



Optimal Sensor Placement for Traffic Data Collection: Case Studies and Challenges

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March 4, 2008

California 511 Workshop



The Problem

Traffic Data Collection Techniques

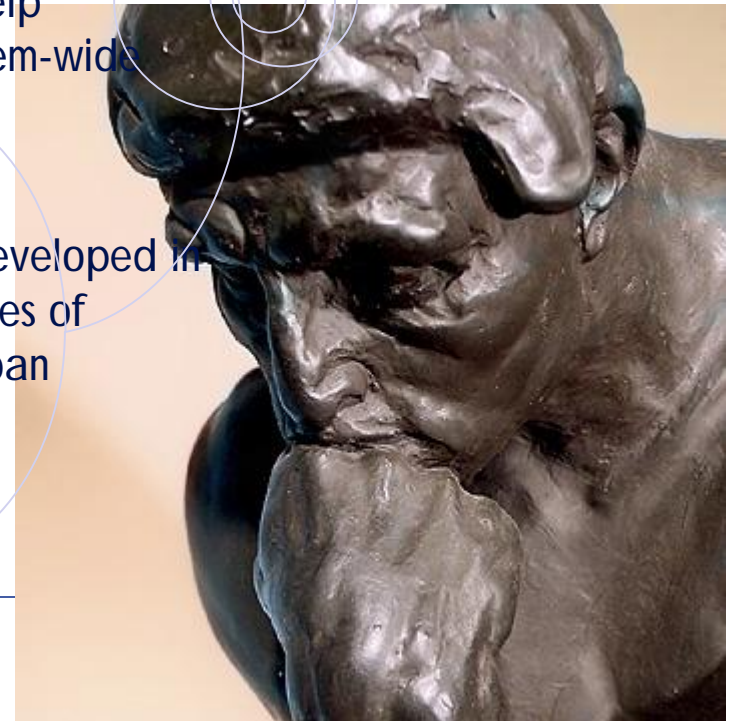


Collected thoughts about traffic sensors

Most sensors and communication infrastructure are installed on a case-by-case basis without knowing whether the associated benefits are fully realized

Caltrans does not have a decision support tool to help evaluate and justify sensor deployment from a system-wide perspective

Optimal sensor deployment strategies should be developed in the context of specific applications for different types of corridors such as rural/mid-size/urban



Deploying traffic sensors

Questions:

- ✘ How many?
- ✘ Which kinds?
- ✘ Where?
- ✘ To what benefits?
- ✘ At what cost?

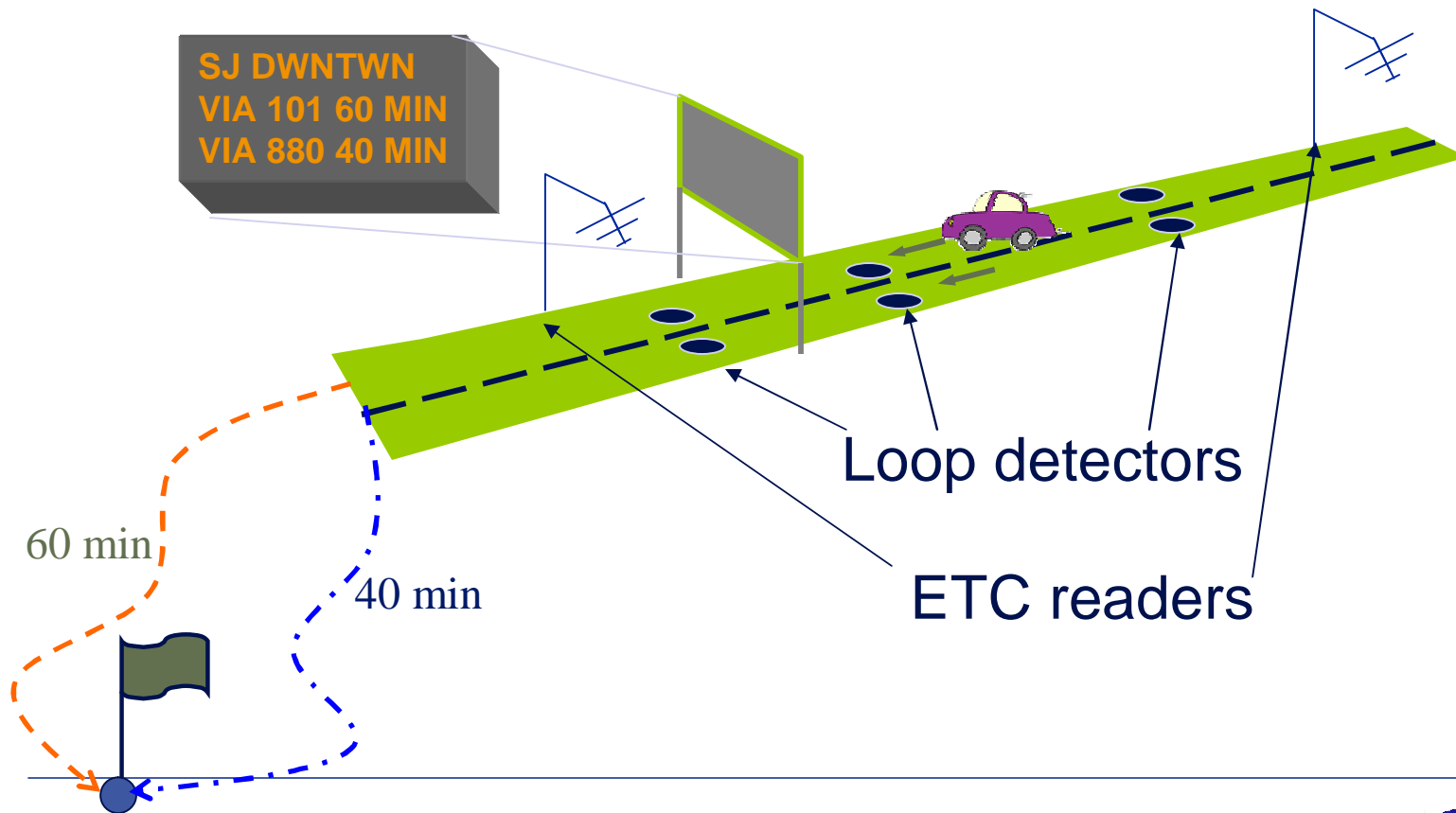
Why they matter:

