HotMobile 2012 Demo: Smartphone-based Traffic Information System for Sustainable Cities

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Traffic Information Systems (TISs) can play a significant role towards creating sustainable cities through improved traffic conditions. The collection of reliable and rich information with low cost is paramount. The use of smartphones carried by individuals for future implementations of TISs present several advantages compared to traditional solutions. This demo integrates our results from previous work addressing challenges on traffic estimation for urban road networks and on security and privacy protection for such TISs.

I. Introduction

Smartphones have several advantages for data collection in traffic information systems. Smartphone-based TISs (Figure 1. illustrates such a system) can have significantly lower cost and achieve larger coverage compared to TISs based on roadside infrastructures or dedicated on-board units. The increasing smartphone penetration has the potential of providing a huge traffic probe base and therefore their integration in TISs is still an open and actively researched topic [1].

Towards a fully operational system of this type, a number of issues must be addressed [2], notably: (i) its security and privacy protection, and (ii) the processing of the collected location data to estimate the traffic state, especially for urban road networks. With several TIS applications and a few field tests, this demonstrator brings forth novel features. Based on our results [2]-[4], we implemented and integrated all necessary components to get a system that: (i) estimates traffic conditions solely based on data from smartphones, (ii) collects data securely to protect the TIS, (iii) does so in a privacy preserving manner. Our system achieves (ii) and (iii) by extending an existing 3G cellular authentication architecture; in distinction to other approaches for vehicular communication systems [5], [6].

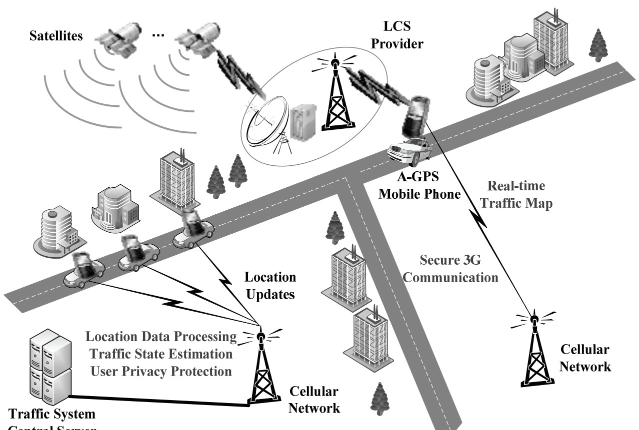

Figure 1. Smartphone-based Traffic Information System

This work was funded in part by the Swedish Foundation for Strategic Research (SSF).

II. Demonstrator Overview

Our demonstrator consists of three components: (i) the Android application running on drivers' smartphones, (ii) the traffic server, and (iii) the authentication server. The application sends location updates to the traffic server and it requests traffic estimates for the nearby area. The server gathers location data and sends the estimated traffic states to drivers.

III. User Functionality

When launching the application, a user can choose between different scenarios. In each scenario a pre-recorded trace of an emulated probe in the selected area is played. The smartphone's position is displayed on a map. Through the application, the user can set the time period for computing his/her location, the period for sending this location update to the server, and the period for requesting traffic updates from the server. The received traffic states from the server are classified into three traffic condition levels: 1) smooth traffic if the reported speed is more than 25 km/h, 2) medium traffic if speed is between 14-25 km/h, and 3) congested if speed is less than 14 km/h. Different colors, (greenorange-red in the application), are used to paint each road segment, as shown in Figure 2. The driver is able to reroute during his/her journey, i.e., choose the optimal path, based on the updated traffic conditions presented on the smartphone's display (as colored road segments).

