

Optimal ITS Infrastructure Deployment using Cellular Network and GPS Probes

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Introduction



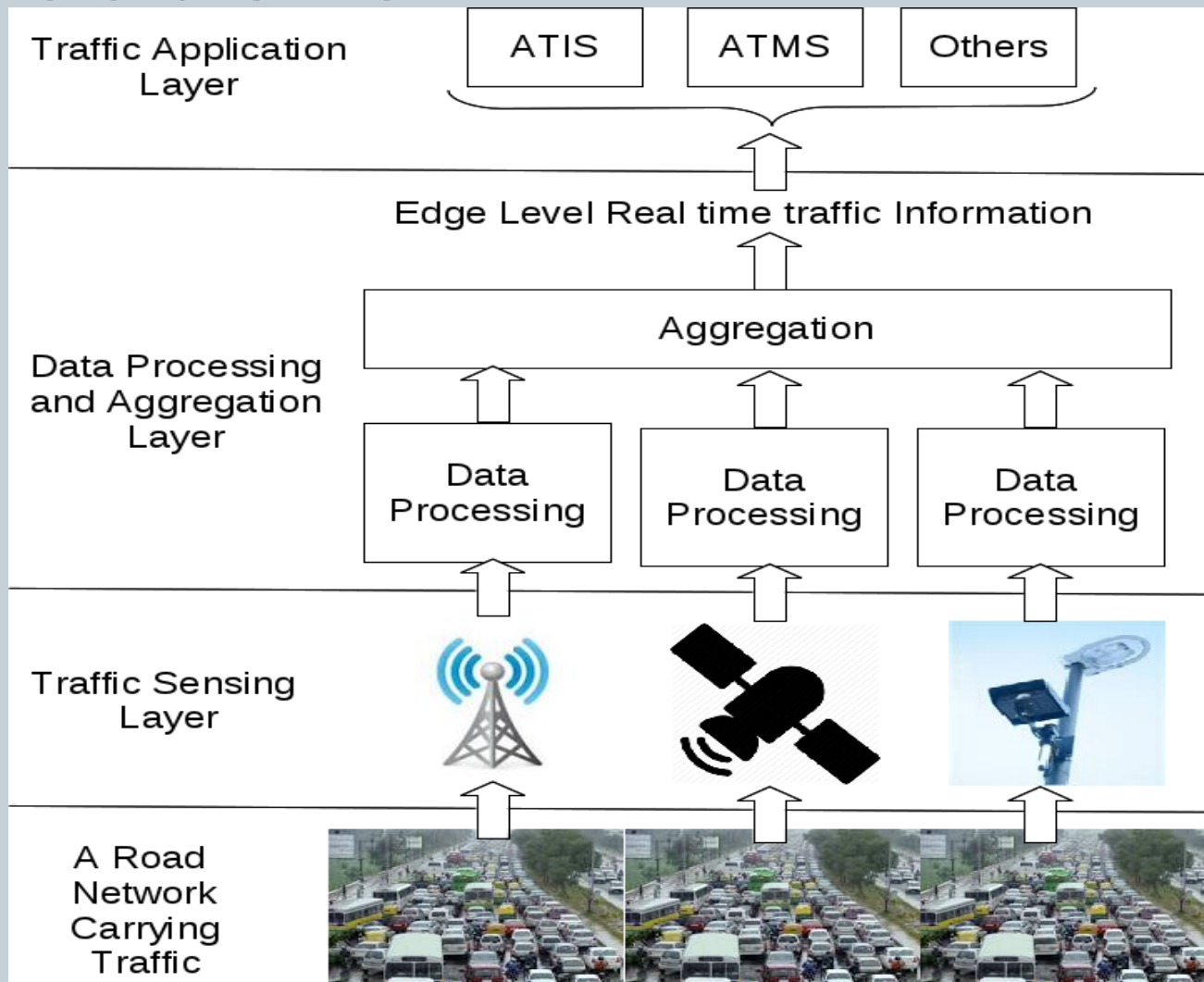
Traffic Congestion!

Introduction

Some Numbers

- The Number of registered vehicles are increasing at the rate of 9.9% in India (2011)
- Road network expansion at the rate of 3.4%
- Efficient use of Road Network is required
- Intelligent Transportation Systems