- ✘ Attaining functional objectives
- ✘ Making the right choices
- ✘ Providing standard guidelines
- ✘ Justifying budget changes



Case Study: Optimal Sensor Placement for Freeway Travel Time Estimation

Application: Displaying Travel Times on CMS



A Dynamic Programming Model

- Empirical Studies

- ✘ Thomas (1999), Eisenman et al. (2006), Liu et al. (2006), Fujito et al. (2006), Kown et al. (2006), Ban et al. (2007)
- ✘ Based on existing sensor deployment, investigate how changes of sensor locations impact the performance of travel time estimation.

- Optimal Sensor Placement Study Sponsored by Caltrans

- ✘ Investigate the requirements for numbers and locations of sensors to collect traffic data for 1) travel time estimation, 2) ramp metering control, and 3) freeway performance monitoring.

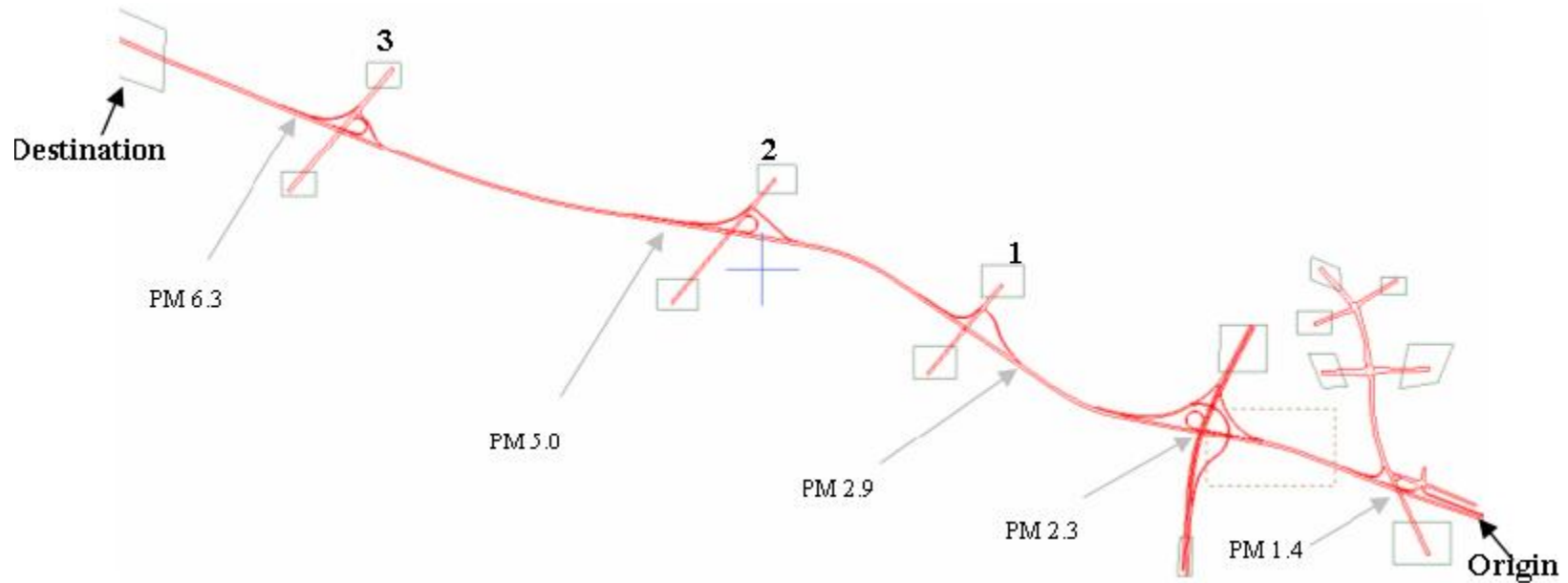
- Current Findings

- ✘ We formulate the problem using Dynamic Programming, which can be solved optimally in polynomial time
- ✘ Test the model and solution algorithm using both simulation and real world data from GPS-Enabled Cell Phones.

