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A Transportation Control System for Urban Environments

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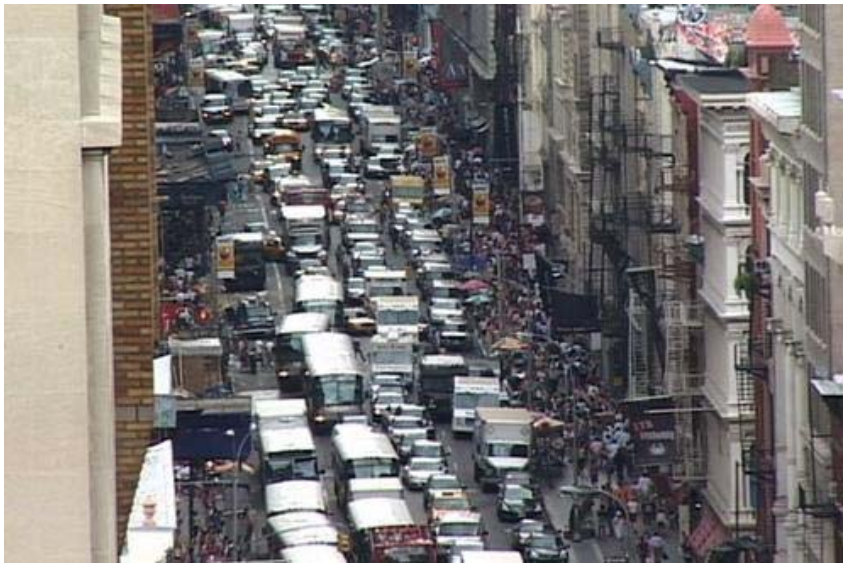
Content

- Motivation and problem description
- Previous solutions
- A system for traffic control
- Traffic model
- Traffic control on a global scale
- Experimental results
- Conclusions

Motivation

- Driving – day to day necessity
- Congestion, pollution and other traffic problems



- Provide accurate and fast directions to users using mobile devices

Problem Description

- Congestion
  - Relates to the excess of vehicles on a section of a road at a particular time resulting in speeds lower than the normal or “free flow” speeds
  - Related to stop-and-go traffic
  - Causes:
    - Traffic influencing events
    - Traffic demand
    - Physical highway features

