# Teleport

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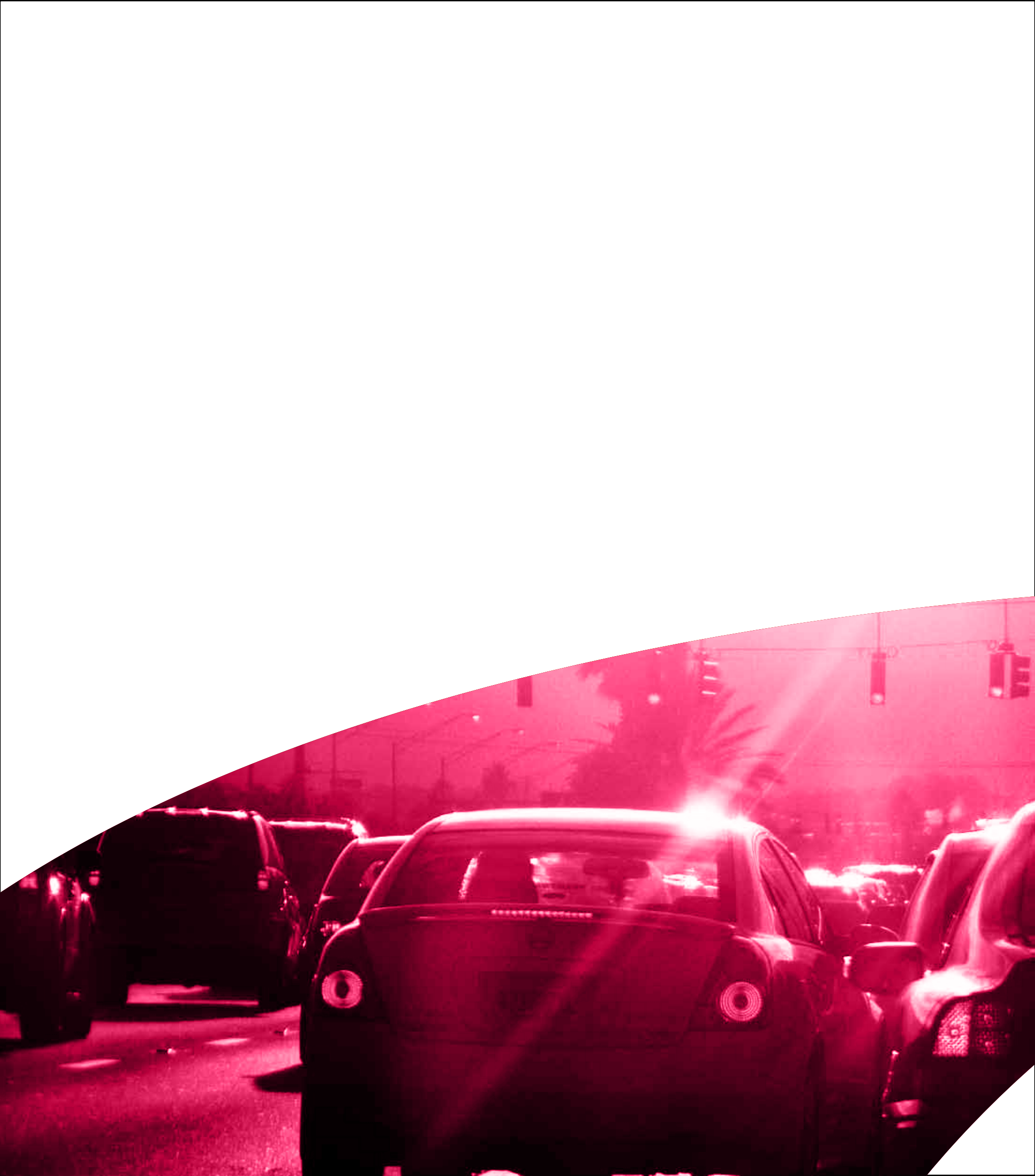

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# Project Profile

Teleport is a traffic congestion solution that accurately estimates travel time using Bluetooth based cell phone penetration and a low-cost Bluetooth sensor network.

The key idea is based on the observation that most phones carried by commuters even in emerging markets have short-range radio interfaces present on the phone. Of these, Bluetooth is the most pervasive (802.11 WiFi could be another option). Given this, our approach is the following. We place low cost Bluetooth scanners along the road-side - these sensors have two key capabilities, detecting other Bluetooth devices in the vicinity, and sending the collected data on a wireless back-haul link to a back-end server. As vehicles with Bluetooth devices travel by, the Bluetooth scanners placed on the road-side passively detect the vehicles and take a note of the MAC id (of the Bluetooth interface) and the time(s) of detection of the vehicles. This information is transmitted periodically by the scanner to a back-end server, which, by correlating a MAC id observed between any two scanners computes the travel time between the points at which the scanners are placed.

By placing such Bluetooth scanners at many points across the city, and correlating their observations, travel time estimates between any two points in the city can be computed. One crucial advantage of our system is that it requires no active participation from commuters. They do not need to download any application on to their phones or incur costs in transmitting positional information. The cost of the scanner-box will be of the order of USD 100-200 - allowing widespread deployment across any city. The system has very little privacy related concerns as it is extremely difficult to match the MAC of the Bluetooth interface of the phone with the identity of the phone user. Also, as we show using our prototype deployment, the system is capable of providing highly accurate travel-time estimates in real-time with the aid of data mining and statistical algorithms.