Introduction



Intelligent Transportation System

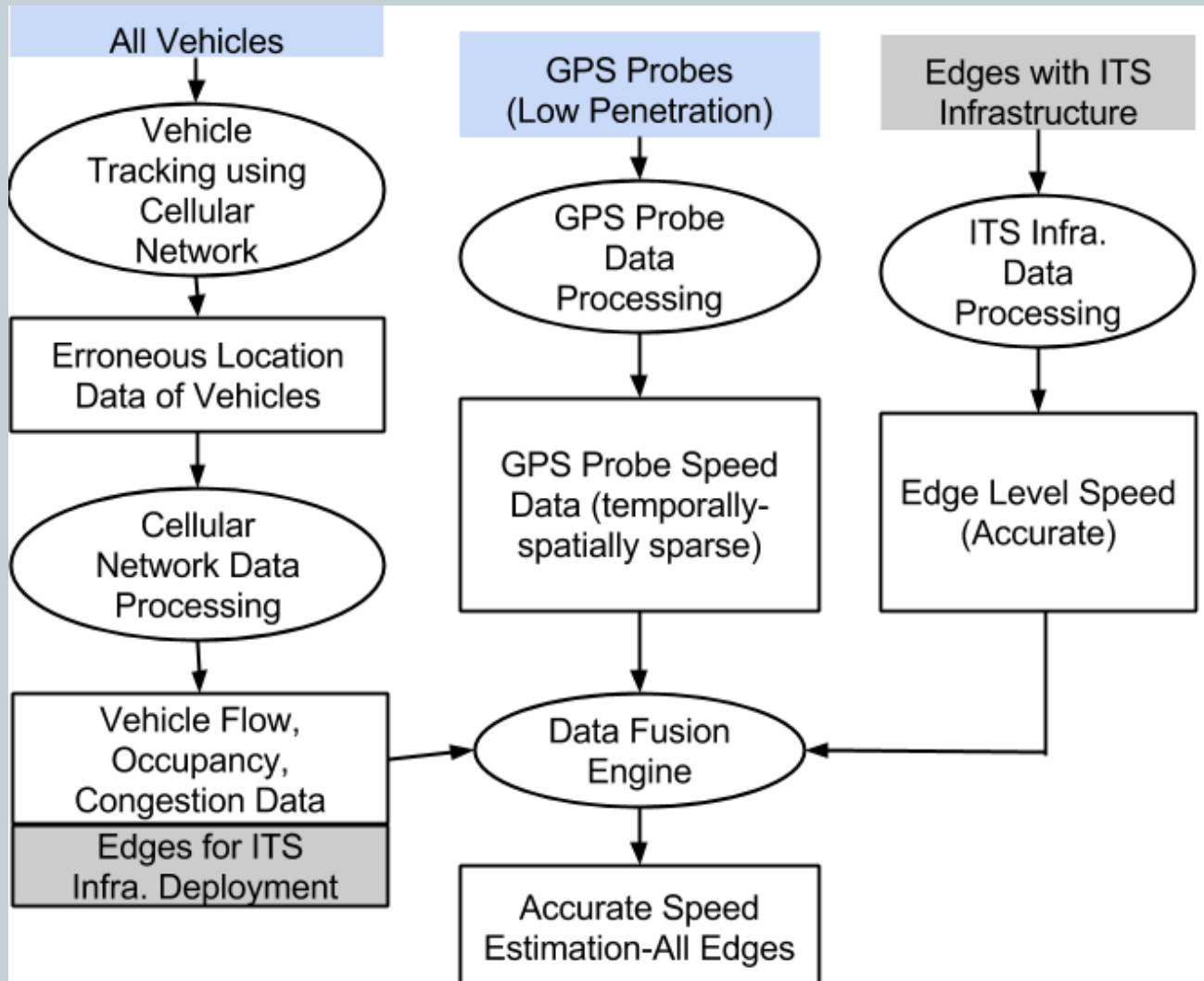
Introduction

- Deployment and maintenance cost of dedicated ITS infrastructure is high

Solution

- Exploit availability of Cellular Network and GPS probes

System Model



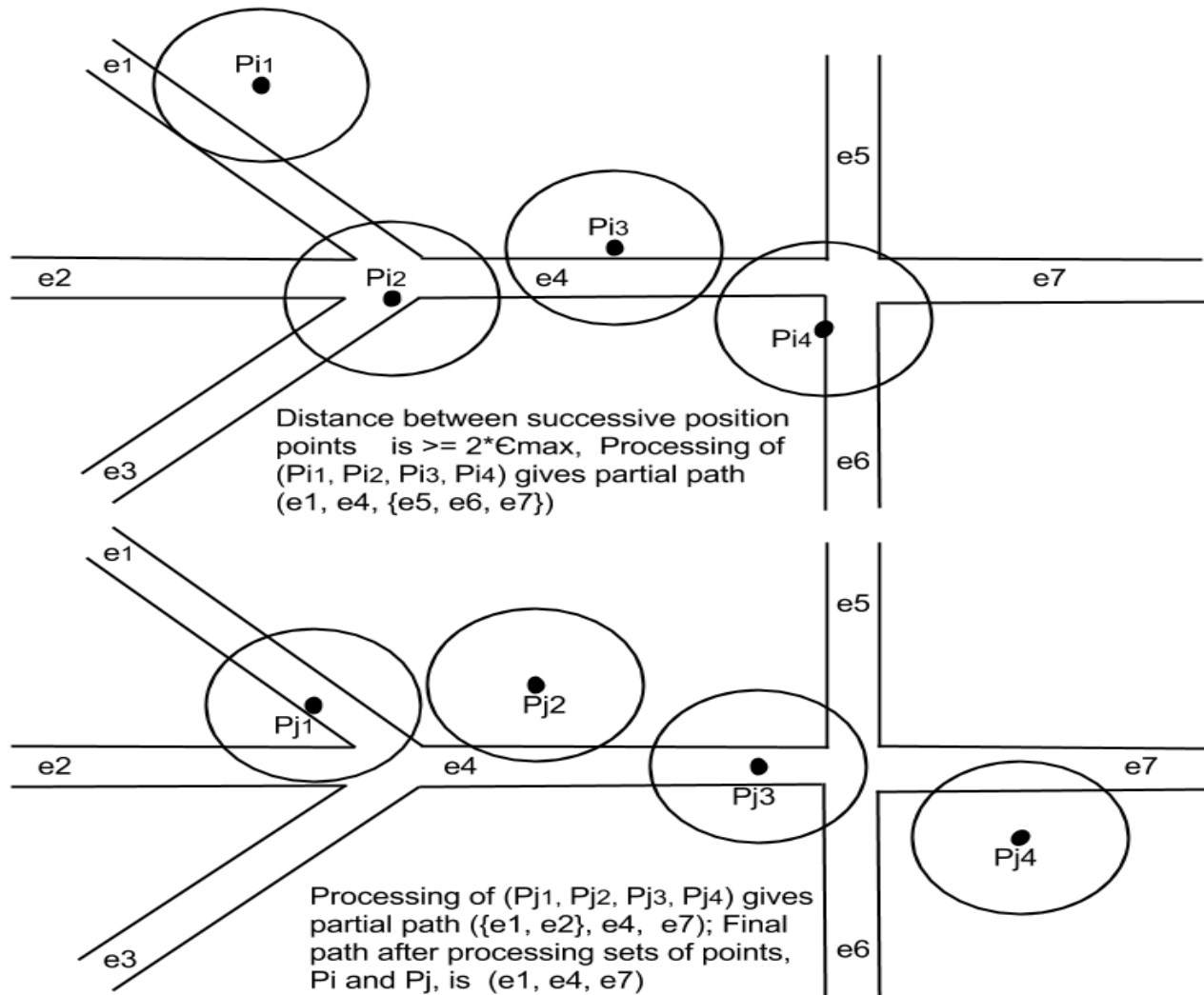
Cellular Data Processing

Localization Experiment Results

- mean location error of less than 50 meters in the regions with very dense cell tower deployment (6-7 neighbor cells with good signal strength of approximately -80 dbm).
