An Efficient Cloud-Based Traffic Signal Manipulation Algorithm for Path Clearance

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ABSTRACT
Beside many challenges that urban cities have to face, one of them is increasing traffic. Unfortunately, in developing countries like, for example, Pakistan, the traffic management infrastructure does not scale accordingly. This leads to two types of problems: congestion and long queues at traffic signals. This makes it difficult for emergency vehicles (EV) such as ambulances to reach their destination on time. Therefore, in this article, the authors have developed an intelligent path clearance system for emergency vehicles. The particular focus is on long queues at traffic signals. Given the GPS coordinates of an EV, a destination, a map, and the traffic light grid system, our system provides a signal free corridor to the priority vehicle by automatically manipulating traffic signals that fall in its path using cloud computing. The idea is to clear the path of the vehicle. The proposed system also makes decision based on the time of the day and current traffic conditions in real time. In case of multiple options, it also calculates the shortest path to the destination.

KEYWORDS
Automated Path Clearance, AWS, Cloud Computing, Google Maps, GPS Location, Lane Clearance, Traffic Signal Automation, Traffic Signal Manipulation

INTRODUCTION
One direct impact of the world’s growing population is Urbanization. Beside many challenges that urban cities have to face, one of them is increasing traffic. Unfortunately, in developing countries the traffic management infrastructure does not scale accordingly. This leads to two types of problems: congestion and long queues at traffic signals. Due to increasing traffic congestion in large cities, emergency vehicles (EV) such as ambulances and fire trucks find it difficult to reach their destination in an optimal amount of time.

A lot of work has been done on controlling traffic signals. Initially, traffic signal control was used to enable smooth traffic flow. This was done using induction loop detector. This idea of using inductive coils for detecting the density of traffic on a road was proposed by Koerner (1976). Induction loops are coils placed under the surface of the roads to detect changes in induction caused by vehicle moving over them. Different alternates for road-based sensors have been proposed such as piezoelectric sensors (Sahitya, & Narayan, 2018) that can also measure pressure and acceleration.
The idea of controlling traffic signals for smooth traffic flow was later on extended to giving priority to EVs. For this purpose, different sensors were used such as infrared (Nithyakumar, Aswin, Shree, Dharmeesh, & Kalaivaniv, 2017), (Parekh, Dhami, Patel, & Undavia, 2019), radio frequency identification readers (Priyadarshi et al., 2018), cameras (Gowtham, Arunachalam, Vijayakumar, & Karthik, 2018), siren detectors, etc. However, most of these sensors operate at very close proximity of the traffic signals. This means that EV has to be very close to the traffic signals to control them. This would be a serious problem in situations when there are long queues at the signal and the EV has to wait for the queues to clear before they can pass. For such cases GPS based system was proposed in which the EV would transmit its GPS coordinates to the receivers installed on traffic signal (Hegde, Sali, & Indira, 2013). The major drawback of this system is that different access points or coordinates for every traffic signal have to be manually defined to prevent other nearby traffic signals from also triggering when a request is made by an EV.

Although different solutions have been proposed, each has its own limitations. The notable one being that none of them cater to pre-arrival lane clearance. In this paper, we propose an intelligent path clearance system for ambulances in order to facilitate them to reach their destination in an adequate amount of time. The system aims to eliminate this problem by providing more ease in navigating through traffic by manipulating traffic signals in order to let the vehicle through. It works without making any changes in the current road infrastructure.

The proposed model consists of five main modules, the operator interface application, the vehicle navigation module, the traffic signal control application, the database and the server. The first four modules will communicate via the web server with each other. The operator interface will provide the telephone operator the ability to enter the ambulance’s destination and basic patient emergency details. Using Google maps API, the system will then calculate the expected time of arrival (ETA). Once confirmed by the operator, these details will be sent to the vehicle navigation application. Once the vehicle application accepts the request, an optimal path is calculated and displayed by the application. Moreover, the traffic signals on the path are identified. As the vehicle starts moving on the path, it will be constantly checking its location coordinates against the traffic signals present on the path. Based on the coordinates of the ambulance and the location of the traffic signals present on that route, the system will start switching the signals to let the vehicle through. The signals will be manipulated on the basis of distance of the ambulance from the signal and once the ambulance has passed, the signals will go back to their regular working. After a vehicle has passed a signal and manipulated it, it will be stored in the log in the database. Since control to the actual traffic signals will not be possible to obtain, a mobile application will be used to simulate a traffic signal. The proposed model will be based on Web, Android and Linux system.

The contribution of this paper is three-fold. Firstly, pre-arrival lane clearance to save time spent on clearing of long queues. Secondly, to make decisions based on real-time traffic conditions. Instead of using a hardcoded criterion such as distance from the traffic signal or time to reach the traffic signal, a more dynamic approach is adopted. Finally, the proposed model calculates the shortest path from source to destination using various parameters one of which is real time traffic conditions.

The rest of the paper is organized as follows: The next section 2 presents a literature review on different proposed solutions that provide path clearance for emergency vehicles. Section 3 gives the proposed solution, while the results are given in section 4. This is followed by the conclusion in section 5.

BACKGROUND

In this section the authors look at the operation of some of the existing systems in order to get a better insight into the problem. In most of the literature review, we uncovered that a detector/device was always used in order to calculate the proximity of the traffic signal from EV. An authentication system was also used to ensure that no rogue vehicles could manipulate the traffic signals. In one
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