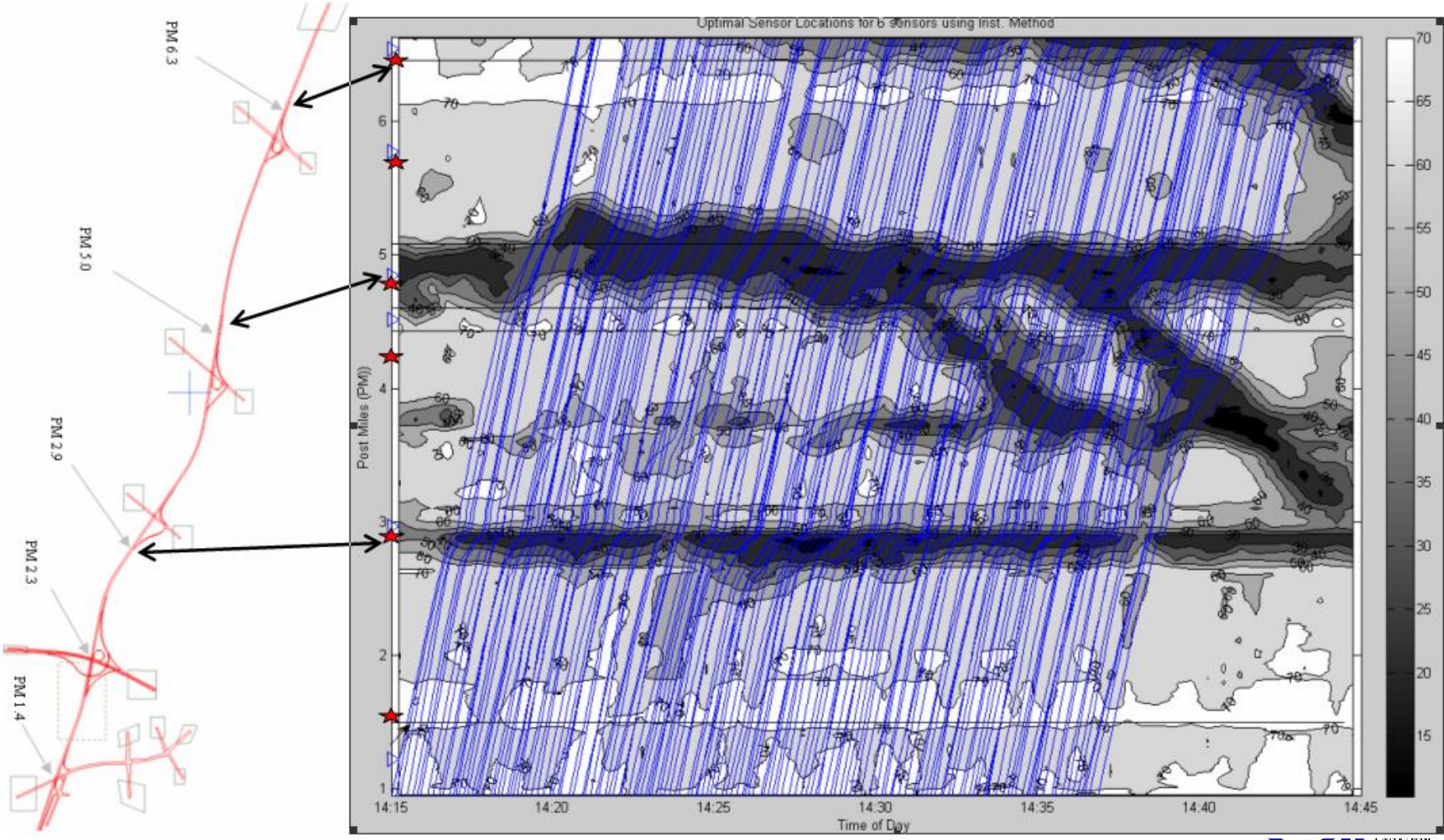


Numerical Results Using Micro-Simulation Data

Simulation Network (I-405 in LA)