- In the regions with relatively sparse cell deployment (2-3 neighbor cells), the mean location error of less than 200 meters is observed.

Cellular Data Processing

Map Matching Process



Cellular Data Processing

- Map-matching permits vehicle trajectory computation
- Edge level vehicle counting is feasible
- Vehicle flow, occupancy, and congestion estimation
- Temporal Extrapolation to remove time-lag in generated information

Speed Estimation

- ITS infrastructure Deployment
- COngestion COverage MOdel (COCOMO)
- Edge COverage MOdel (ECOMO)
- Both the models use Congestion Profile of edges

Speed Estimation

- COCOMO aims to cover all six congestion levels using infrastructure
- An edge that spends sufficient time ($>25\%$) under given congestion level is a candidate for having infrastructure
- Infrastructure deployment is done to K-cover every congestion level
- Infrastructure requirement is independent of road network size

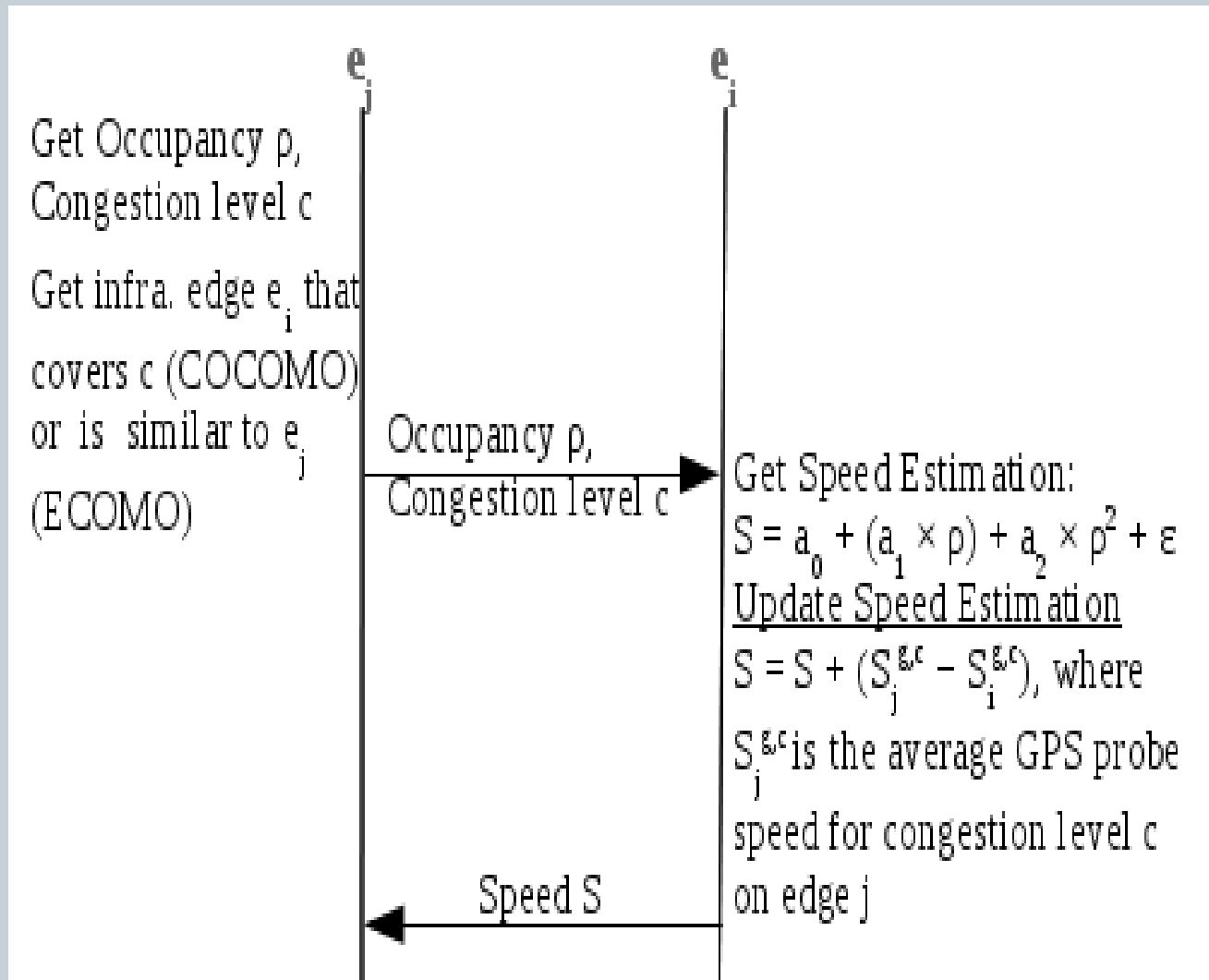
Speed Estimation

- ECOMO aims to cover all the edges in a road network using infrastructure
- An edge e_j is said to be covered by an infrastructure edge e_i if e_i and e_j have similar congestion profile
- Chi-square test is used to measure similarity