IV. Server Functionality

The traffic estimation integrated in this demo is based on a simulation test-bed [3]. The microscopic traffic simulation is used to generate the urban road networks and emulate the traffic conditions. The emulated smartphone location updates are processed first by a 2-step filtering processes: Kalman filtering and data screening. The resultant position/speed estimates are then allocated to the nearest road links by a simple map-matching algorithm. These individual speed estimates are aggregated for each road link at pre-defined time intervals. Finally, with a simple threshold technique, estimated road link speeds are classified and color-coded into traffic conditions levels (as shown in the section III). The probe traces displayed in the scenarios are recorded from a microscopic traffic simulation. All communication functionality, including the security and privacy mechanisms are implemented along with anonymous authentication running on the smartphones [4]. Legitimate users are authenticated, with the help of the authentication server, based on the credentials in their SIM card. Each authenticated user obtains a unique group signing key (Note: the cryptographic primitive used, is a group signature scheme). The Android application reports the smartphone's location by initiating a TLS connection to the traffic server. This connection is encrypted with the traffic server's public key to provide confidentiality. Moreover, the user is able to authenticate the server. Every reported sample of location is signed with the user's unique signing key in order to provide mutual authentication. This way, the traffic server verifies that the incoming message comes from a legitimate user; however, due to the group signature properties, the user remains anonymous within the group of legitimate users.

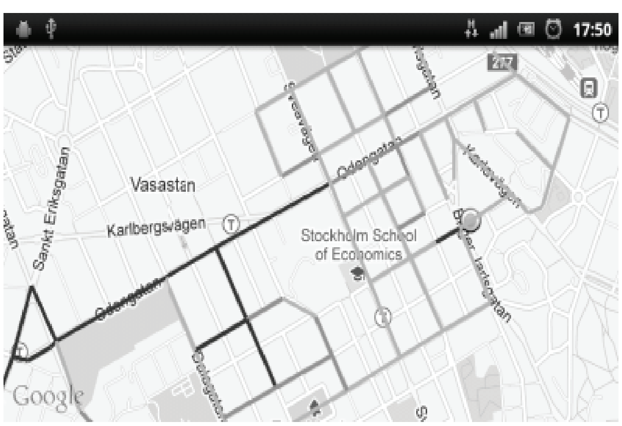

Figure 2. Screenshot of the Android Application

V. Demo Setup

The two servers are demonstrated running locally at a laptop. The smartphones communicate over WiFi or 3G with the servers.

References

[1] H. Dezani, F. Damiani, N. Marranghello, U. Viudes, and I. A. Parra, "Mobile application as a tool for urban traffic data collection and generation to Advanced Traveler Information Systems using Wi-Fi networks available in urban centers," 2012 IEEE Intelligent Vehicles Symposium, June 2012, pp. 288–292.

[2] V. Manolopoulos, S. Tao, S. Rodriguez, M. Ismail and A. Rusu, "MobiTraS: A Mobile Application for a Smart Traffic System," in the 8th IEEE NEWCAS Conference, June 2010, Montreal, pp. 365-368.

[3] S. Tao, V. Manolopoulos, S. Rodriguez, and A. Rusu, "Real-time Urban Traffic State Estimation with A-GPS Mobile Phones as Probes," in SCIRP Journal of Transportation Technologies, vol. 2, no. 1, 2012, pp. 22-31.

[4] V. Manolopoulos, P. Papadimitratos, S. Tao, and A. Rusu, "Securing Smartphone Based ITS," in the 11th IEEE ITST Conference, September 2011, St. Petersburg, pp. 201-206.

[5] P. Papadimitratos, A. La Fortelle, K. Evenssen, R. Brignolo, and S. Cosenza, "Vehicular communication systems: Enabling technologies, applications, and future outlook on intelligent transportation," IEEE Communications Magazine, vol. 47, no. 11, Nov. 2009, pp. 84–95.

[6] P. Papadimitratos, L. Buttyan, T. Holczer, E. Schoch, J. Freudiger, M. Raya, Z. Ma, F. Kargl, A. Kung, and J.-P. Hubaux, "Secure vehicular communication systems: design and architecture," IEEE Communications Magazine, vol. 46, no. 11, Nov. 2008, pp. 100–109.