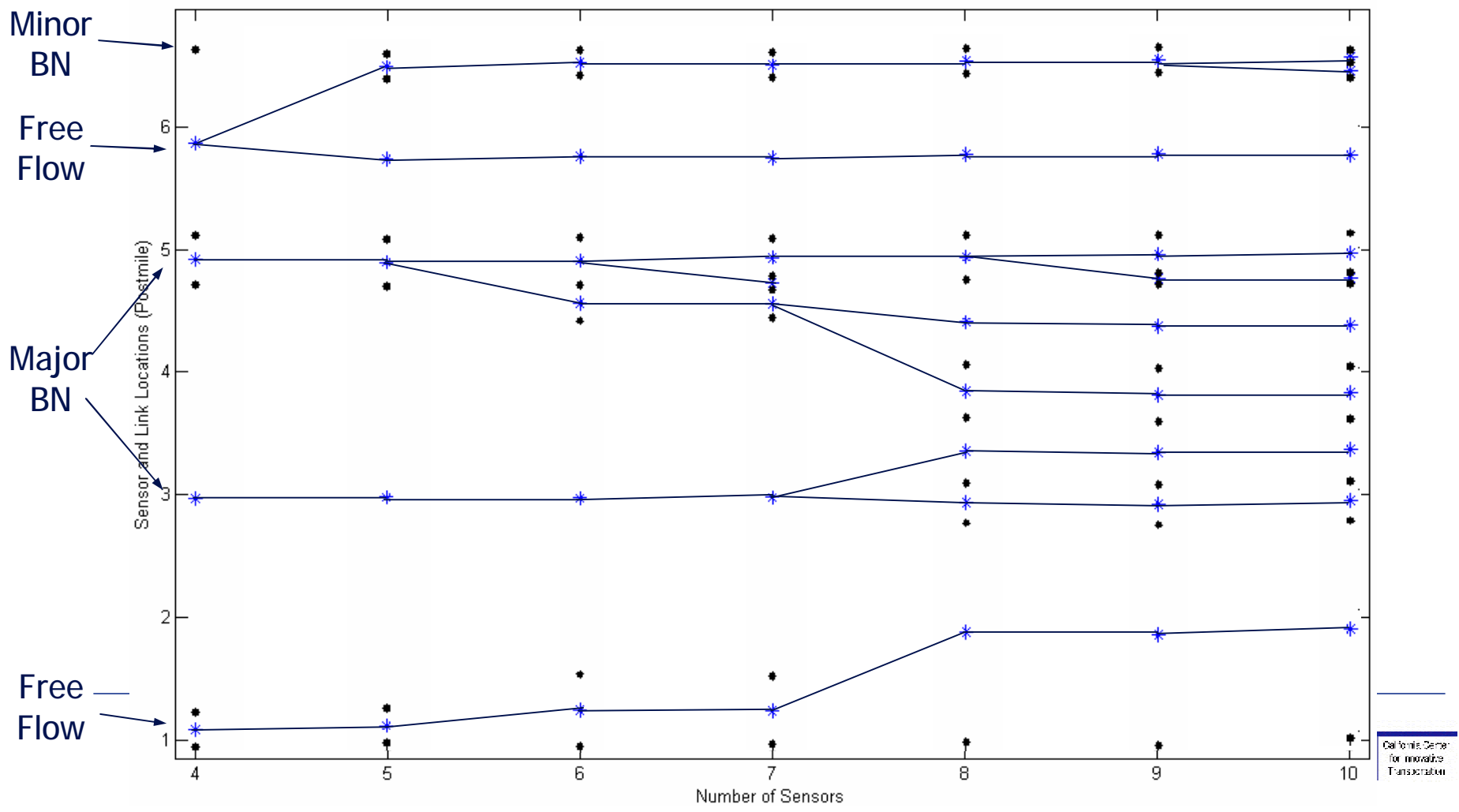
Optimal Locations for 6 Sensors



Evolution of Optimal Sensor Locations



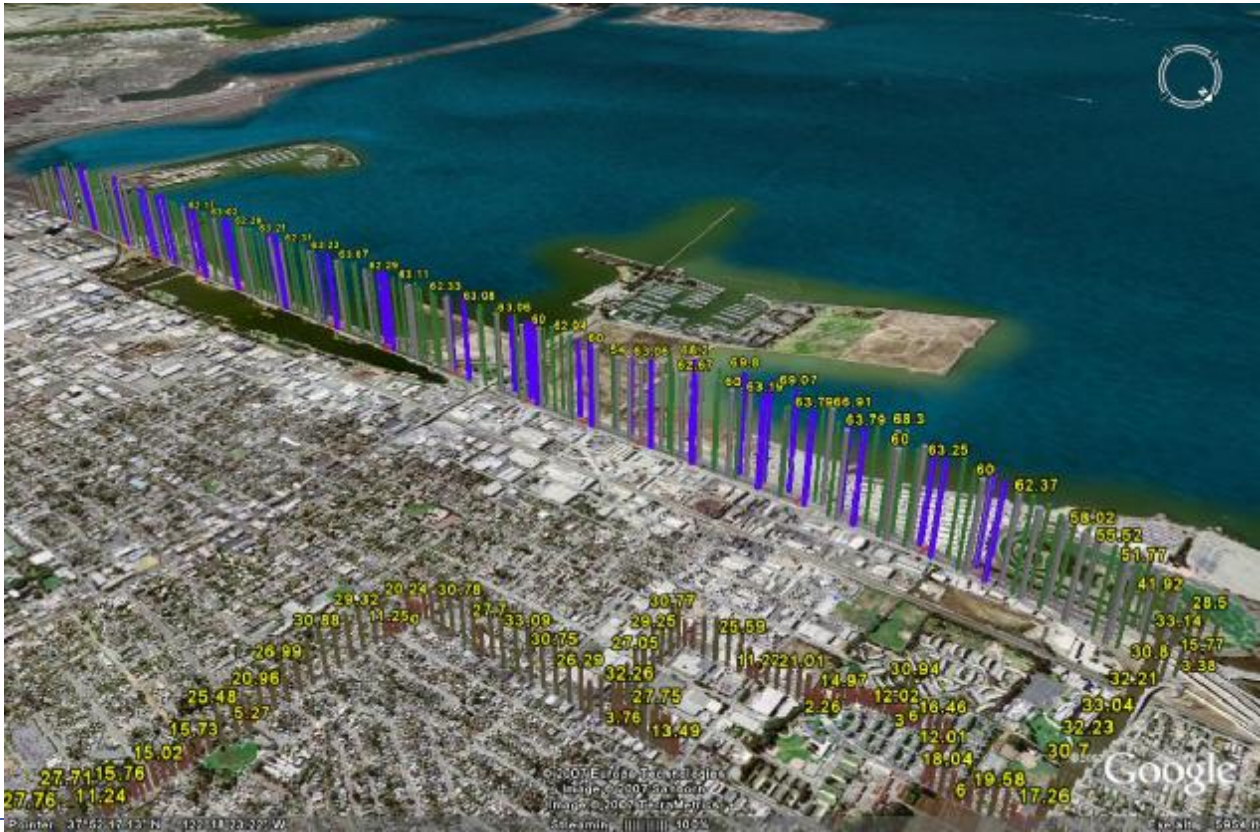
