A Simple and Efficient Traffic Light Preemption by Emergency Vehicles using Cellular Phone Wireless Control

HUSSEIN R. AL-ZOUBI, BALQEES A. MOHAMMAD, SAHAR Z. SHATNAWI and ALAA I. KALAF
Department of Computer Engineering
Hijjawi Faculty for Engineering Technology
Yarmouk University, Irbid 21163, Jordan.
halzoubi@yu.edu.jo http://www.faculty.yu.edu.jo/halzoubi

Abstract: - The short travel time is critical for the successful operation of emergency vehicles like ambulances and fire vehicles. Traffic lights at road intersections represent bottlenecks in the way of emergency vehicles especially at times of congestion. Traffic light preemption is one of the most useful approaches to help emergency vehicles reach the intended destination faster. Many methods have been proposed in the literature for the implementation of traffic light preemption. In this paper we propose a simple, yet efficient method for this purpose. Our proposed method is a new approach, where we use cellular phones to control the operation of traffic lights by the emergency vehicle driver. In the paper we illustrate the details and benefits of the proposed technique.

Key-Words: - Traffic light preemption, Emergency vehicles, Cellular Phones.

1 Introduction

The rapid growth in populated areas places burdens on the fire/rescue and other emergency vehicles [1]. Immediate arrival of patients and injured persons to the local hospital is a critical time issue that concerns several people like rescue teams, physicians, health authorities and patients themselves. More generally, in critical situations, emergency vehicles need to get to the scene as fast as possible to save lives and proprietary.

Traffic signal preemption for emergency vehicles helps in reducing delay time, improving safety and minimizing the cost [1]. Using signal preemption to provide emergency vehicles a green light at intersections can reduce conflicts, improve emergency response times, and reduce other drivers confusion and thus can dramatically reduce the number of emergency vehicle crashes. This has the potential to translate into cost savings for the community. Emergency vehicle traffic signal preemption systems are a promising approach which comes with many benefits for individuals and the community. There has been extensive research on this subject from different perspectives. The subject of automatic traffic light control systems has also gained special importance in the recent years [2] - [4].

In this paper, we propose using wireless cellular phone transmissions to perform the operation of preempting traffic lights by emergency vehicles. The emergency vehicle driver uses a cellular telephone to call another cellular telephone embedded with the traffic light controller, which triggers the preemption signal that switches the state of the traffic light to the emergency preemption state. At this point, the green light is granted to the direction from which the emergency vehicle is approaching. The traffic light switches back to its normal state after a specified amount of time that enables the emergency vehicle to pass the intersection safely. To the best of our knowledge, we think that this idea is novel.

2 Design Description

The proposed system consists of a sender mobile phone, a receiver mobile phone, a dual-tone multiple frequency (DTMF)

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chip, a PIC microcontroller, a headset, and other complementary parts like power supply, crystals, resistors, capacitors, and wires. The implementation of the proposed system is shown in Fig. 1.

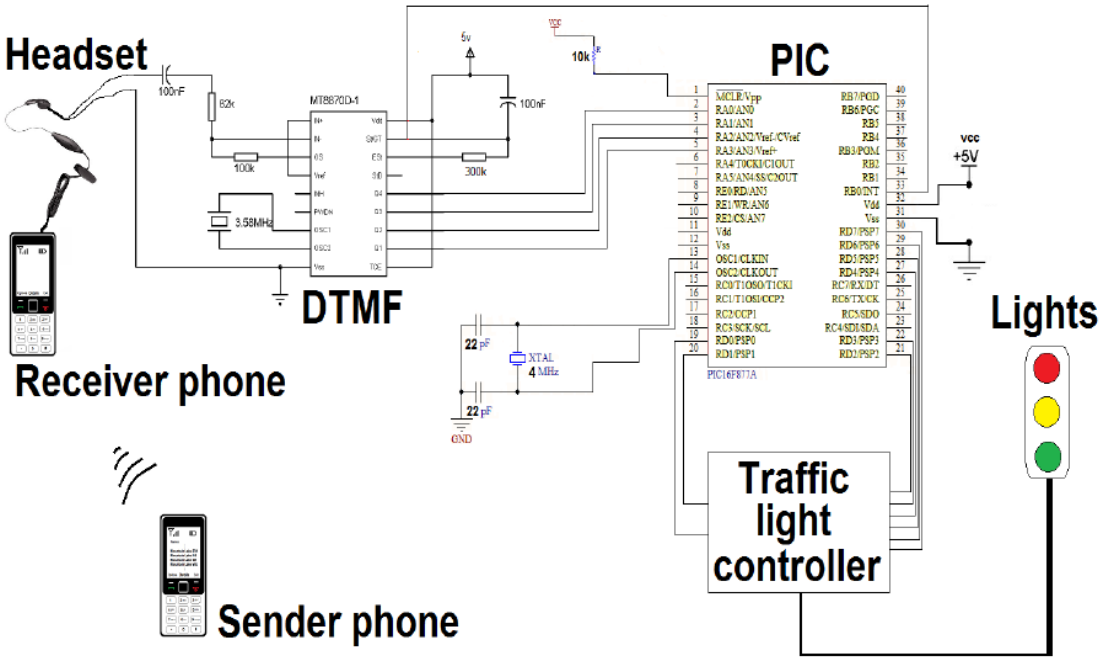

Fig. 1. The proposed traffic light preemption system.

The sender is a regular mobile telephone used by the emergency vehicle driver. The receiver is another regular mobile telephone embedded with the traffic light controller. The receiver telephone is switched to the automatic answering mode. This service exists in almost all mobile phone devices.