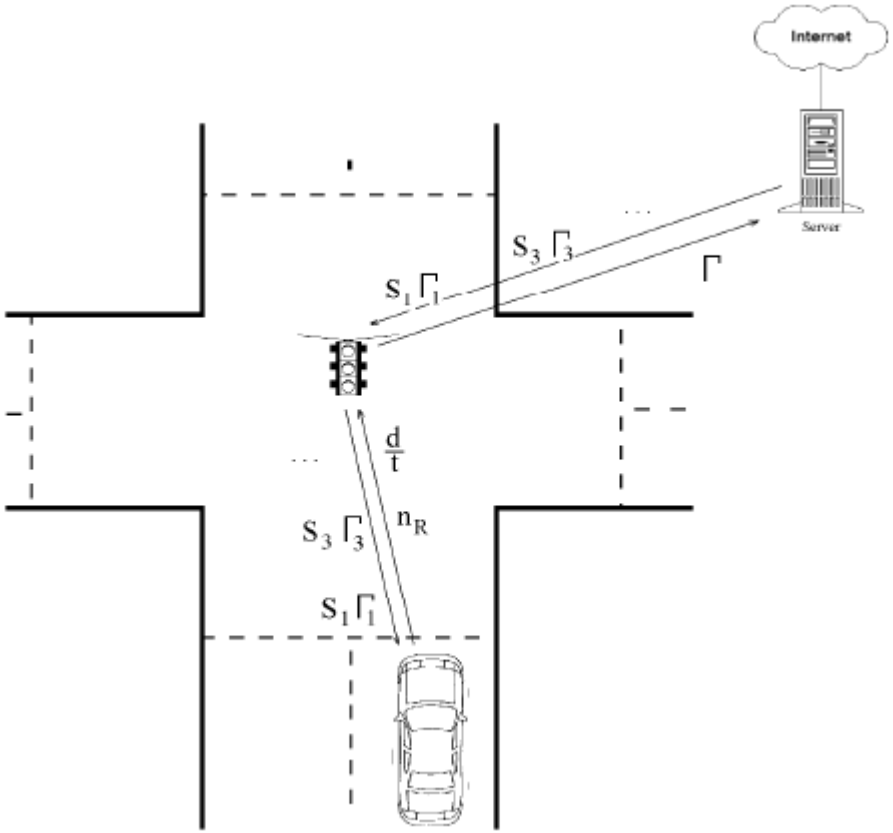
Previous solutions

- Mobile Millennium
- Vtrack
- Google Traffic View
- Waze
- CarTel
  - Special boxes installed in vehicles
- TrafficSense
  - microphone, GSM, radio, GPS => potholes, bumps, braking and honking
- TrafficView
  - e-Road project
  - GPS + wireless connections

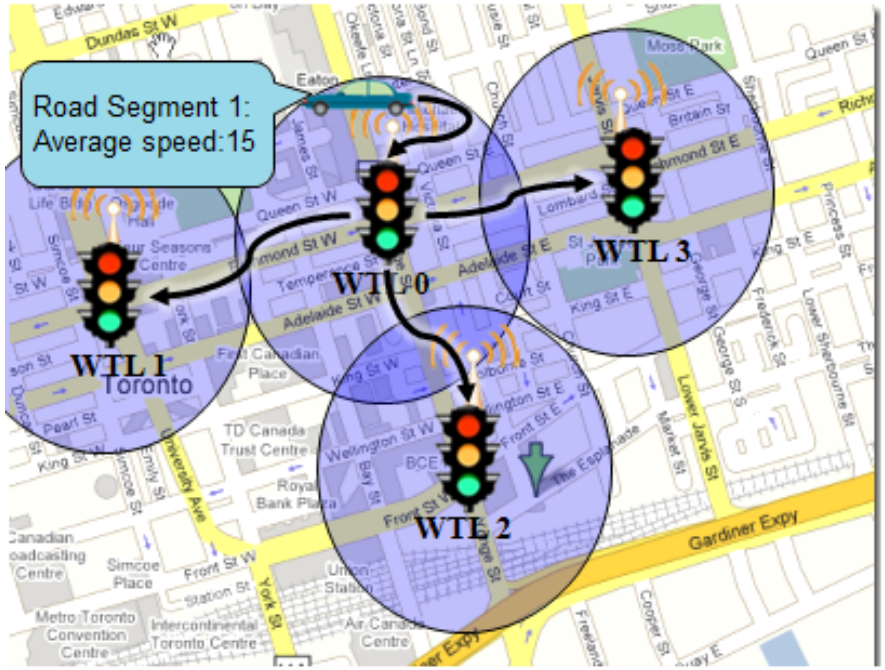
A system for traffic control (I)

- Several entities
  - Cars equipped with wireless devices
  - Traffic lights acting as communication gateways
  - Local server
- The city is divided in traffic areas called Traffic Zones(TZ)
- Used to implement a congestion control mechanisms
  - Cars receive and support information about traffic conditions and adapt their routes
- Several aspects
  - System balances traffic by sending different data to different cars
  - Cars are equipped with devices with limited computation and communication abilities
- Three phases
  - Traffic monitoring
  - Data aggregation and development of a traffic model
  - Traffic controlling using data feedback and dynamic route adaptation

A system for traffic control (I)



Entities within the system and their interactions



WTLs exchange traffic updates with cars and between themselves.

