GUI: GPS-Less Traffic Congestion Avoidance in Urban Area with Inter-Vehicular Communication

Zhen Jiang, Jie Wu, Paul Sabatino
CIS Dept., Temple University
CS Dept., West Chester Unviersity
Information Security Center, West Chester University

Presenter: Zhen Jiang
E-mail: zhen.jiang@temple.edu or zjiang@wcupa.edu

Outline

- Target Problem
- Challenges
- Our Approach
- Experimental Results
- Conclusion

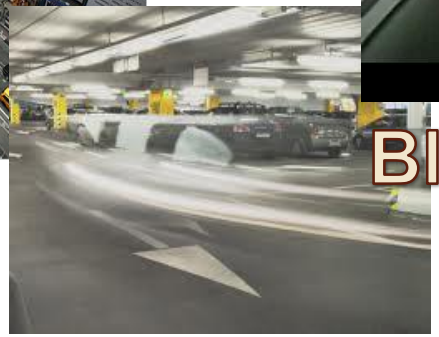
Target Problem

- Turn problem

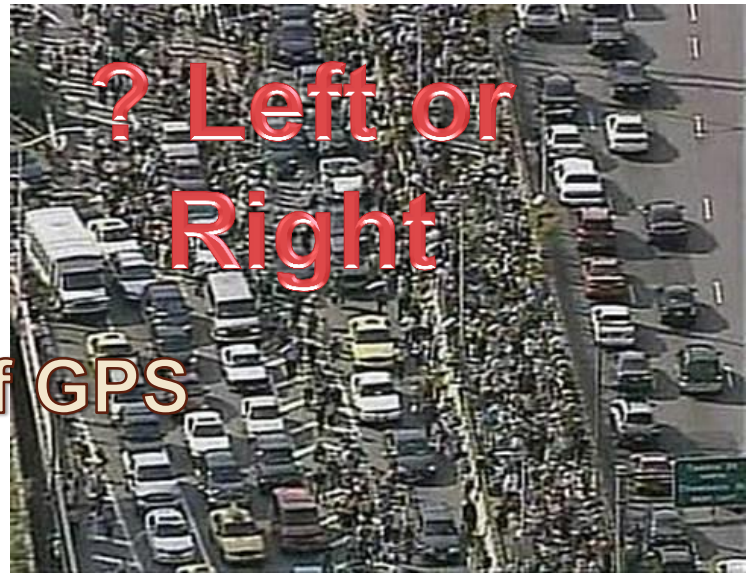
Challenges

- Mass congestion in urban area

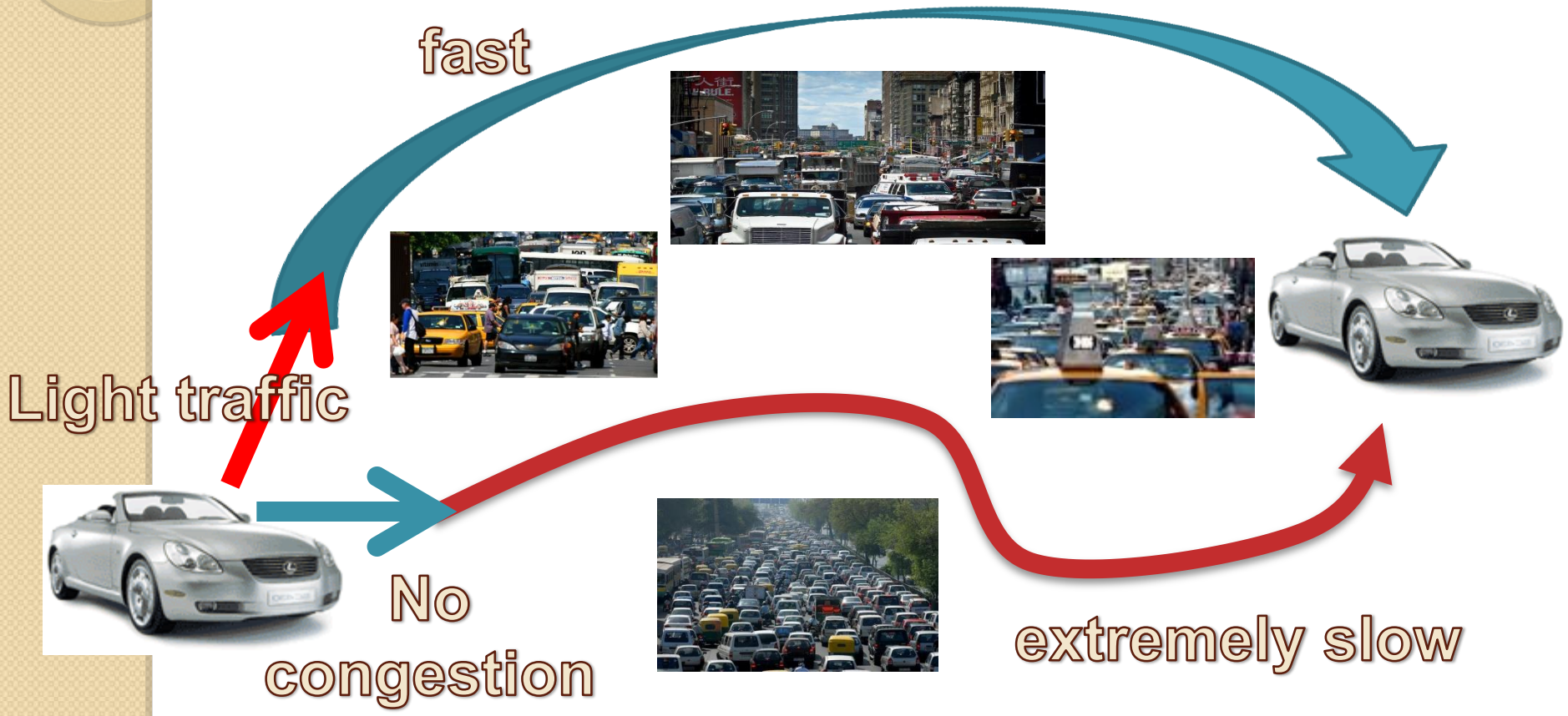
- GPS?
  - A short range focus