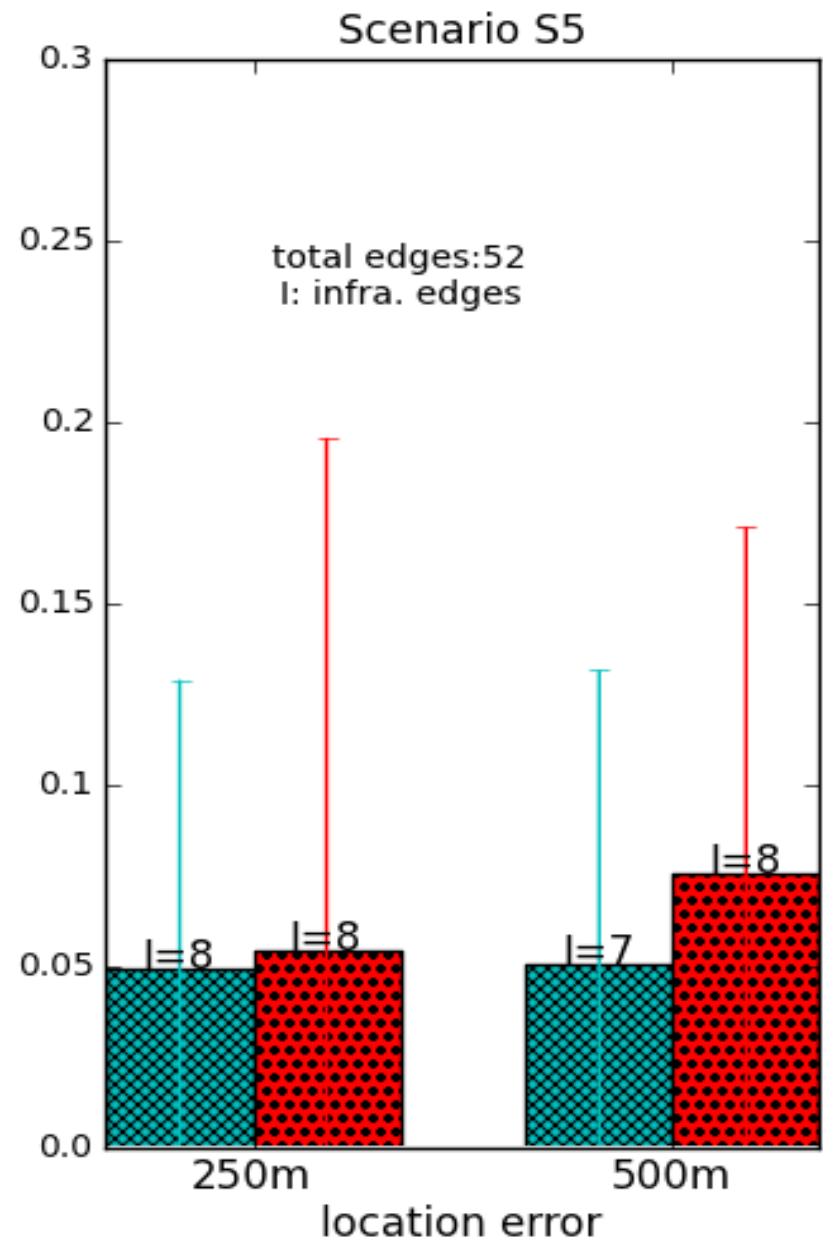
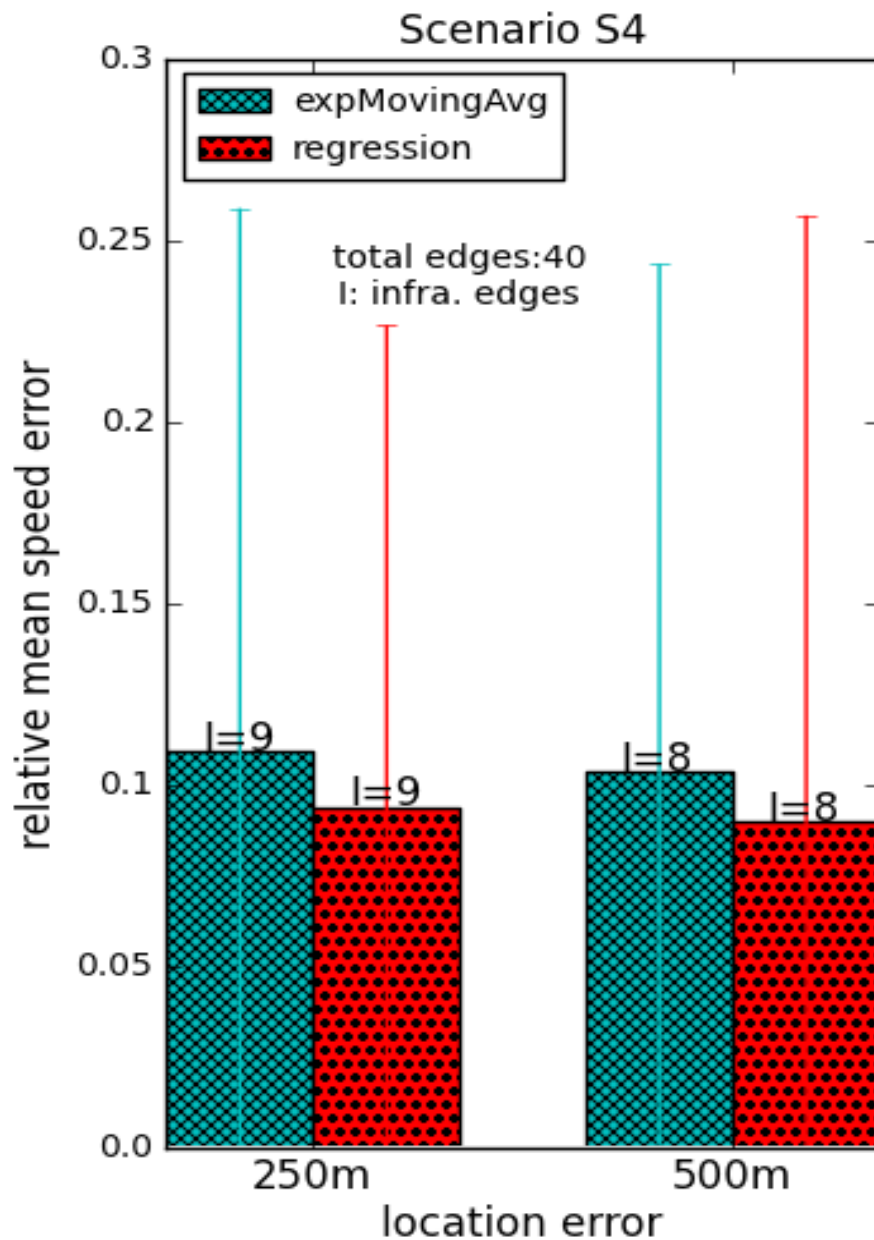
Speed Estimation

