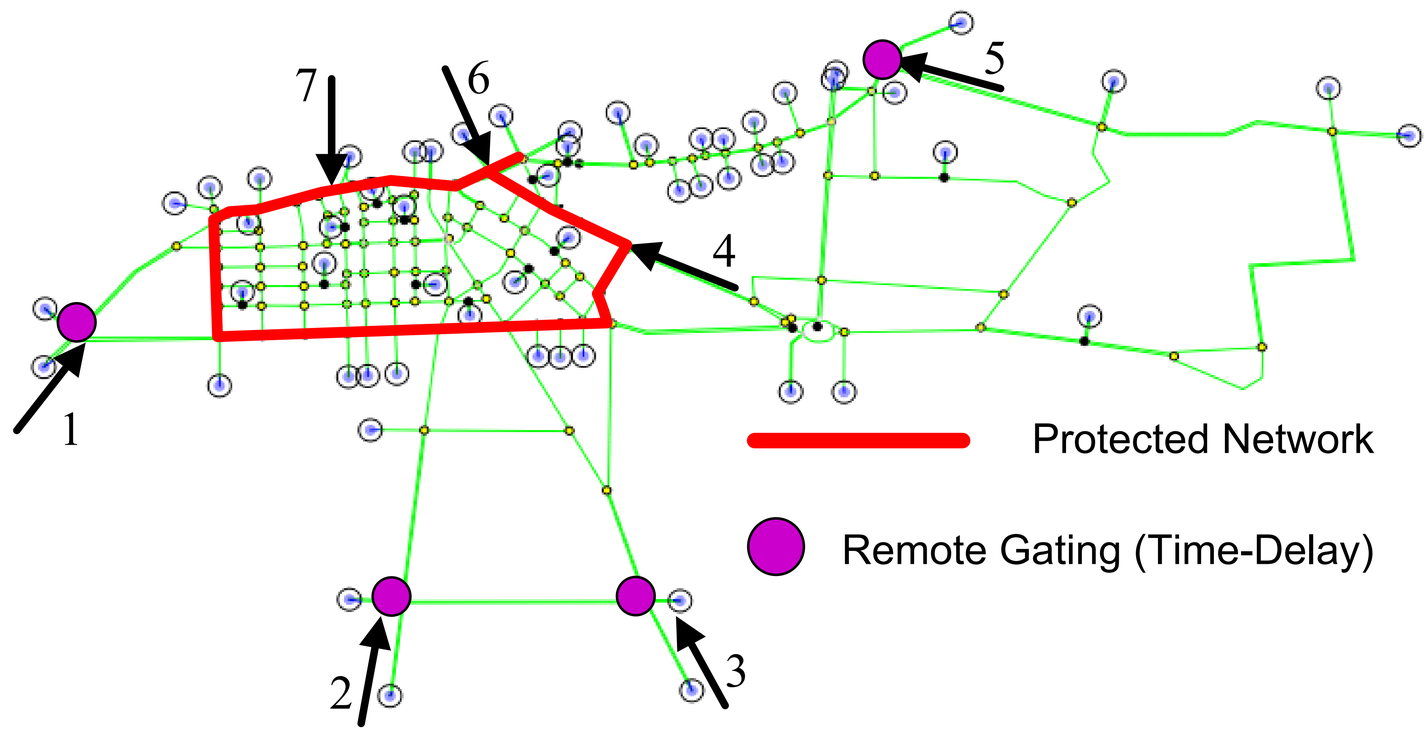
Mehdi Keyvan-Ekbatani, PhD
Delft University of Technology
Transport & Planning
m.ekbatani@tudelft.nl

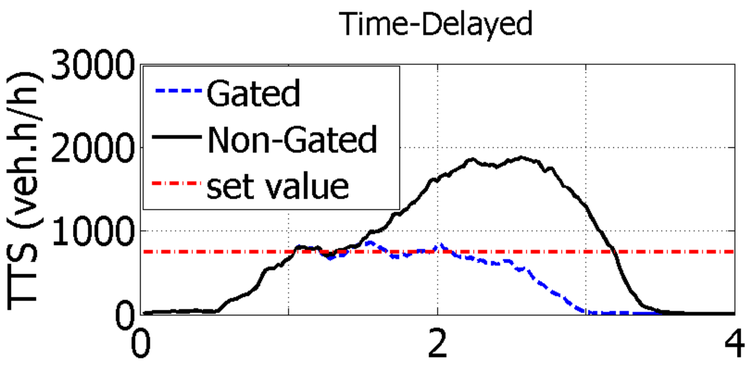
K_P and K_I according to different time-delays

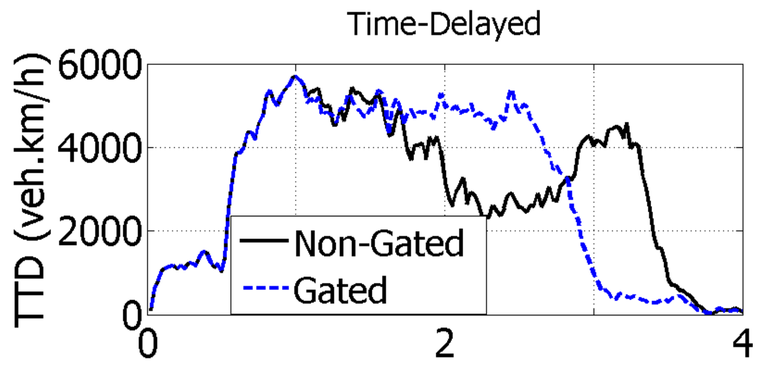
m	K_P	K_I
0	μ/ζ	$(1-\mu)/\zeta$
1	$\mu/(3\zeta)$	$(1-\mu)/(3\zeta)$
2	$\mu/(5\zeta)$	$(1-\mu)/(5\zeta)$
3	$\mu/(6\zeta)$	$(1-\mu)/(6\zeta)$
>3	$\mu/(2m\zeta)$	$(1-\mu)/(2m\zeta)$