When the emergency vehicle driver dials the phone number of the intended traffic light, that phone automatically answers and the connection between the two mobile phones is established. At this point, the emergency vehicle driver sends the security code. It is known that for each button on the telephone keypad, two frequencies are generated. When the receiver telephone receives the security code, the headset takes the tones and outputs them to the DTMF, which uses digital counting techniques to detect and decode tone pairs. For each digit of the security code, the DTMF generates an impulse signal with four-bit binary code. The DTMF is connected to the interrupt bin of the PIC microcontroller.

The binary numbers generated by the DTMF are also fed to the PIC, which verifies the correctness of the received code. The PIC then requests the traffic light controller to switch to the preemption mode if the received security code is correct. Otherwise, the PIC does nothing. The preemption state lasts for a reasonable amount of time that gives a safe passage to the emergency vehicle after which the traffic light controller toggles back to its normal operation.

The PIC also can handle rare situations when two emergency vehicles arrive at the same intersection at the same time from two different directions. In these cases, the green light is granted to the emergency vehicle that dials first, the other one has to wait. The process followed in the proposed system is illustrated by the block diagram shown in Fig. 2.

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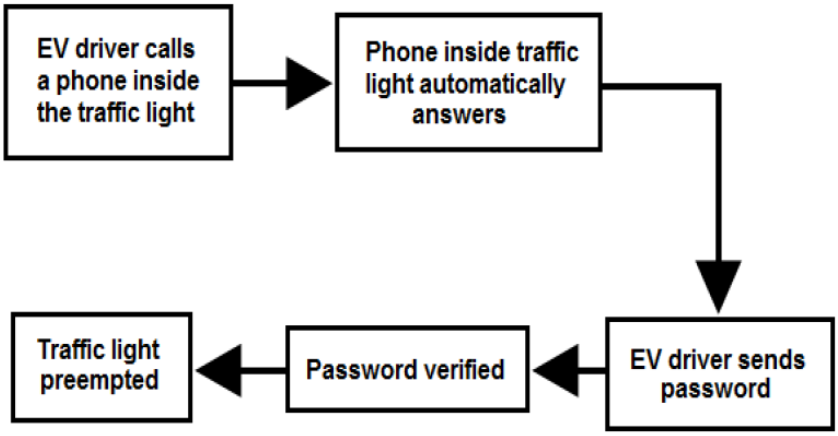

Fig. 2. A block diagram illustrating the process followed by the proposed system to preempt traffic lights by emergency vehicles.

3 Benefits of the Proposed System

Our new design has many attractive features. Among others, the following are the most prominent points:

• **Simplicity and ease of installation:** as has been shown in the previous section, our proposed design consists completely of low cost off-the-shelf components. The connections are straightforward and do not require professional skills, to compare with one of the most popular products in the market, the Opticom™ Infra red traffic light preemption system of the Global Traffic Technologies, LLC (GTT) [5]. The Opticom™ infra red system consists of many components, mainly the Opticom™ 792 Emitter and the Opticom™ 721 Detector. The Emitter must be mounted on top of the emergency vehicle with the required housing. The detector must be fixed on top of the traffic light on a place that can be clearly seen by the emergency vehicle. Installation and maintenance requires closing the street and using a winch. On the other hand, our proposed design can be simply hidden inside the traffic light controller as it occupies a small area, with very short cables. It can be easily replaced and maintained.

• **Does not require line of sight and not affected by weather:** unlike the state-of-the-art designs, our proposed approach does not require line of sight to operate. This feature allows the emergency vehicle to preempt any traffic light even if it is hidden by a building, a tree, etc., or being behind a curve. Moreover, the proposed design is to a great extent not affected by weather conditions, The Opticom™ system on the other hand is based on the infra red technology that requires line of sight.

• **Cost Effectiveness:** as mentioned in the previous section, our proposed design consists of low-cost off-the-shelf components. The Opticom™ system on the other hand is at least two to three orders of magnitude more expensive.

• **Convenience:** our proposed system is very convenient for use by the emergency vehicle driver, who just needs to call the correct number. As an example, Fig. 3 shows how the numbers can be saved on the drivers mobile phone. This example illustrates that the traffic light that lies on the intersection of the Mountain Street with the Lake Avenue can be accessed from any of the four directions. If coming from north to south for example, the emergency vehicle driver calls Mountain Lake NS to preempt the traffic light. This does not interrupt the emergency vehicle driver since in most of the cases, he or she has a companion, to whom this job can be handed.

• **Security:** as mentioned in the previous section, it is not enough to know the mobile numbers of the traffic light in order to preempt it; a security code is also required. The numbers as well as the security codes are both unknown to the public. This makes our proposed design more secure than the existing ones.

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4 Results

Our proposed traffic light preemption system has been practically implemented and tested. In our experiments we used PIC 16F877A microcontroller and MT8870D-1 DTMF. The system works with any telephone model and headset. Therefore, different models of mobile phones and headsets have been tested. The benefits listed in the previous section have been verified.

5 Conclusion

In this paper we propose a simple and efficient method for Traffic light preemption using cellular phone transmissions to remotely control the operation of traffic lights by the emergency vehicle driver. We believe that the attractive features of the proposed design qualify it to compete and replace the existing alternatives. For future work, we suggest fully automating the system by using GPS. By knowing the location and direction of the emergency vehicle, a computer program can call the correct cell phone number at each signalized intersection en route at the proper time.

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Fig. 3. Saving traffic light numbers in the drivers mobile phone.

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