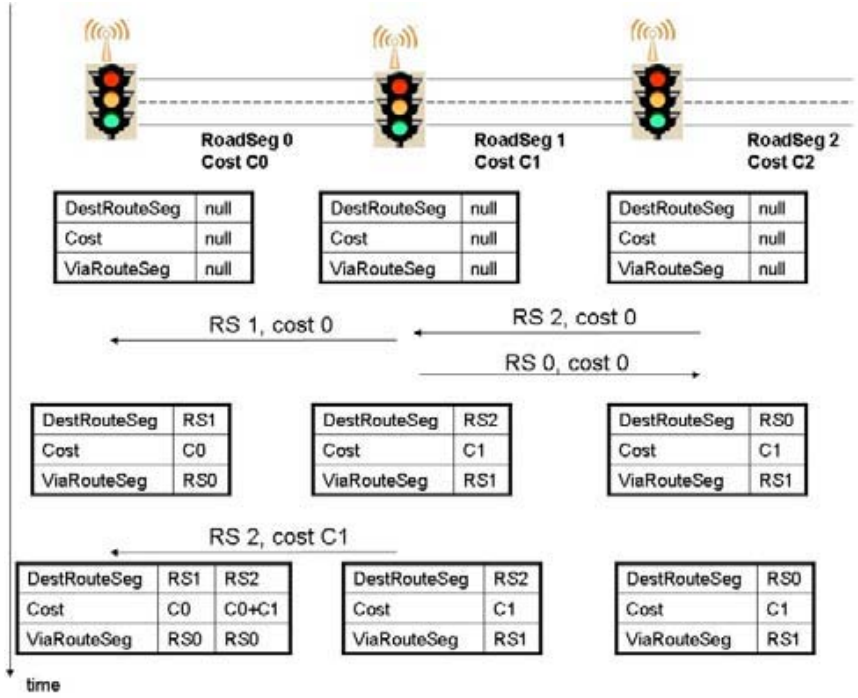
Traffic Model

$$\Gamma_{car} = \begin{cases} 255 * \left(1 - \frac{v_m}{v_{Max}}\right), & v_m \le v_{Max} \\ 0, & v_m > v_{Max} \end{cases}$$

$$v_m = v_{cruise} * \left(1 - \frac{n_R}{n_{RMax}} * \frac{F_{\min}}{F}\right)$$

- congestion degree – Γ_{car}
- v_m – average travelling speed of the car on a specific road segment
- v_{Max} – maximum allowed travelling speed
- v_{cruise} – average cruising speed between two stops at a red light or until we reach the intersection
- n_R –red lights that the vehicle has waited in an intersection
- n_{RMax} – maximum red lights the vehicle could wait for on a specific road segment
- F – frequency of cars that passed the intersection
- F_{min} – minimum frequency of cars that crossed the intersection, collected in the last hour

