

Construction of Black Box to Detect the Location of Road Mishap in Remote Area in the IoT Domain

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Abstract

In recent years, both developed and developing countries have witnessed an increase in the number of traffic accidents. Aside from a significant rise in the overall number of on-road commercial and non-commercial vehicles, advancements in transportation infrastructure and on-road technologies may result in road accidents, which generally result in high mortality. More than half of these fatalities are the result of delayed response by medical and rescue personnel. If an accident site receives quick medical treatment, an accident victim's chances of survival may improve considerably. Based on the IoT-based multiple-level vehicle environment, this study proposes a low-cost accident detection and alarm system. Vehicles are equipped with a "Black Box" board unit and an accident location identification module for the Global Positioning System (GPS), in addition to mechanical sensors (accelerometer, gyroscope) for accurate accident detection. This study has evaluated the proposed system with average packet delivery ratio (PDR) vs. relay nodes. Our simulation results have evaluated the evolution of relay nodes in the mobile / sensor node through internet gateway. It has also been demonstrated that the packet delivery ratio is inversely related to the incremental number of relay nodes.

Keywords: IoT, GPS, GSM

1. Introduction

As already known, one of the most serious concerns in cities is the unprecedented increase in traffic accidents. This is due to the increased usage of vehicles such as cars, increasing bike accidents, and driving in dangerous areas [1]. The increase in the number of cars has numerous negative consequences, including, but not limited to, congestion in densely populated areas and overcrowding urban infrastructure. Every year, it also contributes to an increase in the number of fatalities associated with driving [2, 3]. Figure 1 depicts a bike accident in a remote area.



Figure 1. Bike accident at remote area

The rationale is because sophisticated procedures are not available, and the accident rate is carefully reduced [4, 5]. A suitable, effective standard solution is necessary to minimize the country's accident rate. There are no sophisticated and efficient approaches for accident reduction and identification at the moment [6, 7]. Figure 2 (b) depicts the generic black box in flight. (a) a basic vehicle block box.



Figure 2. Black Boxes for Car or Bike and Flight

Furthermore, the rate of mortality increases due to the delay in reaching the ambulance and the delay in sending information about the condition of victim to the hospital. The system was in place to identify accidents and monitor cars that took longer time to arrive at the hospital, allowing victims' treatment to be postponed [8, 9]. The proposed technique shortens the time between the occurrence and required equipment and deals with the victim promptly by utilizing medical instruments. The following two major components are often included in an accident detection system

The first module determines whether or not the car was shocked or vibrated. The car gets connected. When the car falls/vibrates above the threshold, the information is relayed to the second module..

The driver's pulse is then examined, and a decision is made. If any irregularities or deviations are discovered, the driver may cancel the order.

The author has demonstrated how to track automobiles for accidents using a microcontroller, Raspberry Pi, and an accelerometer [10]. This system tracks the car using GPS

and GSM. This article describes a method for monitoring vehicles and identifying whether or not they have been involved in an accident. This accident detection system is an automatic accident location tracking wire, which delivers an alert message along with the accident location information [11]. This approach is highly beneficial in the car business since it helps patients to go to the hospital as quickly as possible. Figure 3 depicts the primary causes of two-wheeler accidents from 1991 to 2021.