* Sensor Locations
 • Link Locations





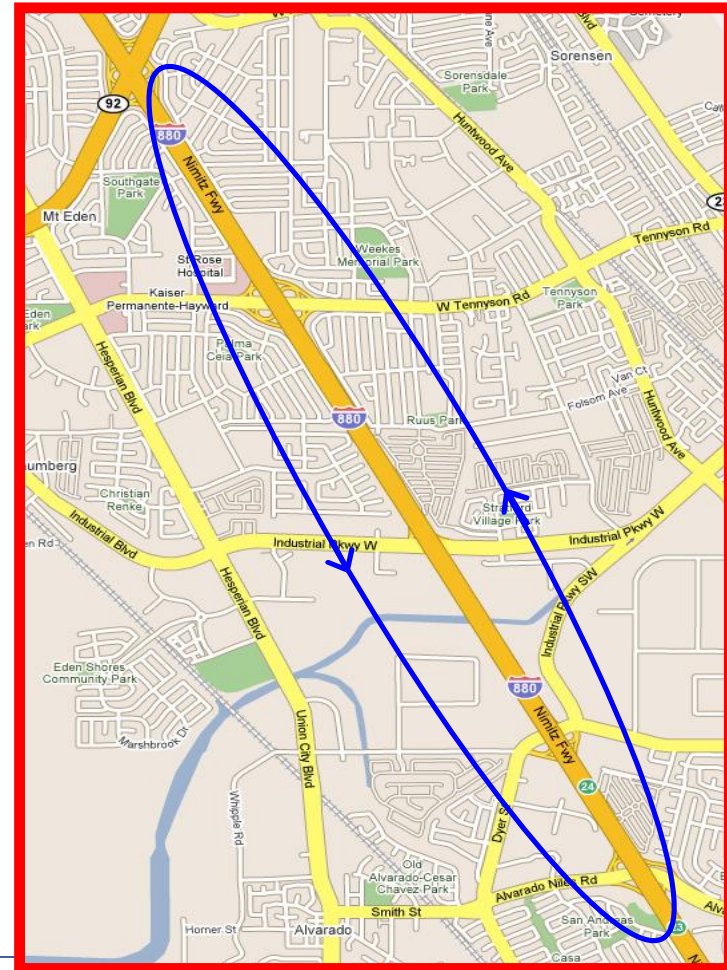
Numerical Results Using GPS- Equipped Cellular Phone Data