Traffic control on a global scale

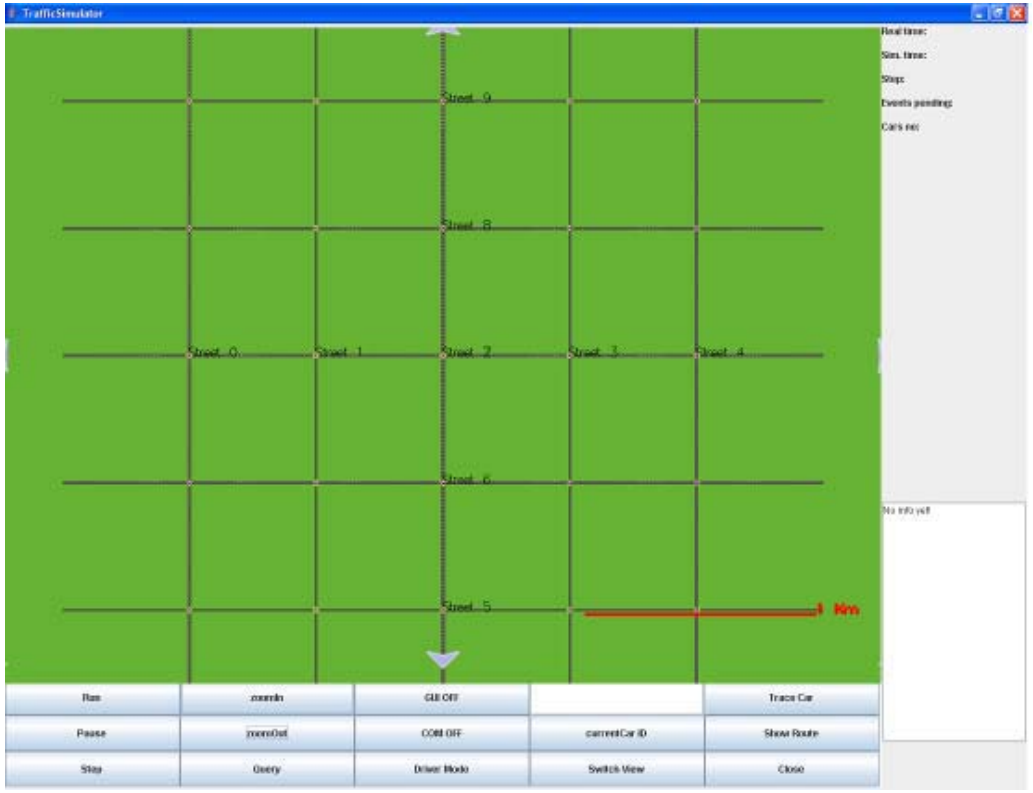


The distance-vector routing approach for route exchanges

- WTL uses distance-vector
- At first WTL knows only the costs to the route segments in its TZ
- A vehicle periodically broadcasts messages data recorded
- WTL receives broadcast:
  - Data is used to update costs
  - Data is sent to its neighbors
- Three lists:
  - Known route segments
  - Costs associated with each segment
  - Segments that a vehicle must go to for particular destinations

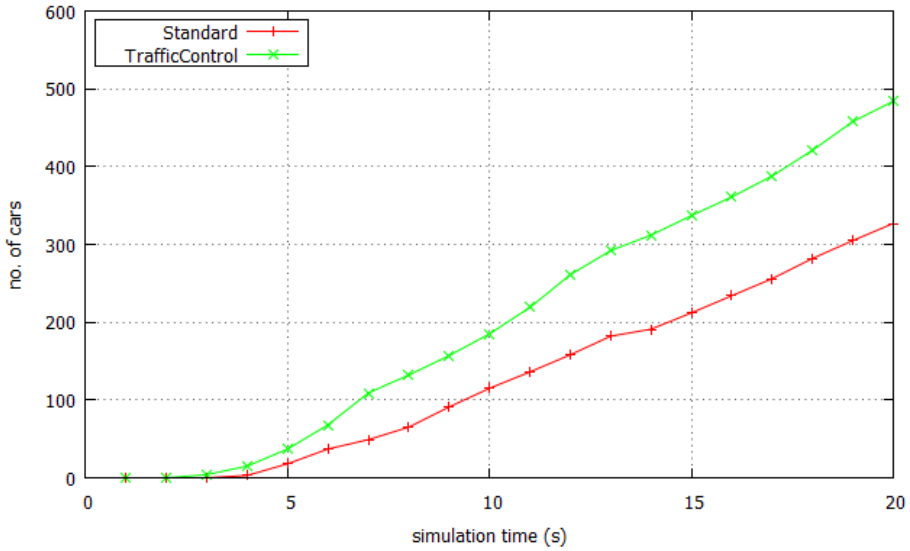
Experimental Results (I)

Real-map of Seattle, Washington, US.