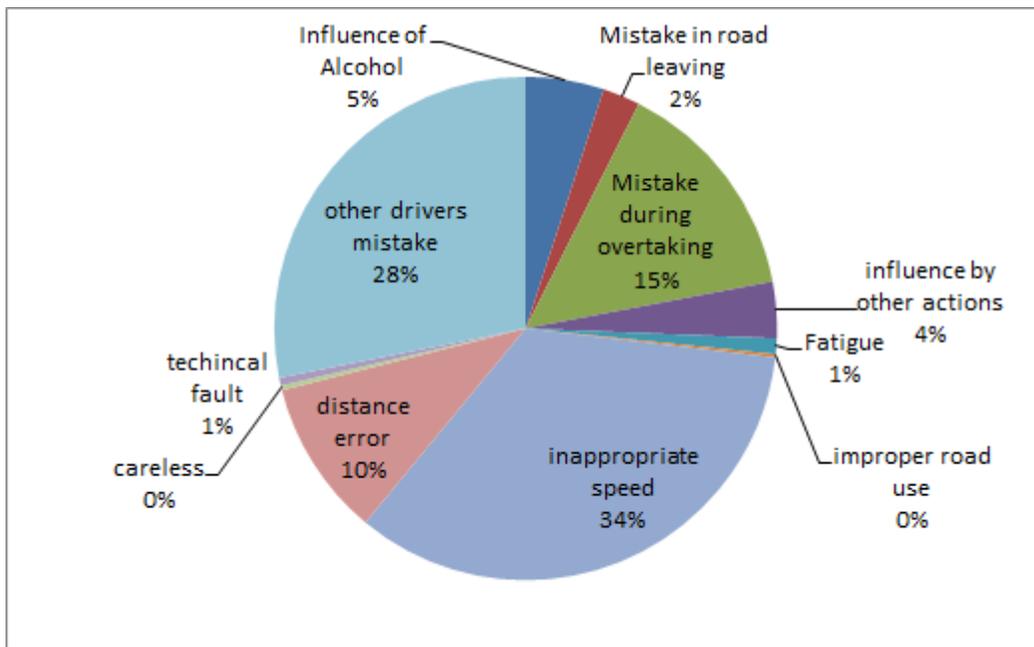


Figure 3. Major Causes of Road Accidents that Occurred in Two Wheeler Vehicles (1991 – 2021)

The primary objective of this project is to create a system to automatically detect and provide traffic congestion warnings in order to decrease the number of casualties by providing medical assistance to the victims of road accidents. This can be done via the Internet of Things (IoT) technology. This research paper aims to develop a block box in order to detect smart vehicle accidents and, with reduce current procedures, such as the improvement of safety in humans and

vehicles, and to reduce accidents in order, to alert the driver on drowsiness level, or to save valuable lives in the event of an event by providing medical emergency services [12].

2. Organization of the Research

The remaining part of the paper has grouped the preliminary work on IoT-based accident detection in Section 3. Section 4 presents the suggested technique for effectively detecting the accidents. Furthermore, the description of the calculated results from the suggested framework is discussed in Section 5. Finally, Section 6 concludes the proposed study project by including its future path.

3. Preliminaries

Hari Sankar et al recommended a comprehensive response to all automobile and ambulance accidents. When a car accident is detected by a vehicle detector, the integrated server automatically transmits it to the ambulance, which is nearest to the vehicle spot. The ambulance driver's android device allows the driver to collect information in the area quickly and securely. Collision automation, including vehicle identification, delivery, and training for ambulance drivers, has been completed [13]. Nicky Kattukkaran et al Computer aims to inform the science center of car crashes of the shutdown for scientific assistance. The attached accelerometer in the car identifies the vehicle's tilt and the pulse sensor analyses the irregularity in the heartbeat to comprehend the criticality of the car collision. The structures are chosen and the records are transmitted to the smartphone linked to the accelerometer and cardiac sensor through Bluetooth. The Android smartphone application will send text messages to the local therapeutic facility and its associates. The software also provides the the location of the nearest hospital, which might save time [14].

The Android program detects the unjustified situations and sends emergency warning messages to the nearest police station and fitness facility, has been developed by Adnan Bin Faiz et al. [15]. This tool is built inside an exterior stress sensor that extracts the car's external stress. It tracks speed and tilts view on Android phones using GPS and accelerometer sensors. This software program also helps to reduce the expense of false alarms by evaluating conditions.

Time response is, as stated in [16], the most important aspect of an emergency response system. In this regard, E-HAMC provided many capabilities for IoT resource-constraint devices, including task-loading and pre-processing latency-sensitive services. The contact numbers of the authorities were stored here and appropriately notified when an emergency happened. The edge and cloud characteristics were used to provide services to automatically send emergency information depending on the increased portfolio of service providers [17]. The same program, which provides sophisticated location mapping with geographical coordinates for the event venue, has been improved. A street view feature and identification of potential paths for quick healthcare to the nearest hospital were also provided. Depending on its successful implementation, the overall latency may be reduced by integrating Edge Technology with current cloud and IoT resources [18]. One major disadvantage of the system was its dependency on the smartphone. The victim or someone is requested to take a picture of the emergency or mishap that is sent automatically to the edge node. For a variety of reasons, relying on the victim or the surrounding person as a real-time application is not a viable option. The major reason is that the sufferer may not be physically or psychologically capable of snapping a picture with his phone, and there is very likely no other spectator who can photograph the scene of the accident [19]. Moreover, a severe accident may harm the mobile phone or any other device capable of capturing photos or delete them. Since it relies on the smartphone, which may also run out of power, it is thus not a viable option for such a situation.