    - in order to clearly see the lane and the turn
  - Cannot have a seamless shift in navigation service
    - Signal is interfered by buildings and other factors
  - Inaccurate turn will lead to more severe results



Blind point of GPS



- Accurate turn navigation with the prediction using the information at the global view level becomes very critical!



Our approach

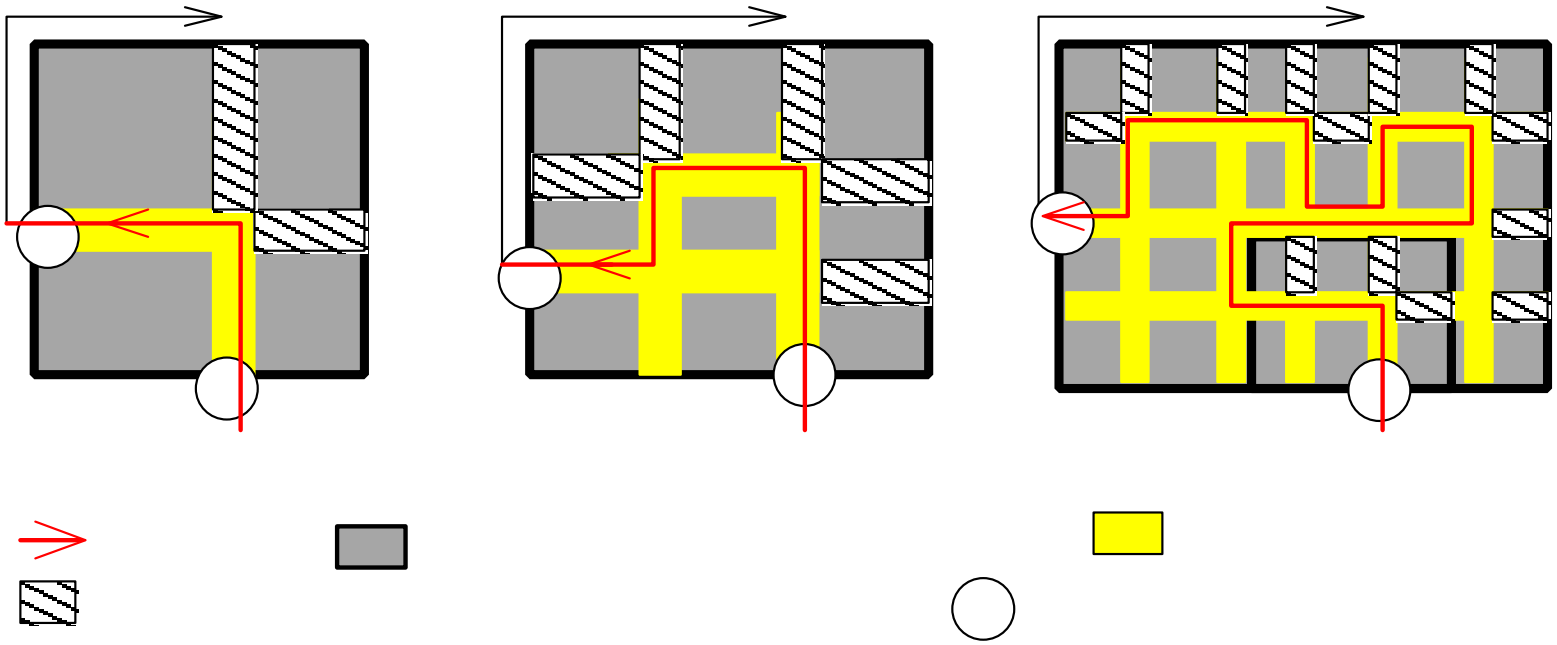
- Form and distribute the information with V2V communication (to enhance the efficiency of prediction)
  - Free of traffic
  - Collaboration to identify blocked street
  - Distribute information in opposite direction to alert incoming vehicles