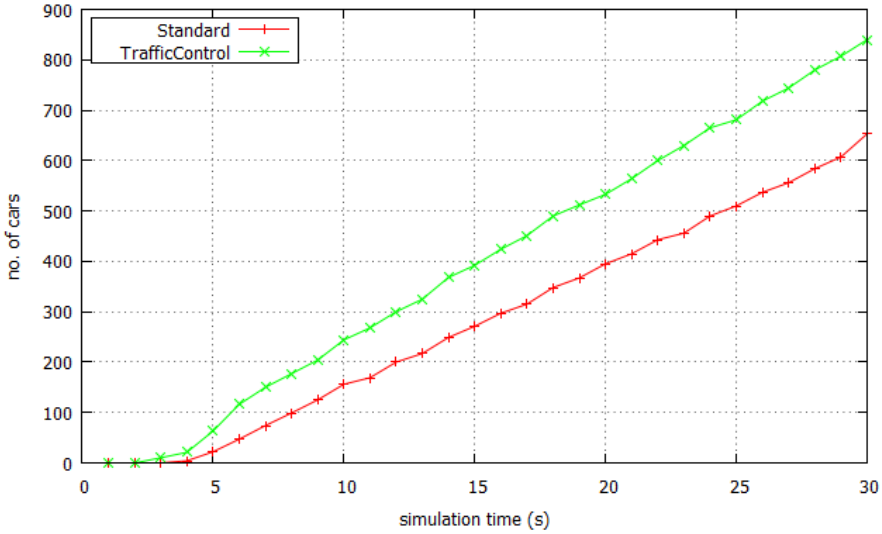


The modelled map used in simulation.

Experimental Results (II)

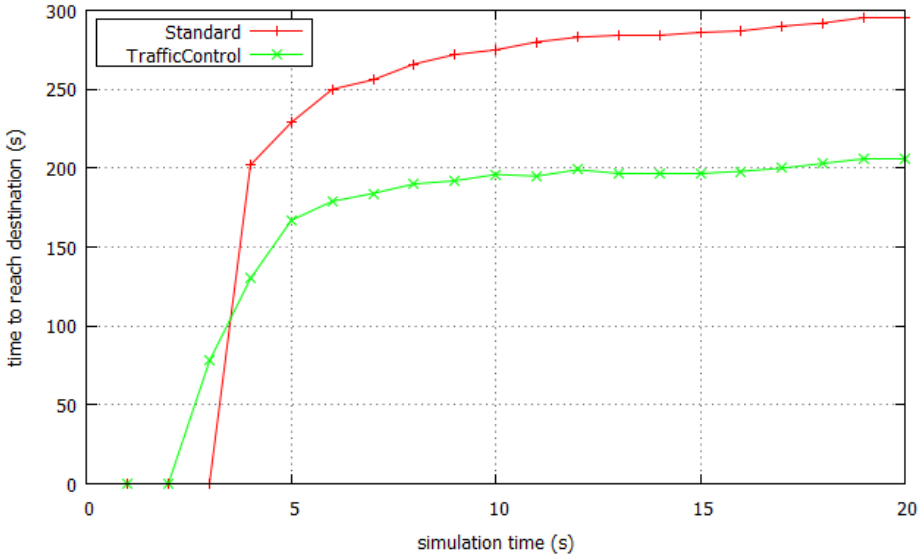


Number of cars reaching their destination, 150 vehicles / lane / hour, adaptive traffic lights

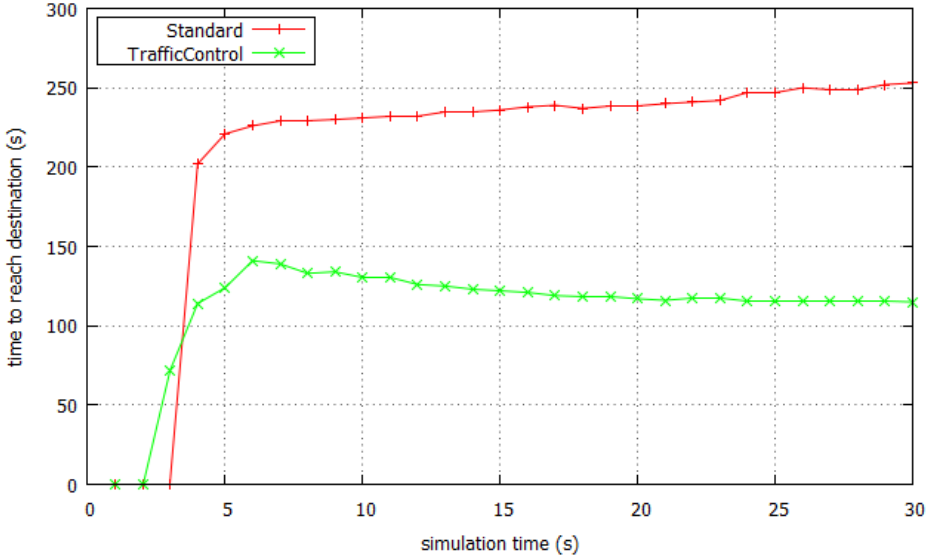


Number of cars reaching their destination, 150 vehicles / lane / hour, adaptive traffic lights