4. Methodologies

The proposed system contains the following three separate sub-systems:

4.1 Black Box items

Road accidents may be precisely identified by using an onboard device called black box, which comprises of

1. Accelerometer
2. Gyroscope
3. Hear Beat Sensor
4. Global Positioning System (GPS)

It has been designed to capture images from the vehicle's interior by using a high-definition camera module and it also communicate the photos/data and other information to the destination. The entire message is routed to the edge node through an ad hoc vehicle network [20].

The computer-intensive system supporting an IoT environment provides better outcomes in an orderly way if it necessarily requires fast processing. Such computer-intensive programs make it very difficult for authorities to run resource-controlled vehicles or mobile devices. In order to achieve the optimum or maximum output, resource-intensive tasks must be allocated to cloud servers [21]. Since it has the ability to handle huge quantities of data with apparently unlimited resources, such applications are computer demanding, which can't be accessed with a vehicle's "black-box", which is operated with the help of gyroscope. Figure 4 shows the basic black box unit with GSM module.

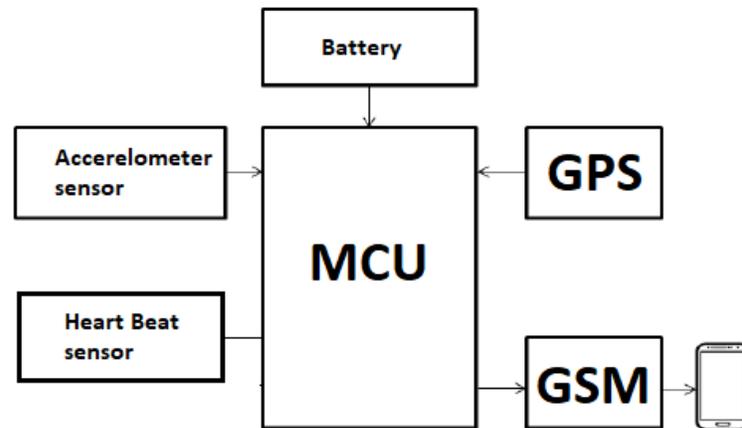


Figure 4. Basic black box units with GSM module

4.2 Control Unit Items

These are the entities in every section of control room. It receives an accident notification and processes the observed data. Edge Gateway also has the ability to distinguish the number of casualties from those involved in accidents using face recognition methods [22]. It also analyzes information from the network nodes and informs the hospital so that the ambulance may be sent immediately. It may also store the information temporarily until it is received securely by the cloud server. There are two basic criteria for event detection and notification:

1. Contextual Awareness
2. Timeliness.

These two features of a particular system may help in identifying an unexpected roadside situation such as accidents. The system may also handle the above-mentioned problems with these features. If an accident happens and the system is notified, it may help individuals who provide emergency services enhance their chances of survival. Visual data from the camera, which is

integrated into the system, may also be used [23]. Visual information through the camera is helpful for the rescue officer to make better decisions. With this capability, the system may be able to provide contextual information to first responders. Furthermore, the system must be sensitive to delays in accident detection. To improve the performance, information regarding accidents must reach the nearest hospital so that the appropriate authorities can treat the victims or wounded properly.

4.3 Exchange of Communications

The information received from the edge nodes is saved and processed on the last but not at the least level of the system. A visualization tool is used here to construct a query to obtain data from the database. Data from road accidents, including research and documentation, are further used to analyze and evaluate various aspects, such as policy decisions [24].