- Our contribution
  - The information is not simply the location of the congestion.
  - It is a snapshot at the global view level
    - Mutual impact of all congestions, i.e., delay chain problem.
    - Subject to any dynamic change in traffic
      - Both target congestion and information delivery
    - Normalized as an index, for vehicle easy to carry and calculate in the presence of dynamics
    - Such normalization is difficult because the block impact can be different when the relative positions of the source and the destination change!

Information Collection

- The congestion identified among neighboring vehicles [7]
- Identification of the block of congested segment
- Calculation of mutual impact of blocks

- Mutual impact of blocks

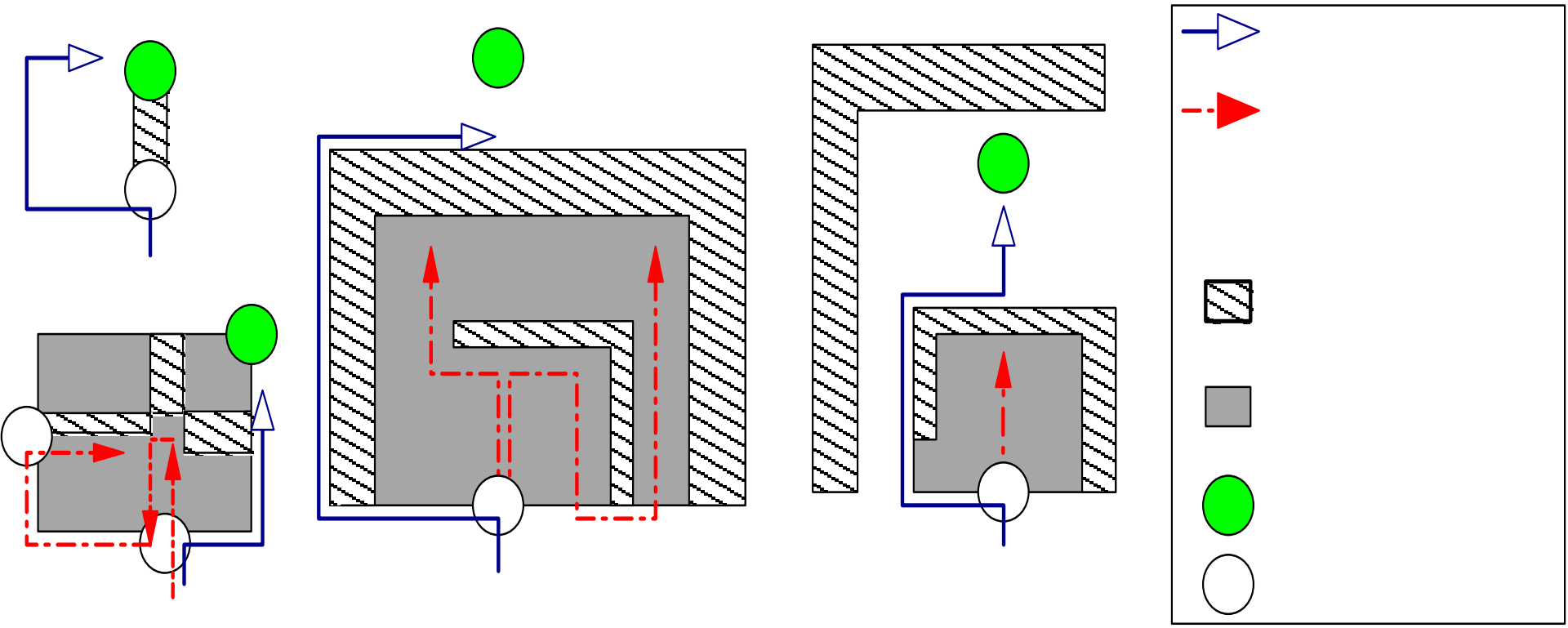


- Mutual impact of blocks
  - Delay chain and relative effect
  - Blocked in the direction to the destination whenever no congestion-free path exists.