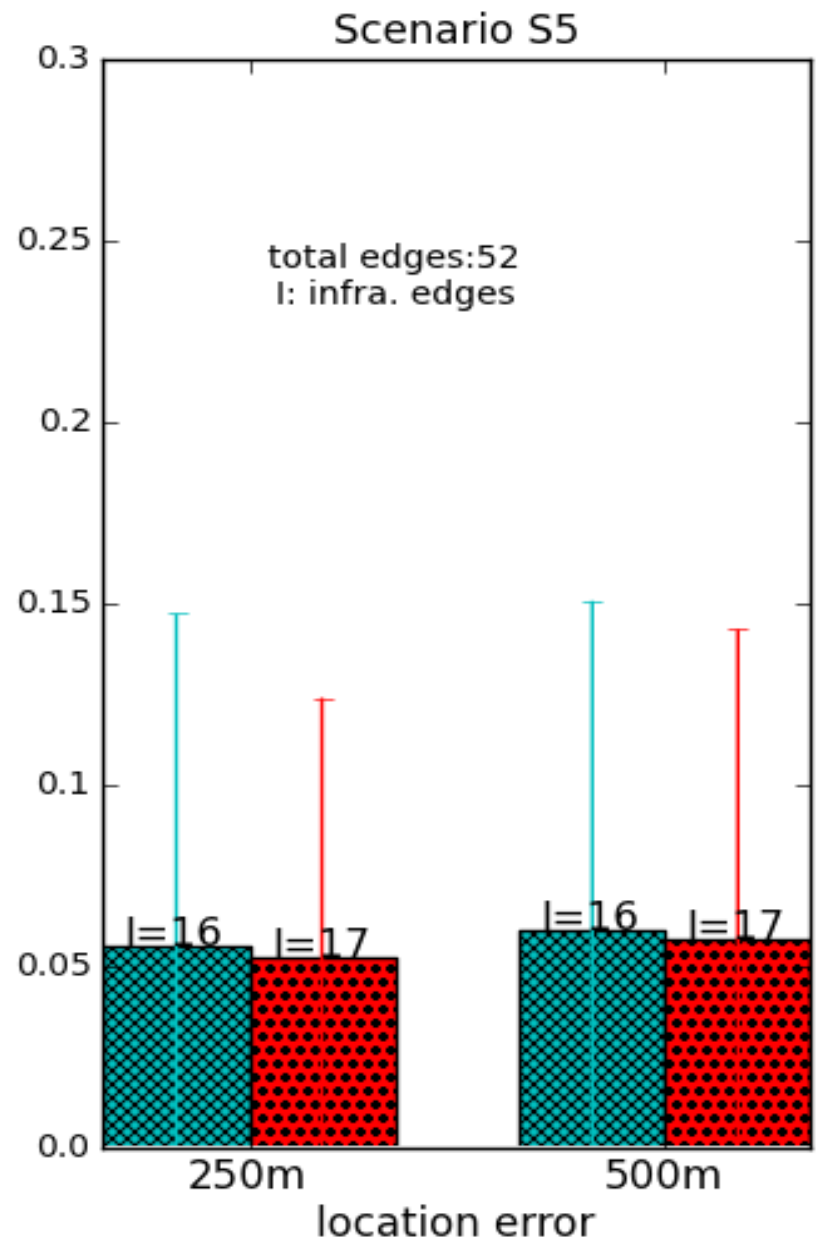
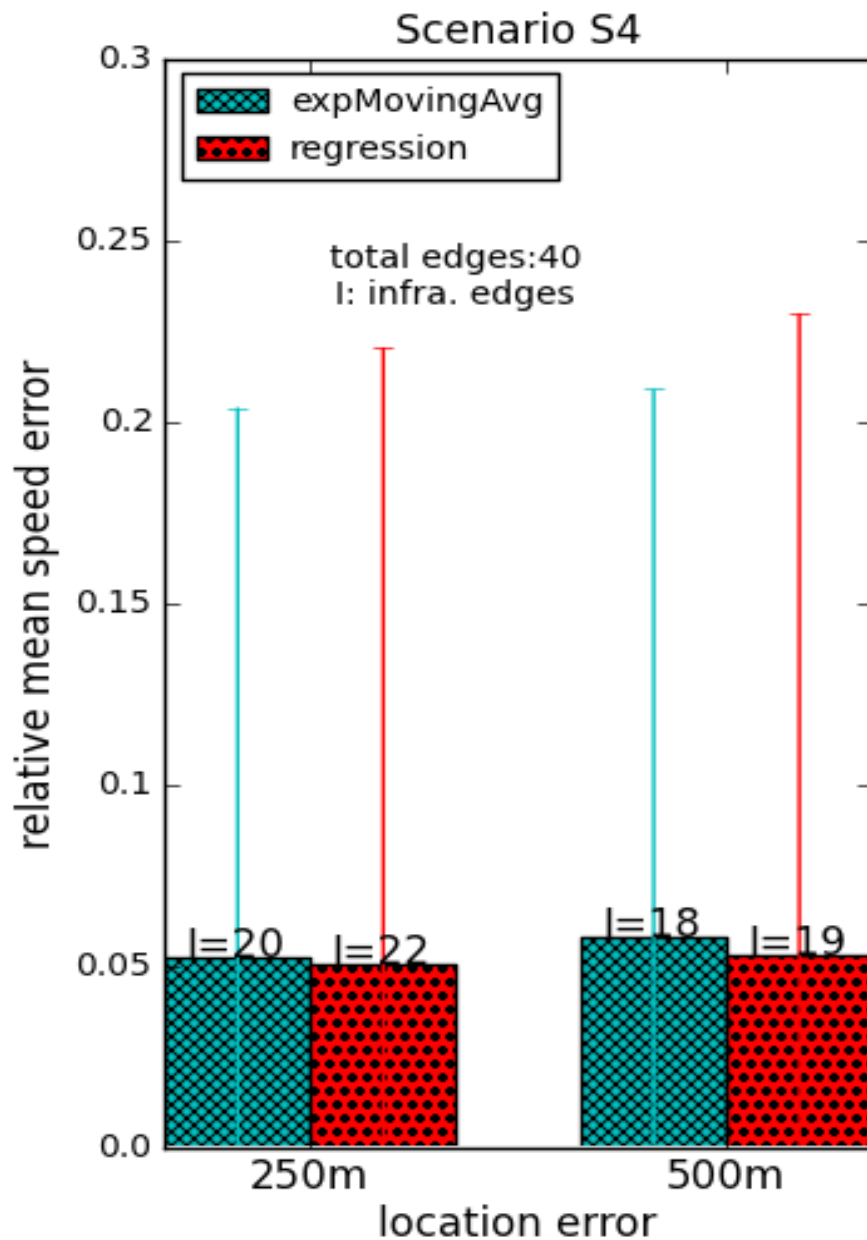
- For every edge e_i , the set of similar edges is recorded
- Infrastructure deployment is done to K-cover all the edges
- Greedy approximation algorithm is used
- Infrastructure requirement depends upon the traffic profile of edges
- Incremental infrastructure deployment is feasible