# Problem & Opportunity

Traffic congestion is an important and topical problem since a high quality transportation infrastructure and the ability to move goods and services in a timely and cost-effective manner, plays a critical role in the economic prosperity of any nation. For example, according to , the GDP loss due to traffic-congestion could be up to 6%in Bangkok, and around 2 % in Japan, while according to  in New York City alone, the annual economic loss due to congestion is USD 13 billion. Clearly, traffic congestion has an even greater impact in developing countries, where the gap between the capacity of the existing infrastructure and the needs of the economy is usually the widest.

Congestion reduction can be alleviated in a variety of ways, such as increasing road capacity, improving public transportation, congestion taxes etc. Each of these methods has its own pros and cons and require government commitment, significant capital investment and public support

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to be successful. We argue that in addition to all these approaches, providing relevant and timely information about traffic conditions to commuters will go a long way in alleviating congestion and commuter stress. Providing accurate information such as the least congested route to take, the expected travel time on the route allows commuters to make informed choices about routes, thereby easing the congestion on the road. In addition archived information on commute times, congestion patterns on different road stretches etc., can be used by urban planners to make informed decisions such as where to improve road capacity, on which routes to increase public transport frequency etc. Providing such fine grained information requires a large scale traffic sensing infrastructure. However current solutions are extremely expensive or woefully inaccurate. Our goal in this paper is to design a low cost traffic sensing system especially applicable to emerging markets.

A good traffic sensing system for emerging markets should satisfy the following requirements.

1. Accuracy: The system should provide accurate travel-time information, with appropriate confidence intervals for the estimate.
2. Low-cost and scalability: The cost of the solution (installation and maintenance) is a major design constraint. In fact, several existing solutions are prohibitively expensive for emerging markets like India, Indonesia etc. Apart from the initial deployment costs, the costs should not increase with the volume of traffic and number of users of the traffic information.
3. Robustness to failures: The system should provide graceful loss in performance with the failure of any of its components.
4. Richness of information: Apart from immediate travel-time information, the system should also have the ability to predict travel times a few hours in to the future, allow users to explore archived data and ideally do vehicle classification.

# Solution

A low cost accurate Bluetooth based traffic sensing solution that accurately measures traffic conditions in real time and provides this information via  simple easy to use API's (e.g. a web based UI)..

The TelePort system relies on two key observations:
(i) many commuters have Bluetooth enabled cell-phones because most cell phones (including low-end cell phones costing even less than USD 50) come with Bluetooth, (ii) a Bluetooth device simply performing device discovery in inquiry state can at least detect the presence of other Bluetooth devices in the vicinity without having to establish a communication between the inquiring device and the detected device. To this end, the key working principle is following: if a vehicle carrying a Bluetooth device A is detected by two Bluetooth sensors/scanners placed at the beginning and end of a road-stretch, then the travel-time on the road stretch can be deduced from the detection times of A.

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# Business Benefits

- Unique low cost sensing technology
- Advanced algorithms to provide reliable travel time estimates, distinguish between pedestrians and vehicular traffic
- Lower cost than in-road sensing
- More accurate than cellular triangulation (TrafficCast/ IntelliOne/TomTom)
- First mover advantage in India and other emerging markets


# Technical Benefits

- Single button deployment
- Standalone deployment with mobile backhaul & alternative energy supply possible
- Remote sensor management and trouble shooting
- Hardware and data center scalable on demand
- Highly secure and privacy preserving
- Expandable to measure other quality of life metrics (e.g., temperature, Co2 etc.)
- Easy to integrate in a wider ITS suite

| | Cost | Accuracy | Travel Time Estimate | Vehicle Classification | Privacy |
|---|---|---|---|---|---|
| Inductive Loop | High | High | No | Yes | Yes |
| Camera | High | High | No | Yes | Yes |
| Cellular Triangulation | Low | Low | No | No | No |
| GPS | Low | Medium | Yes | ? | No |
| TelePort | Medium | High | Yes | ? | Yes |

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# Innovation & IP


1. To the best of our knowledge, ours is the first work to design and rigorously evaluate a near-field communications based traffic sensing mechanism using Bluetooth-based sensors. Our system is capable of providing highly accurate real-time estimates of travel time, has a very low deployment and maintenance cost, and is robust to failures.

2. We conducted extensive experiments to characterize the efficacy of Bluetooth as a traffic sensing solution.

3. We designed, implemented and deployed (for over a month) a pilot system in the city of Mumbai, India.

4. We presented an extensive analysis of the traffic data and observed interesting patterns.

5. We designed algorithms that exploit this structure to predict travel time. For the data we collected, our algorithm significantly outperforms recently proposed algorithms in literature. We provide a novel improvisation of a well known statistical estimation technique (LMSE) to improve the estimation accuracy of travel time on a road stretch even when very few Bluetooth devices are present.

# Team

- **Vikram Srinivasan**
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- **Markus Berg and Marios Nicolaou**
- **Samik Datta**
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