Experimental Results (III)

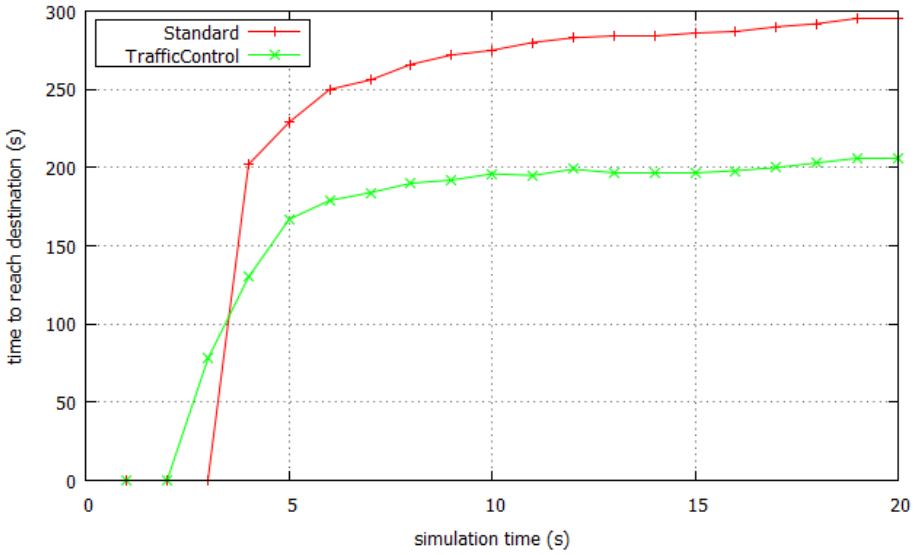


Average time to reach destination, 150 vehicles / lane / hour, non-adaptive traffic lights

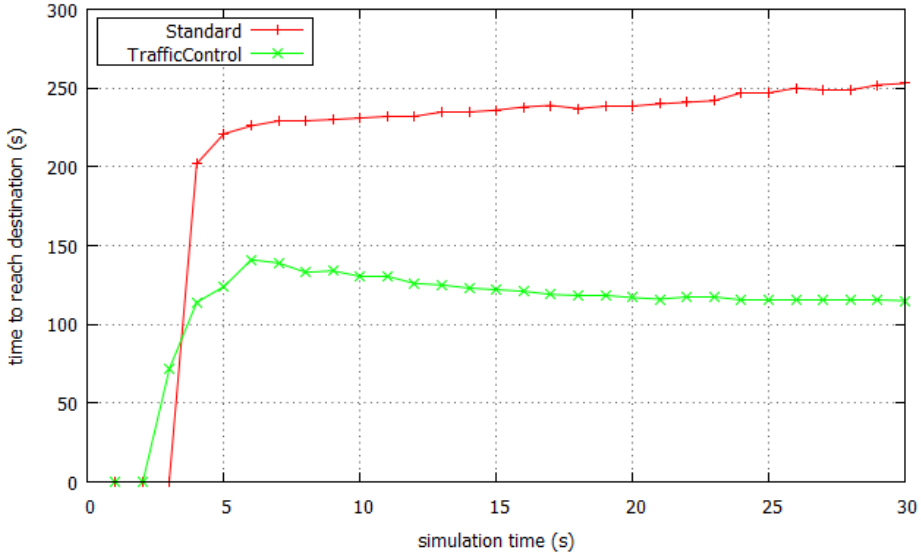


Average time to reach destination, 150 vehicles / lane / hour, adaptive traffic lights

Experimental Results (IV)