Conversely, cloud technology does not usually offer important features like location awareness, low latency, and mobility support for vehicles [25]. In these circumstances, the utility of Edge or Fog Computing offers an alternative. When there is some middleware that can communicate simultaneously between the cloud and the sensor network, technology is constructed as a sandwich. The requirement for knowledge of situations is included and the time for the accident notification is limited to the providers of emergency services. This concept of a sandwich layer between the central cloud and the distributed sensing network may therefore handle the critical tasks locally. Figure 5 shows the overall block diagram of proposed system.

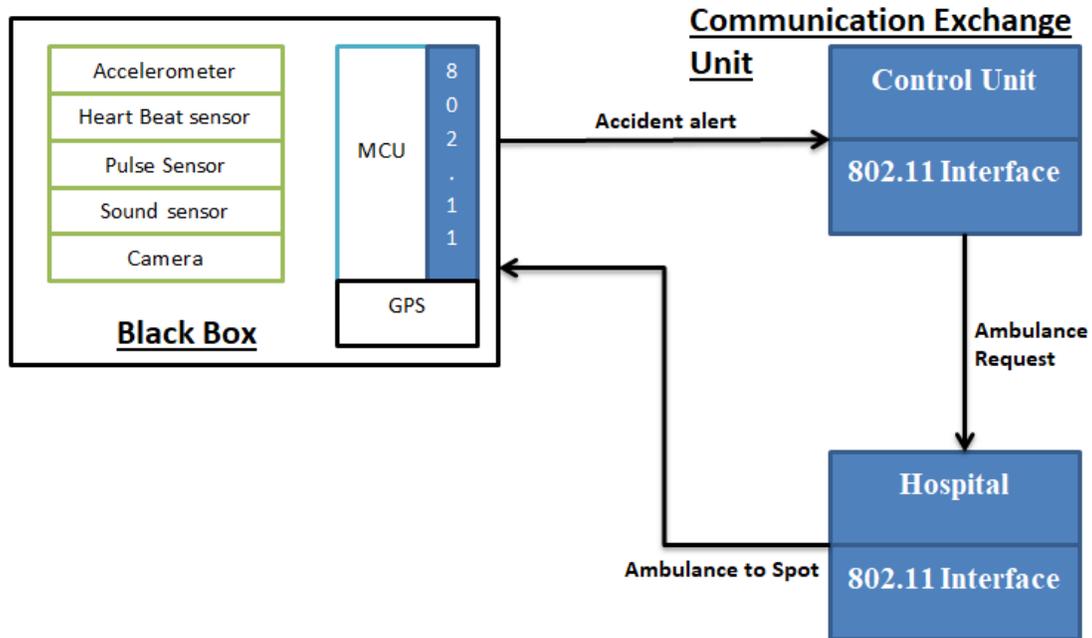


Figure 5. Overall Block Diagram of Proposed System

5. Results & Discussion

Several testing settings were carried out to evaluate system performance by generating an accident based on the performance of the recommended ad-hoc test bed apps. Several analytical factors are considered such as the

1. Controversial Size Window
2. Distance between vehicles and
3. Node Density

Depending on the circumstances, the above stated parameters were calibrated. A total of 24 nodes, ensuring the function of limited relay nodes have been deployed in the test site. Exact

specifications for board units such as GPS, camera and its frame rate are given in each specific scenario. In order to test the viability of the system, a dense environment was investigated, which required at least two neighbouring nodes in each relay node.

Furthermore, no specific topology is used in this study; nevertheless, the nodes are linked such that the network is not disconnected. The total laboratory space in which the network is deployed is about 500m². The cars vary from 20 to 60 km/h at random speeds, although the speed decreases quickly in the event of an accident. The nodes are deterministic; however all black box units should be in working conditions and as relay nodes depending to the circumstances. Furthermore, the maximum transmission range of each network node and inter vehicle distance are adjusted to change the total number of nodes inside the simulation. Relay nodes are the nodes utilised in the next hop for transportation of traffic to or control room. The black box, we used includes an integrated MCU, GPS, IMU and camera module, and an ad hoc, on-demand remote vector routing technique.