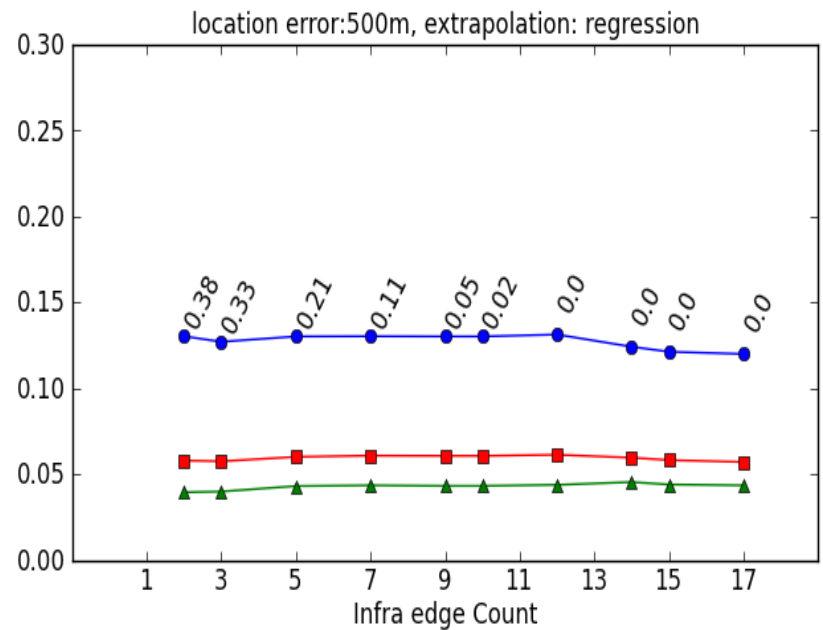
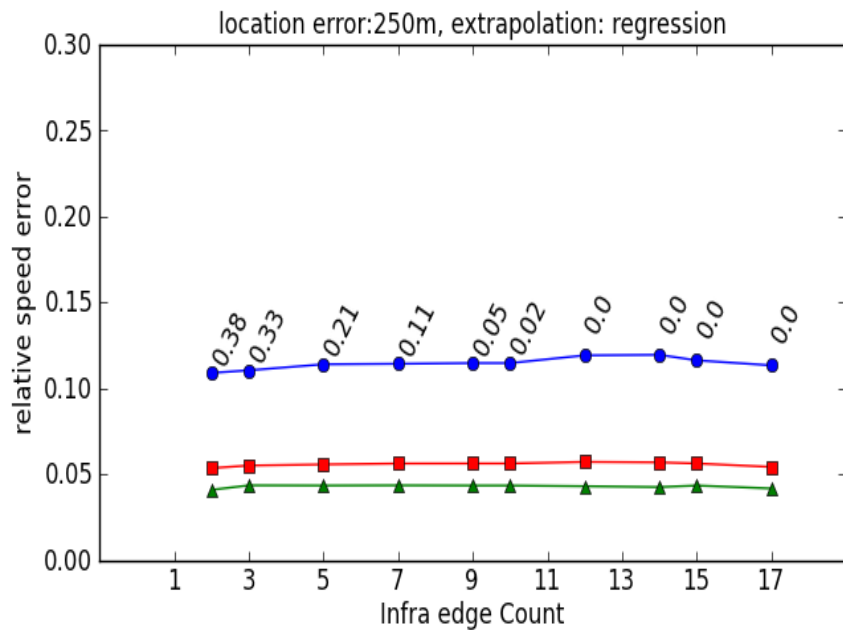
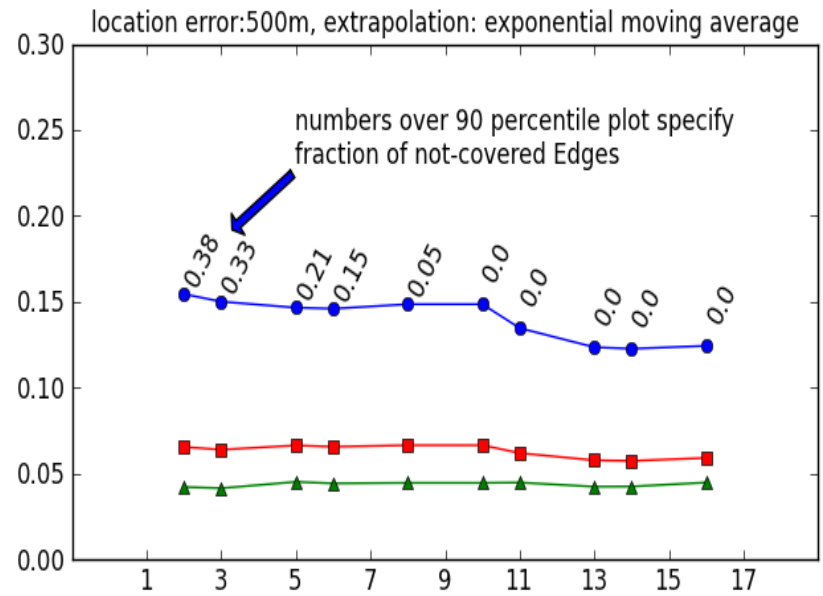
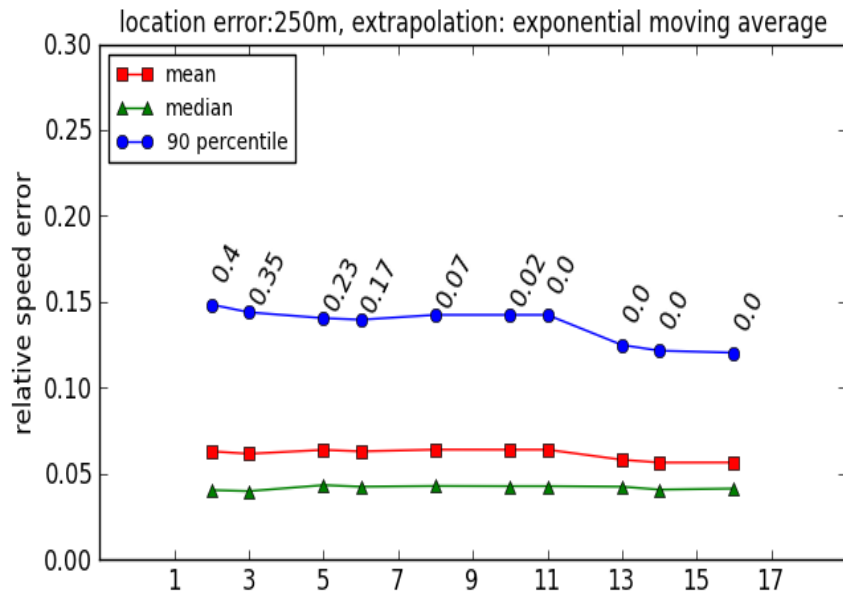
Speed Estimation