Cell Phone Data

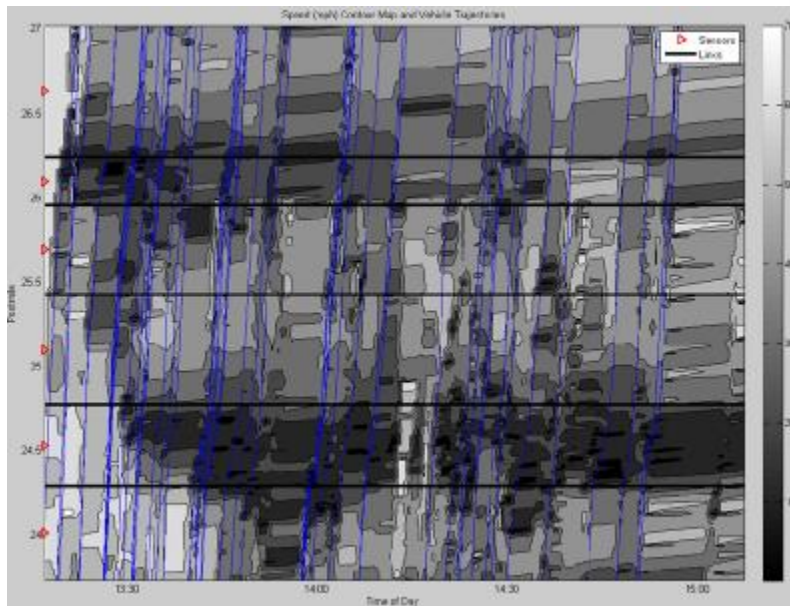


Data Collection

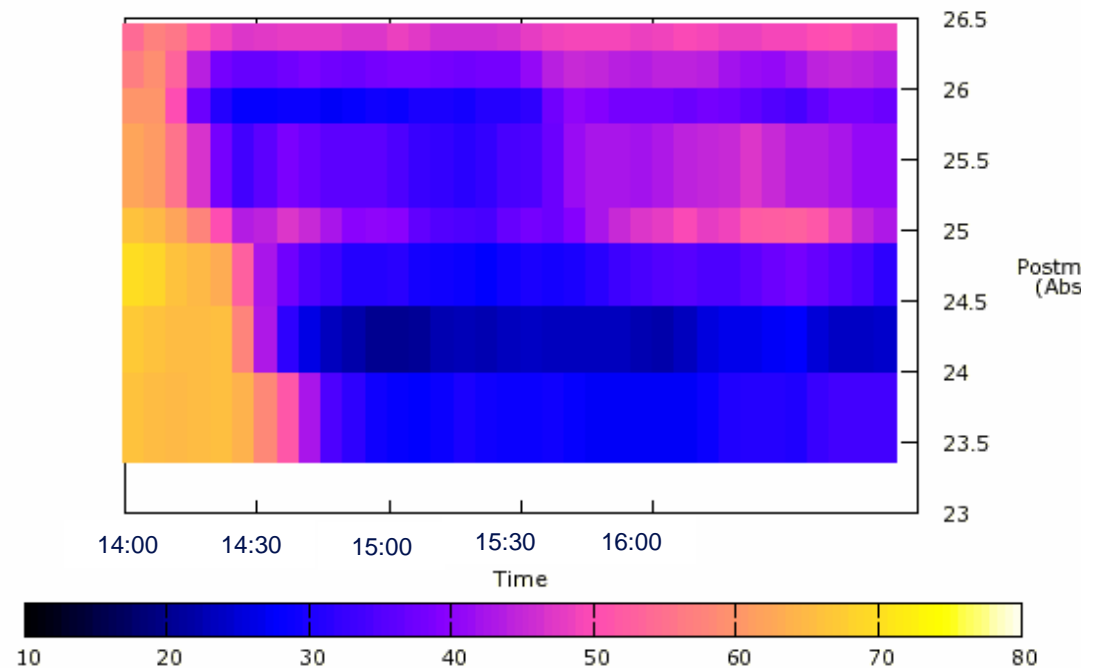
- 20 Cars Equipped with Nokia GPS N-95 Cell Phone, looping between Alvarado Niles Rd and CA-92 (about 3 miles) from 1:00 pm to 5:00 pm on Nov. 02, 2007.
- Average loop travel time is about 20 minutes, equivalently 60 veh/hour, which is about 1% of the total freeway volume on that day (6000 veh/hour).
- Collect trajectories of looping vehicles
- Estimated speed fields of the study route for 2:00 pm – 4:00 pm.