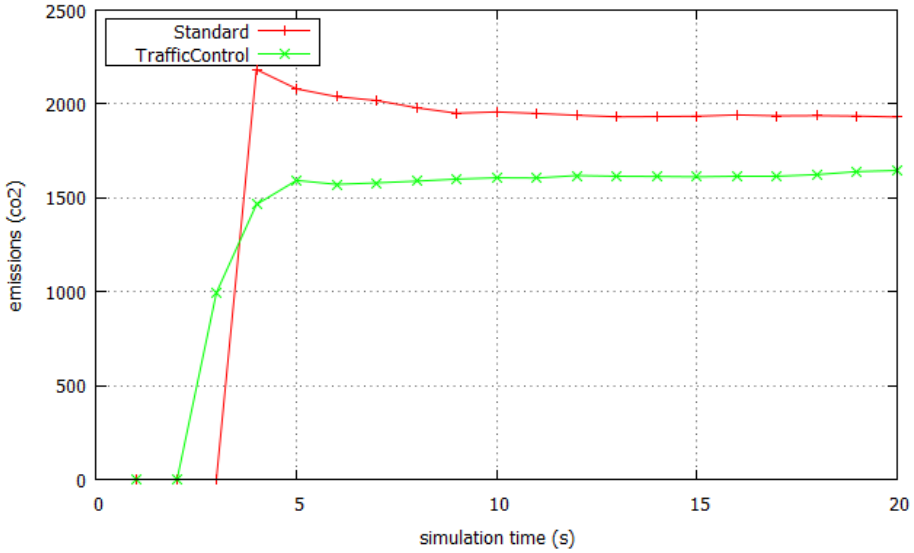


Average fuel consumption, 150 vehicles / lane / hour, nonadaptive traffic lights

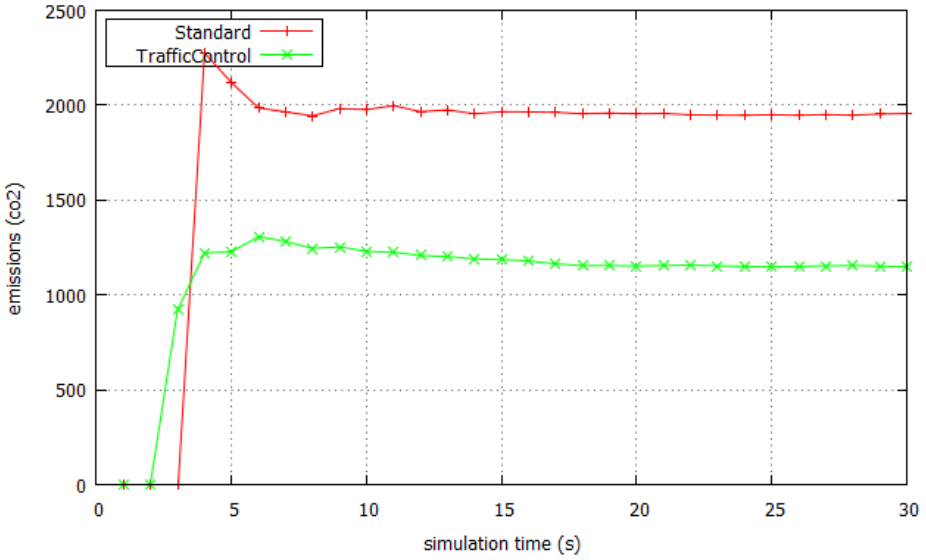


Average fuel consumption, 150 vehicles / lane / hour, adaptive traffic lights

Experimental Results (V)



Average emissions, 150 vehicles / lane / hour, non-adaptive traffic lights



Average emissions, 150 vehicles / lane / hour, adaptive traffic lights

Conclusions

- Model for traffic control and congestion avoidance
- Proposed a traffic system designed to solve traffic congestion based on networking protocols
- Average time for reaching destination decreased by up to 40%
- Average fuel consumption decreased by 1 litter per 100 kilometers
- Emissions decreases vary between 14% and 40%

Thank you!