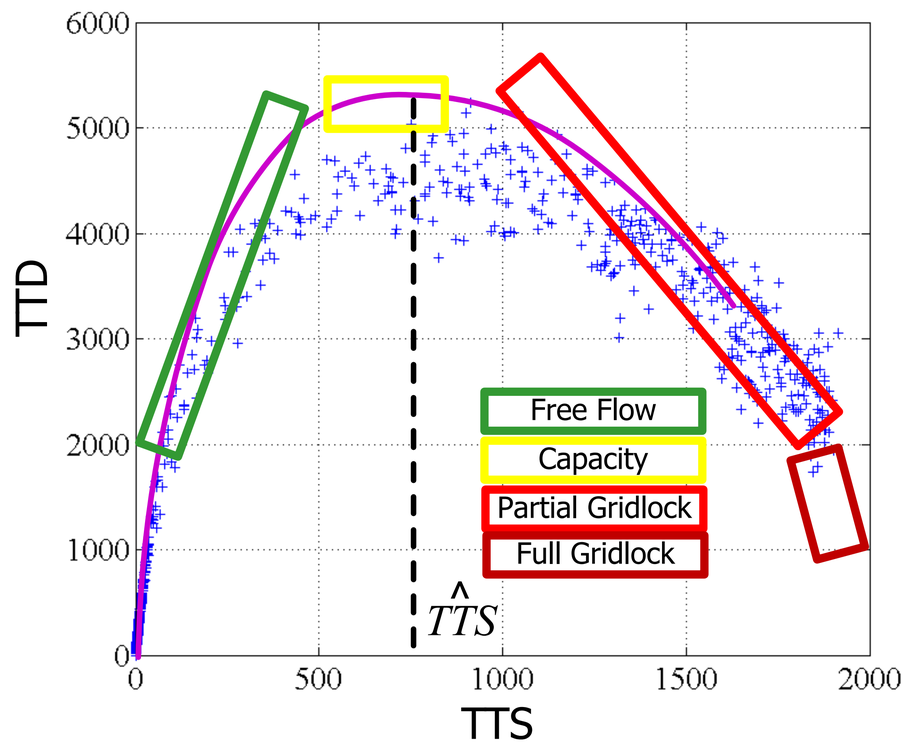
Chania urban network modelled in Aimsun

Simulation Results

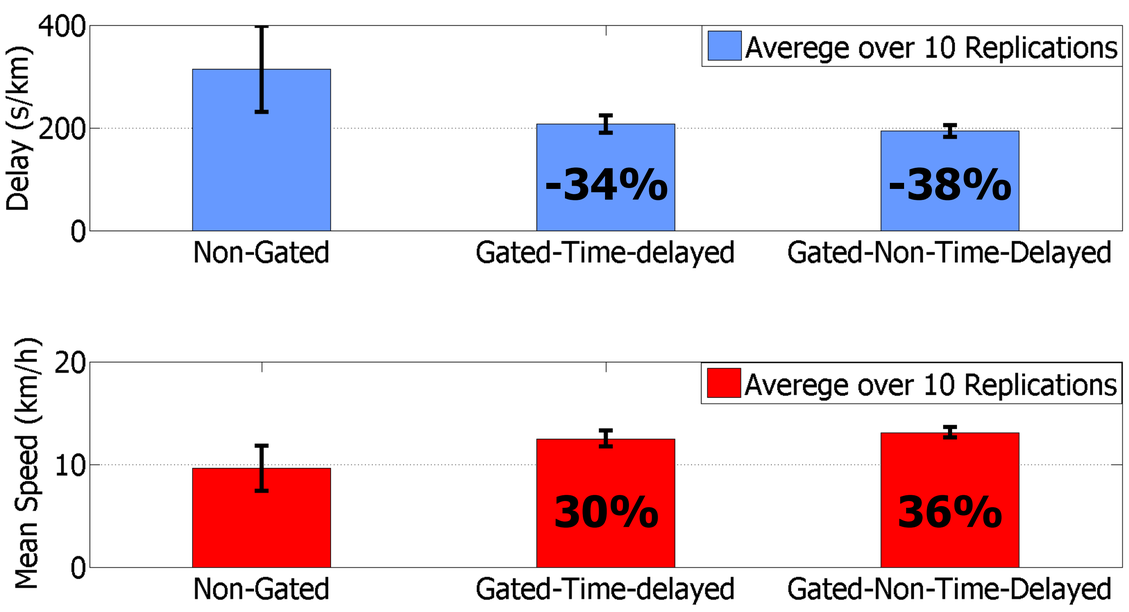




TTS and TTD before and after remote gating



NFD of protected network



Results (improvement compared to Non-Gated)

Conclusion

- Generic procedure for developing control design model and deriving its parameters
- Controller design in presence of time-delay in the traffic system
- Applicable on various problem
- Lower travel times, and higher overall mean speed when applied on limiting inflow into city centre
- Similar results in remote gating with and without time-delay (bigger control steps)
- Gating at lower pace and large control step is hence possible; this finding is very important for field implementation
- On-going research: queue management at gated junctions