  - *MCC block region – Type 1 – an intersection is inside block region if and only if both east and north direction are blocked (by adjacent congested segment or blocked intersection)
    - Heuristic search of congestion-free path in the reversed direction, by our block information constitution
    - In the proactive manner
    - Total four types, sufficient enough for guiding the vehicle in any possible direction

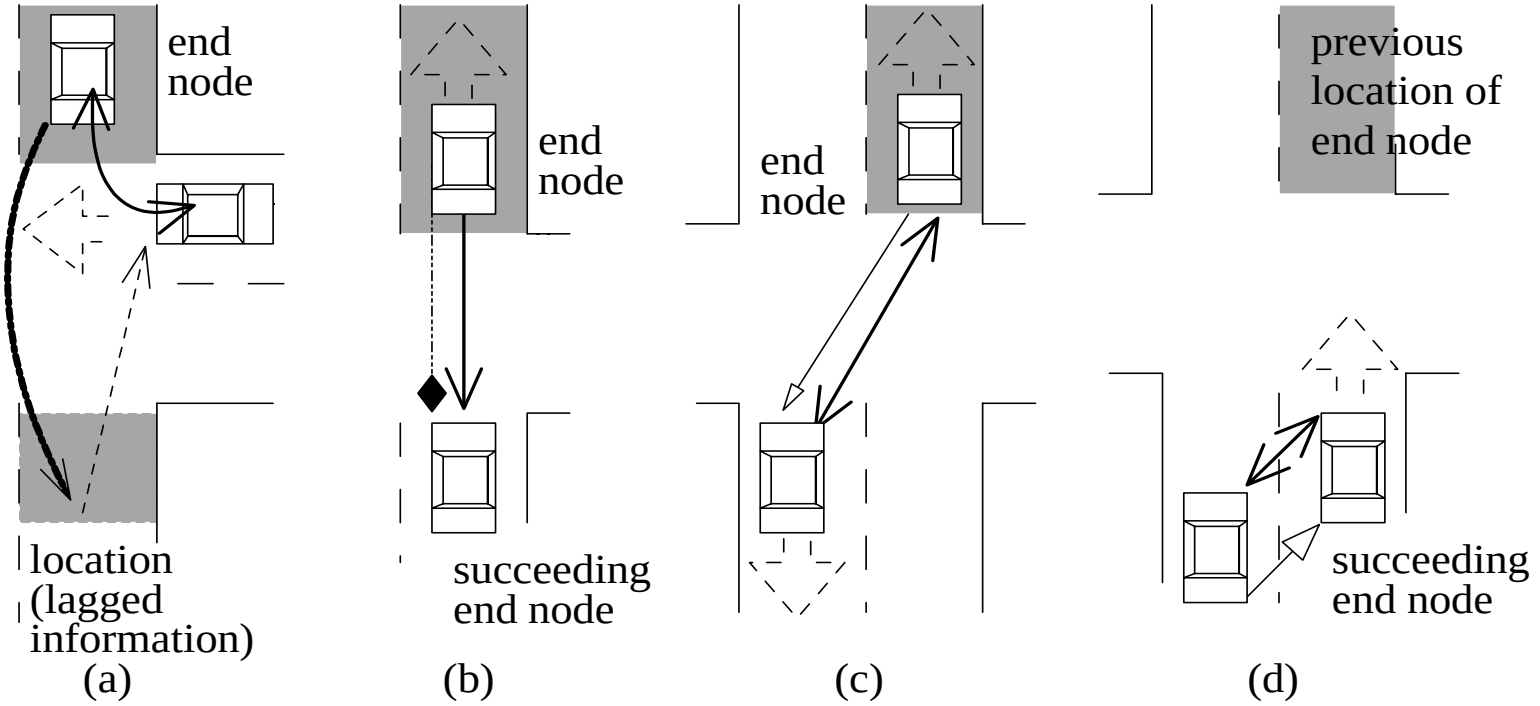
- Solution for information collection
  - The congestion can be identified among neighboring vehicles, by the collaboration with V2V communication in [7].
  - Identification of the block of congested segment at the "end node" [16] when the information can be propagated via V2V communication (or carried by vehicle) in the opposite direction.
  - "End node" will receive information from both directions at the intersection, and then determine whether this intersection is inside the (MCC) block region.