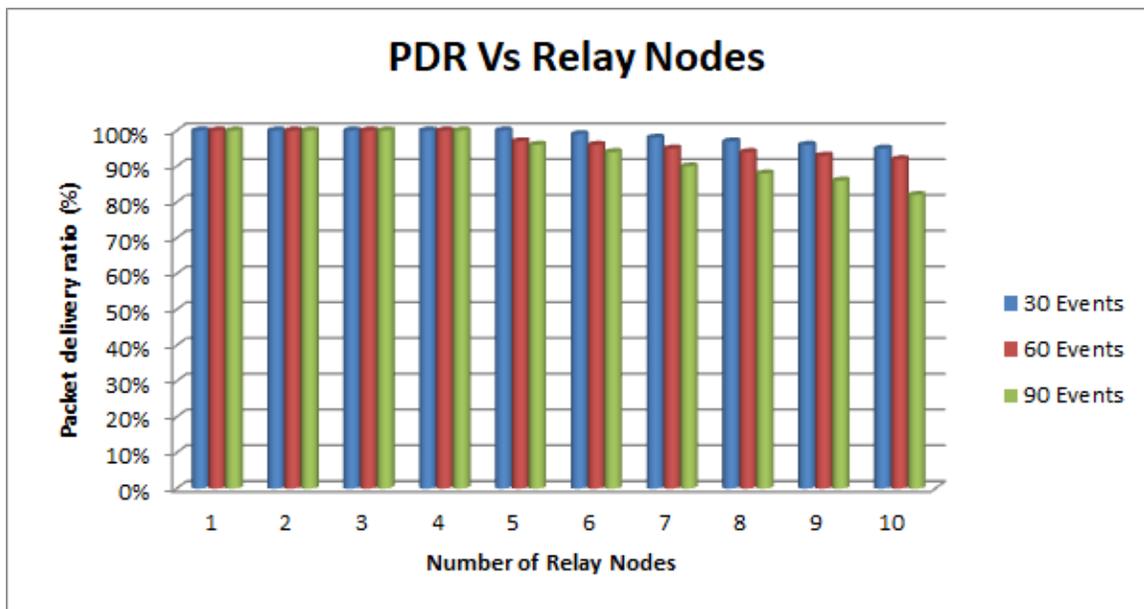


Figure 6. Results obtained for PDR vs. Increasing relay nodes

In the event of an issue, traffic is sent to the control room, where a collision or a roll over is possible. The average packet delivery ratio (PDR) for each setup was determined by increasing the number of relay nodes, as illustrated in Figure 6. When the number of relay nodes is between one and four, it was found that all messages sent were received by the target node successfully indicating that all messages sent were received by the target node successfully. However, when there are more than four relay nodes, the reported PDR value decreases significantly, suggesting that network communications are being lost. As the number of nodes in a wireless network grows, data loss may occur due to interference and congestion of the channel.

6. Conclusion

As a result, our suggested automated approach is effective in locating the accident site and sending out accident alerts at the appropriate time and it is named “black box” of road transport. According to the findings of this study, a vehicle testing environment for the Internet of Things was created that automatically detects, reports, and notifies the appropriate organizations of accidents and roll-ups. Moreover, in this research project, an open-source Web-Server application was created and accident alerts were received from all vehicles that use correctly configured black boxes in the system. Once the proposed system is constructed, the nearest hospital will be alerted to a rescue squad. It allowed traffic accident victims to get timely medical care. Our research article displays the average packet delivery ratio vs. number of relay nodes and it is illustrated in the graph which is in previous section. In addition, an open-source Web-server application was created and accident alerts were received via suitably equipped OBUs from all vehicles in the system. When the system was constructed, it would send a rescue team to the nearest hospital. As a result, the victims of traffic accidents were able to receive prompt medical treatment.

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Author's biography

Joy Iong-Zong Chen is currently a full professor in the Department of Communication Engineering Dayeh University at Changhua Taiwan. Prior to joining Dayeh University, he worked at the Control Data Company (Taiwan) as a technical manager from Sep. 1985 to Sep. 1996. His research interests include wireless communications, spread spectrum technical, OFDM systems, and wireless sensor networks. He has published a large number of SCI Journal papers on the issues addressed by the physical layer for wireless communication systems. Moreover, he also majors in developing some applications of the IOT (Internet of Thing) techniques and Dr. Joy I.-Z. Chen owned some patents authorized by the Taiwan Intellectual Property Office (TIPO).

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