Speed Estimation using COCOMO or ECOMO



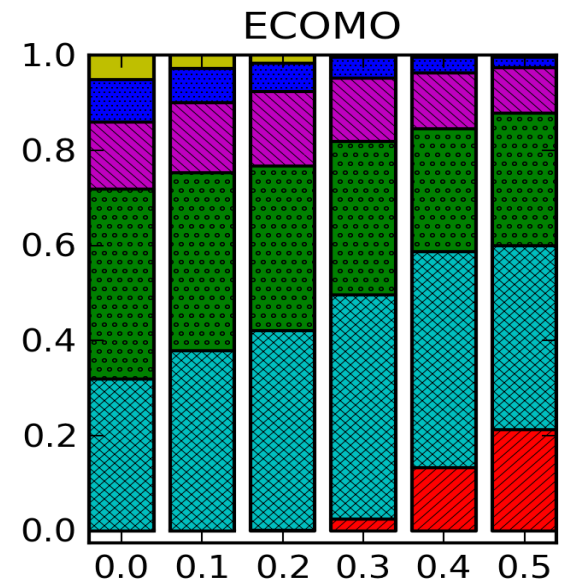
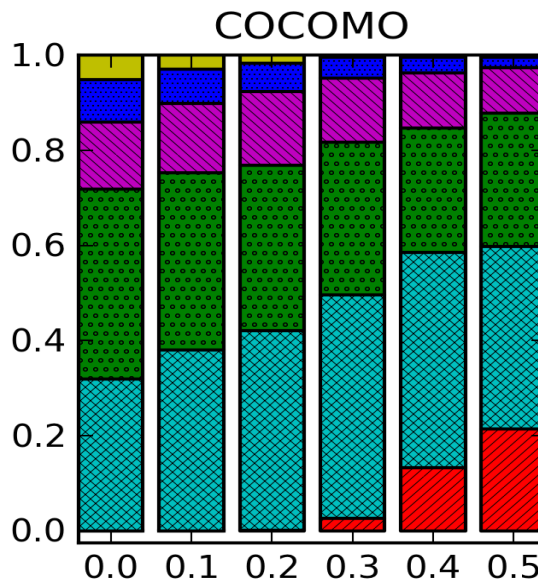
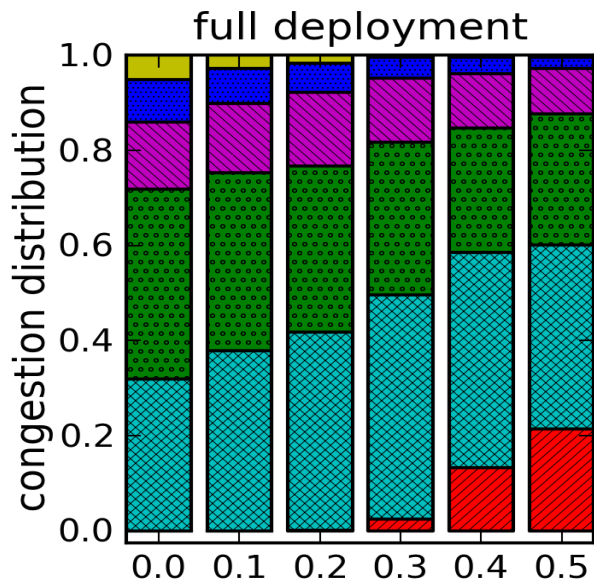
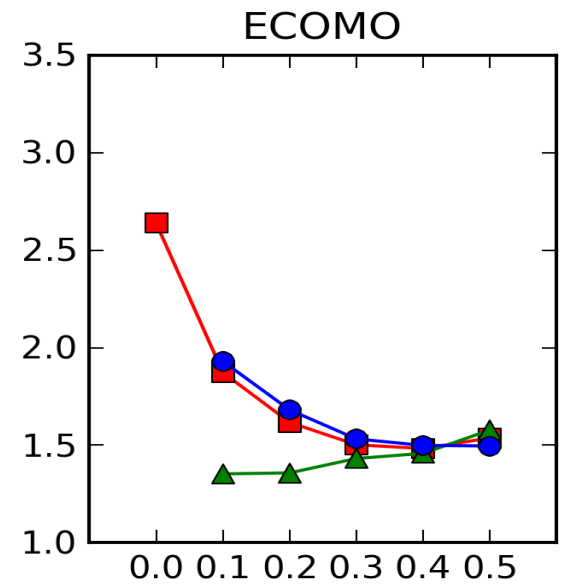
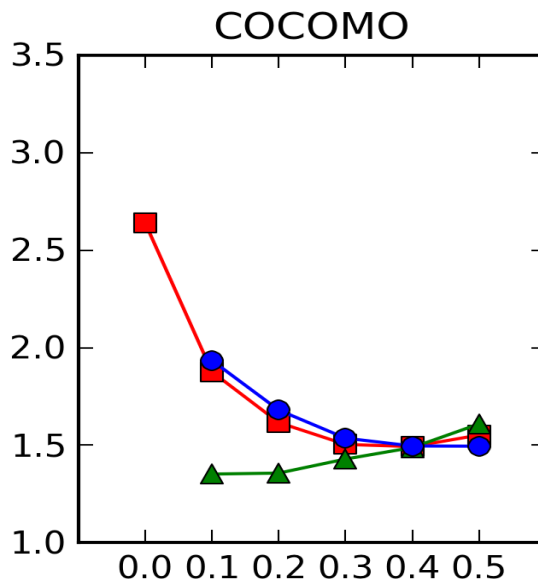
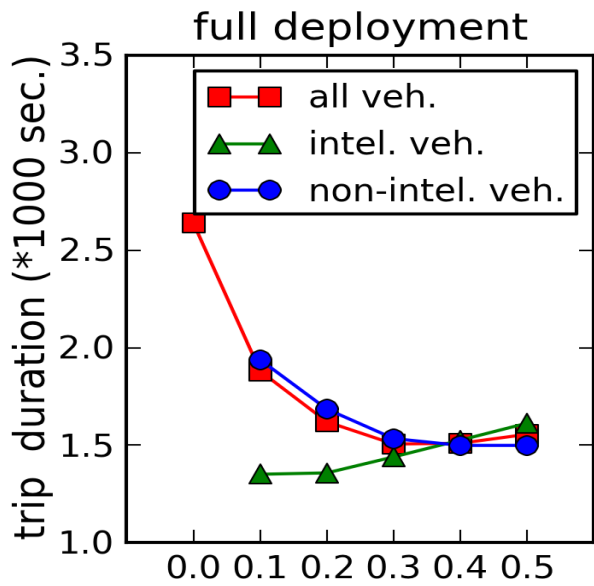




ECOMO: Effect of Limited Infrastructure Deployment

Application

- Advanced Traveler Information System (ATIS)
Suggest trip route and enroute changes to the commuters
- Advanced Traffic Management System
Suggest diversions
Adapt Traffic light schedules



Performance of ATIS with COCOMO and ECOMO

Summary

- A novel design of an Intelligent Transportation System (ITS) is proposed that utilizes cellular network data and GPS probes to minimize the ITS infrastructure requirement
- A methodology for generating edge level traffic information is demonstrated

Thank You

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