- Navigation solution
  - Follow the GPS guidance when the vehicle is out of any block region.
  - To avoid entering the block region along the boundary, perimeter routing until it is safe to approach the destination in the congestion-free path.
  - Escape from a congestion region.

- Solution (of type 1)



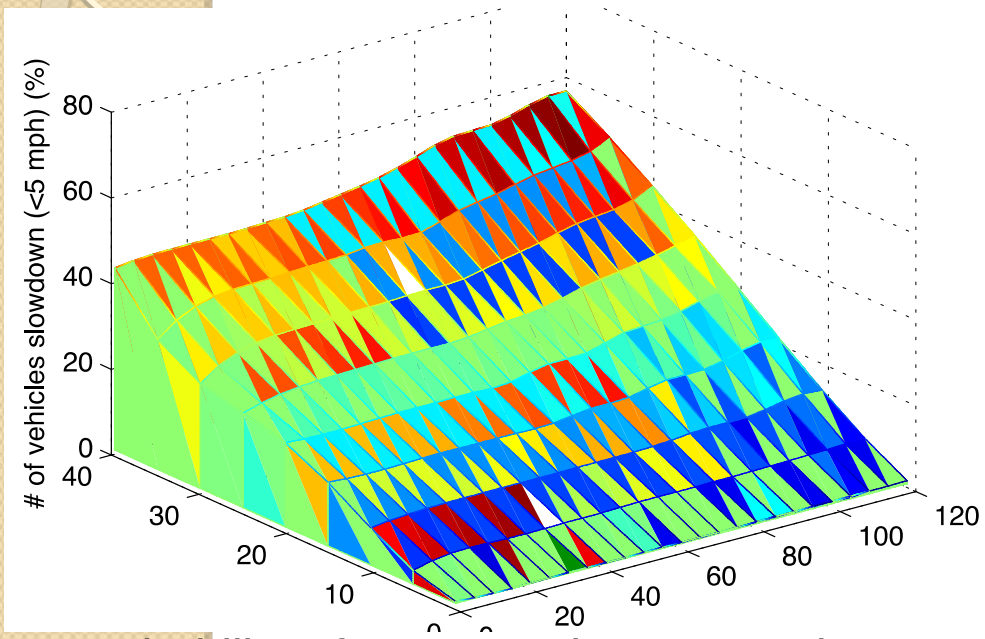
- Extension
  - 2 directions => multiple directions
    - Sufficiency of our approach
  - Size of block
  - Mobility and disconnections