Optimal Locations for 6 Sensors

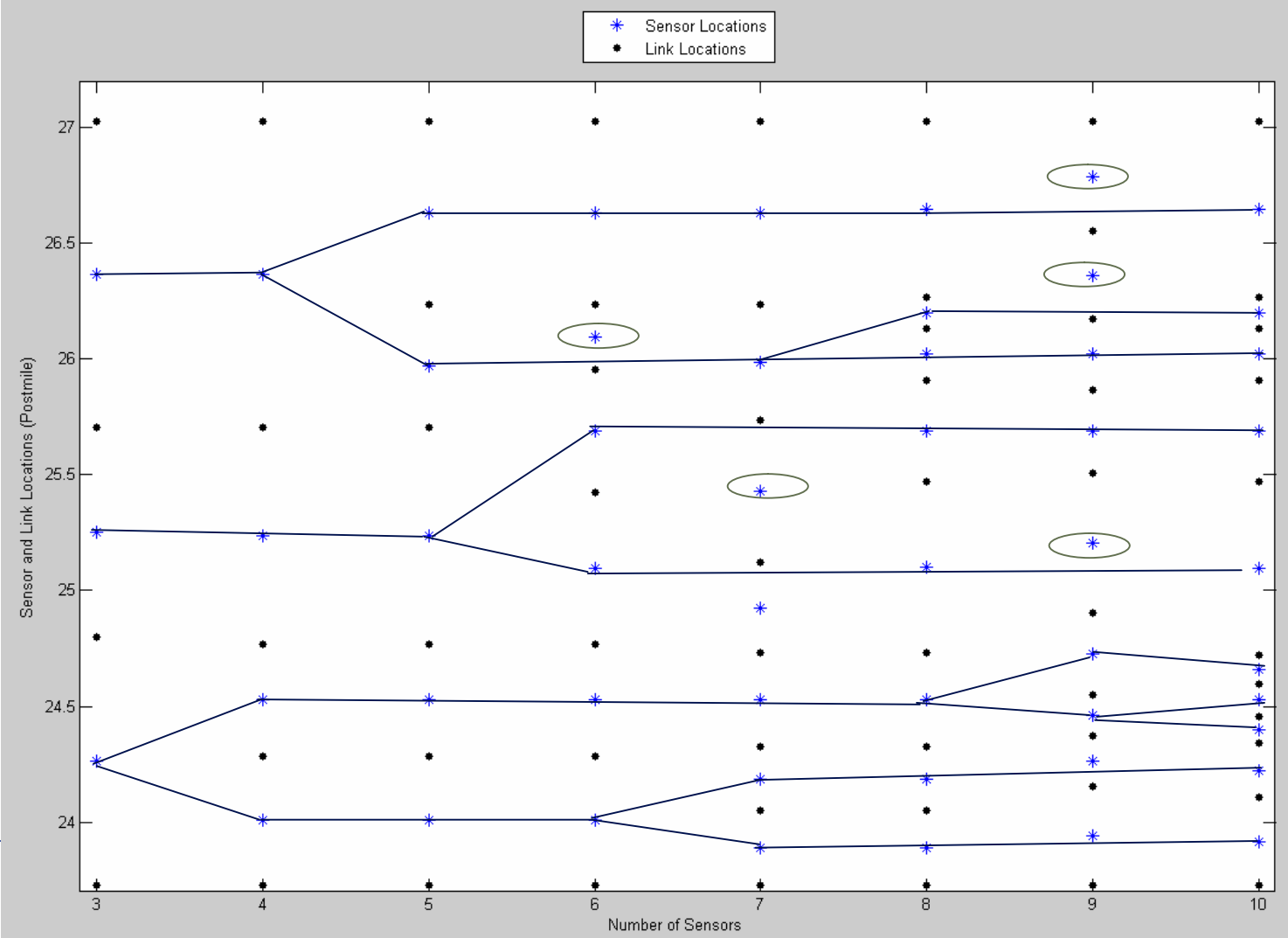


20-Car Experiment

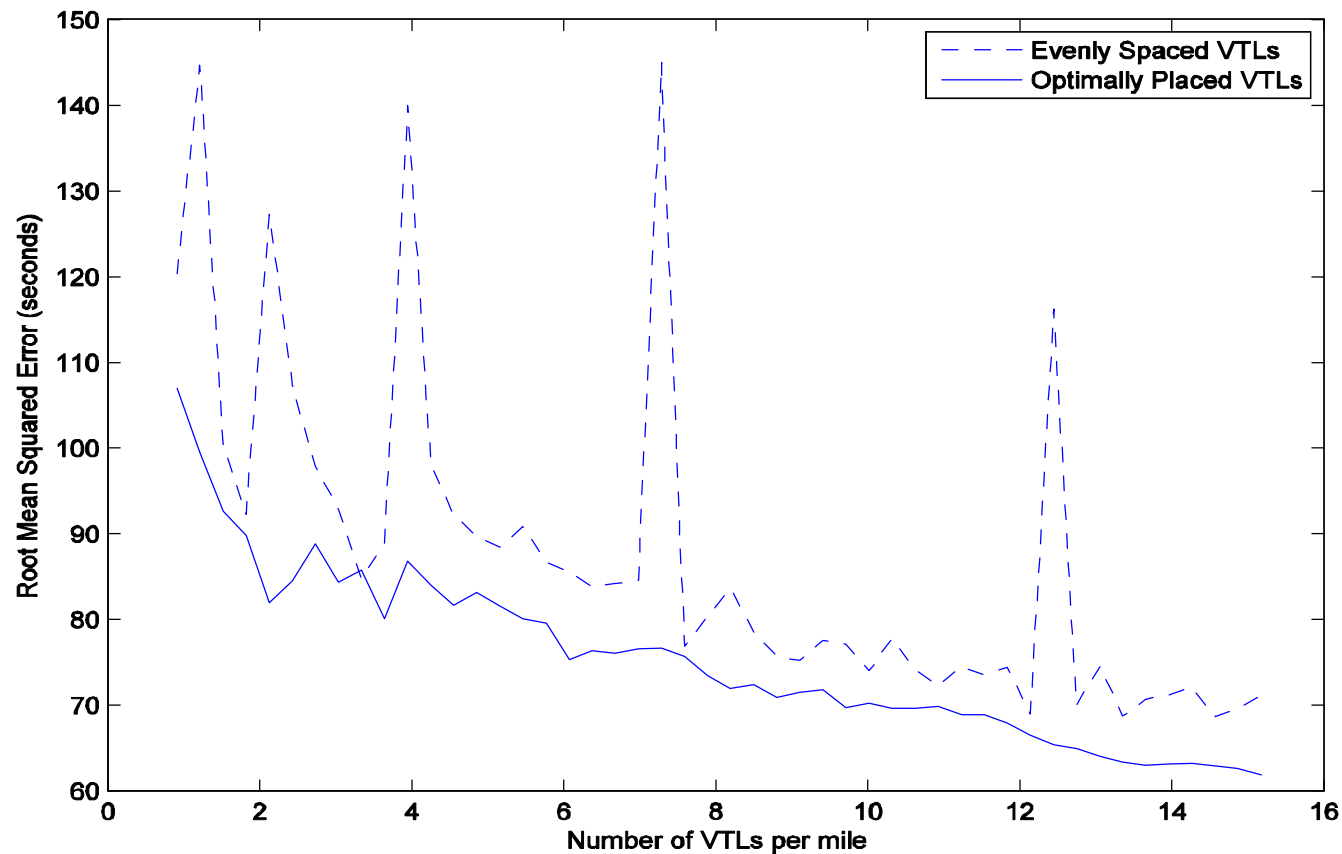



PeMS Data

Evolution of Optimal Locations



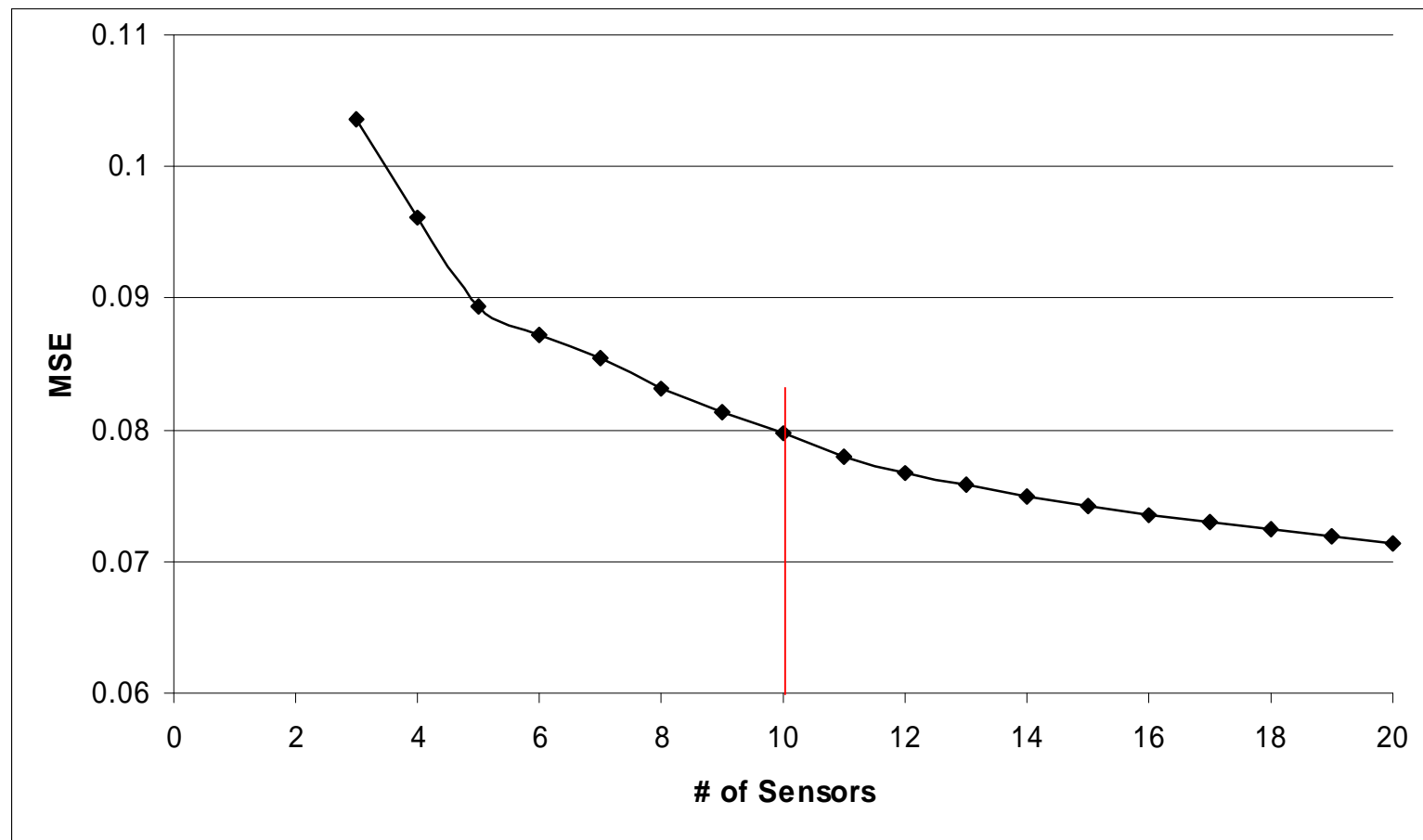
Performance Comparison of Optimally Deployed Sensors with Evenly Spaced Sensors





Challenges: How to Value Information Quality (Accuracy, Reliability, etc.)?

Travel Time Estimation Error vs. # of Sensors (via Simulation Data)



Potential Directions

- System Perspective: information coverage (geographical and demographic), system performance improvement (delay reduction, accident/incident reduction)
- User Perspective: travel time reduction, willingness to pay

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