A scalable server-side solution for the real-time handling of road safety notifications

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Abstract

Accidents are the main hurdles for using bicycles to change our transport habits. Many studies have been proposed, but still there is no generally adopted solution for the coexistence between cars and vulnerable road users (VRUs).

In this context, two (non exclusive) approaches can be applied: one is based on direct communication or detection among vehicles; to do this, usually extra instrumentation or communication hardware is needed. The other approach consists of communicating through an external server placed on the cloud which alerts drivers by sending warnings to the concerned vehicles in real time. In the latter case, if smartphones are used as the only instrumentation, the adoption of the system could be straightforward.

In a previous work we validated the usage of conventional smartphones communicating over the 4G cellular phone infrastructure to create the client-side of a warning system to alert drivers about the presence of VRUs. Instead, in the current work we address the other critical part of such a system: the server part. Such a server has to meet several requirements, such as being scalable (both in terms of number of users, and in terms of geographical scalability), efficient, able to meet severe real-time restrictions, as it has to be able to deal with heterogeneous users.

We have implemented a prototype of a server which treat the traffic of a region and we have tested it with thousands of synthetic clients. We provide an idea of the response time, and how it should be scaled.

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1 Introduction

In order to reduce the ecological footprint, together with the search for a healthier life, people are changing transport habits, and the use of bicycles or other light vehicles such as scooters is increasing. For instance, a city such as Copenhagen is expected to reach half of the displacements with these vehicles, and in general it could be said that we are living a *bicycle renaissance* [5] . However, the coexistence with cars is not always easy. In urban areas authorities are making clear efforts to adapt road layouts, but still the problem exits in crossings and junctions, or parts in which all type of vehicles share the road [7]. Cycling is a very popular sport, but up to this time there are many accidents with serious injuries and deceases in secondary roads produced mainly to the difference of speeds and weight between bicycles and cars. In [2] it is stated than, in 2020, 47% of the fatalities in severe accidents correspond to vulnerable road users (VRUs), and this figure increases up to 70% in urban areas.

Warning or alarm systems could help to alleviate this problem. Different projects and studies have been proposed during the past decade, but still a general solution has not been adopted [4].

In the literature, two different approaches for a traffic alarm system can be differentiated regarding how vehicles interact. One set of proposals is based on direct communications or detection between vehicles. These projects usually need extra hardware to be installed in vehicles such as sensors or wireless communication equipment, with the addition of batteries in the case of vehicles without electrical power. This is a major inconvenient for any technology to be massively adopted.

The other kind of solutions are based on sending data to an external server, which can analyze the received data, and send alarms to the concerned vehicles. Obviously the weak point of these solutions is the response time. It must be said that the two types of solutions are non exclusive, and they can (and even will) be mixed [3].

Some of the projects based on an external server propose using smartphones as the unique instrumentation, given that they are almost ubiquitous. Thus, the adoption of such systems would be straightforward [4]. In fact, smartphones have several wireless communication devices (Bluetooth, WiFi, and the cellular phone network), and a GPS interface providing acceptable accuracy [6].

In a previous work we validated the use of smartphones communicating to a centralized server over the Internet when relying on a 4G phone network for our non-critical traffic alarm system. We tested the communications response time, the accuracy of the smartphone's GPS, and the coverage of the 4G cellular network for urban and inter-urban routes. The system reacted with success in different traffic scenarios and speeds, allowing the driver enough time to pay attention to VRUs. We tested relative speeds until 90 km/h, obtaining communication response times of about 0.01 seconds [1].

In this paper we now center our attention on the server part of the alarm system. The server has severe restrictions. In particular, it has to be able to track the position of a great number of users, to detect alarms and send them to the appropriate users, and all tasks, including communications, have to be performed with response times lower than one second. To validate this part of the traffic alarm service, we provide measures of three square regions with sides 170, 17 and 3 kms, and with different traffic densities, increasing up to 20,000 simultaneous synthetic users. Finally, we propose an algorithm to scale-up the server by taking advantage of the fact that users are distributed geographically.

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