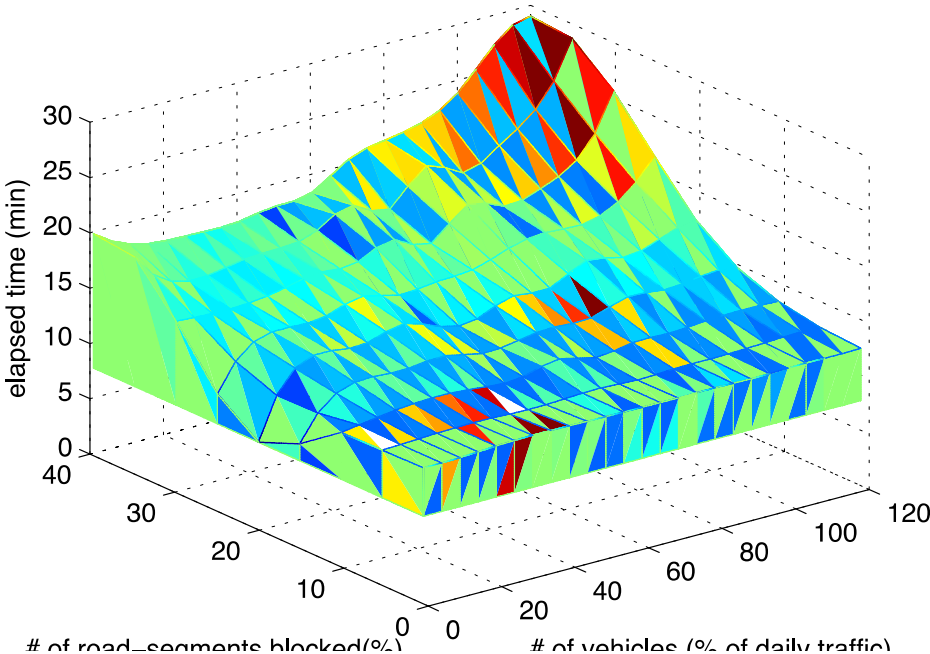
Experimental Results

- Map of New York City, Manhattan, OpenStreetMap [17]
- Central Park to Madison Square Park
- Daily traffic with different volume (10 to 120% of the average)
- Trace Data generated by SUMO [8]
- Average speed (~10 min to pass through, with +/- 25%)
- Random congested segment (1 to 40%)
- V2V communication

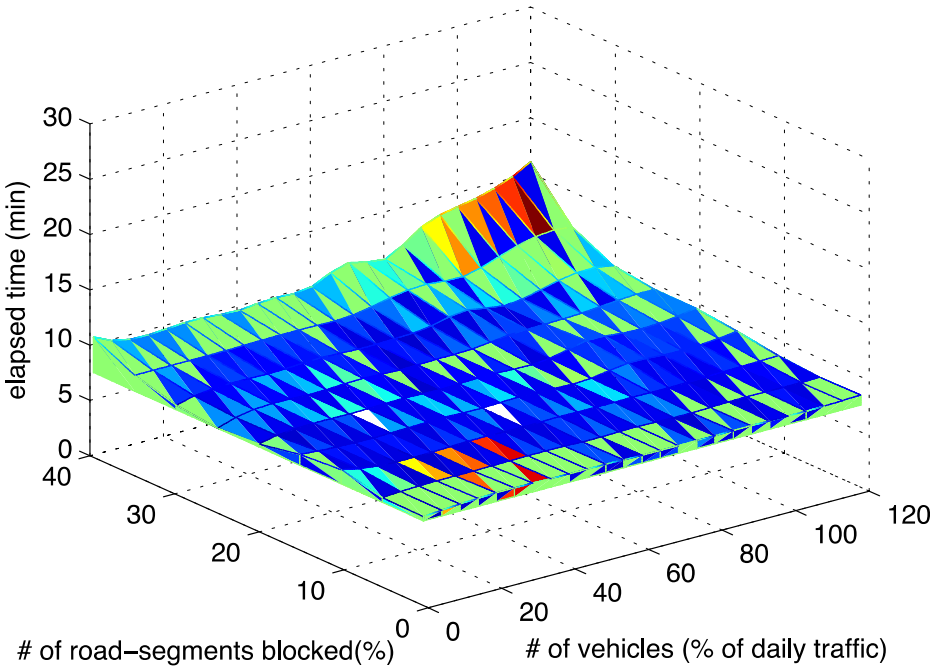
GPS



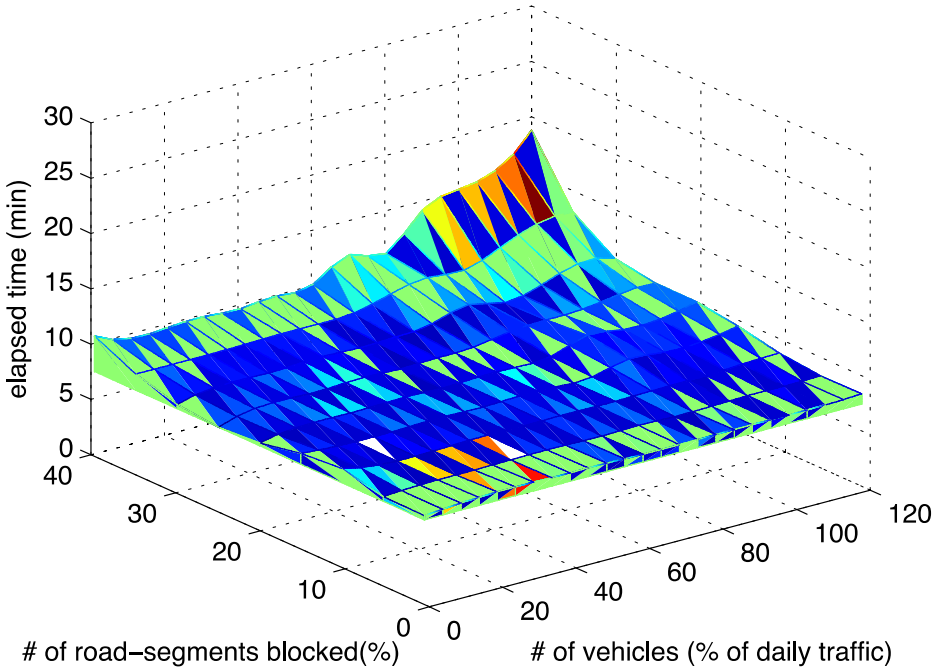
Probability of encountering congestion



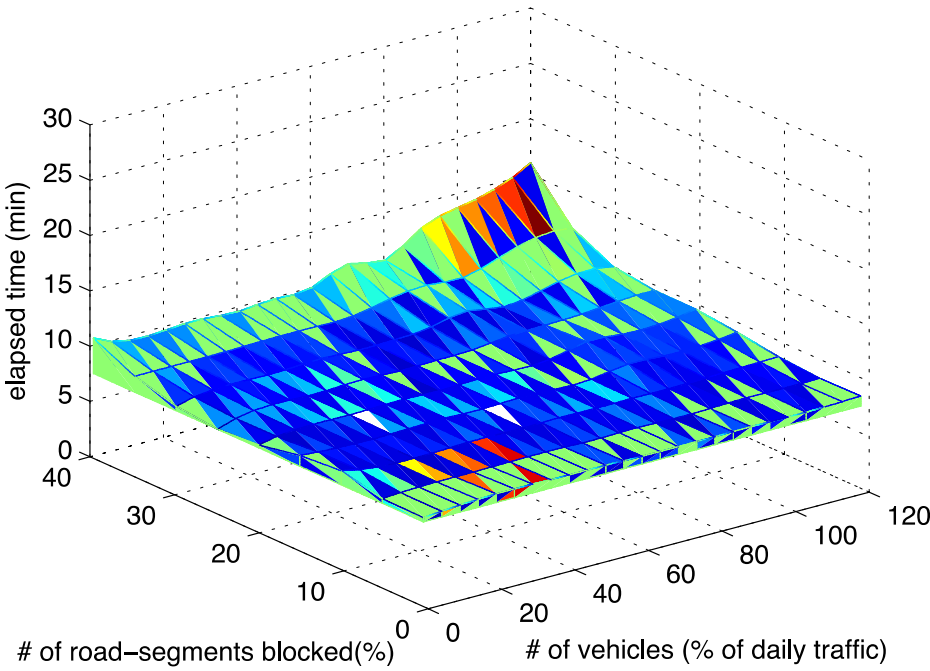
GUI



Existing proactive solution with the consideration of dwell time (under ideal mode)



GUI



Summary (of experimental results)

- Block region is an accurate estimation of mutual impact of congestions.
- Up to 35% reduction is achieved with our block information, compared with the best proactive solution in existing work.
- GPS navigation in urban area may frequently encounter the live-lock and delay chain problem. The vehicle requires to take double time to reach the destination, compared with the performance of GUI.

Conclusion

- Precise information collection/distribution with a fully distributed manner
- Dynamic adjustment
- Retrieving a global view of possible congestion-free path with a simple index
- Optimistic manner adopted, reducing the overhead cost
- Study of the mutual impact of congestions
- Quick way for the vehicle to pass urban canyons.

Thank you!

- Questions and Comments