Study and Implementation of Internet of Things (IoT) Based Vehicle Safety Alert and Tracking System

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Abstract

The project studies and implement Internet of Things (IoT) technology into the current vehicle system, with sided towards the safety portion of the aspects. With the problems of today's post-accident death due to loneliness in the event of accident, and huge monetary loses from stolen vehicle has inspired the author to test out the idea to mitigate them. The purpose of this project is to able to ultimately provide safety alert system such as accident and vehicle theft alert without human intervention throughout the process. Moreover, this system shall be able to also let user locate the vehicle also known as the prototype in this project. This will be achieved by integrating IoT technology with microcontroller, embedded sensors along with the use of Open Source materials, platforms, and Cloud services. The author will be utilizing a GUI interface to allow the monitoring of the prototype. The proposed system is able to avoid extra costs gone to waste in case of a hijacking event and also in some cases help to save lives from succumbing by the power of after crashes.

Keywords

Automated, Vehicle, Safety, Alert, Notification, Accident, Hijacking, Tracking

Introduction

Vehicle Safety polices have been imposed worldwide ranging from legislations to product liability considerations in the hope to strengthen vehicle safety. Car manufacturing plays a huge part too in ensuring the safety of the passengers on board, however in this day and time, too many vehicle companies are focusing on accident prevention as their safety concerns, but most of them neglected the importance of post-accident safety concern. If someone had an accident in rural area where no witnesses will be there to report, it will be life threatening. Besides, there are many vehicle thieveries in every country, built-in vehicle alarm buzzer does not work all the time, and remote alert system usually are highly costed or are rare to be acquired in some places.
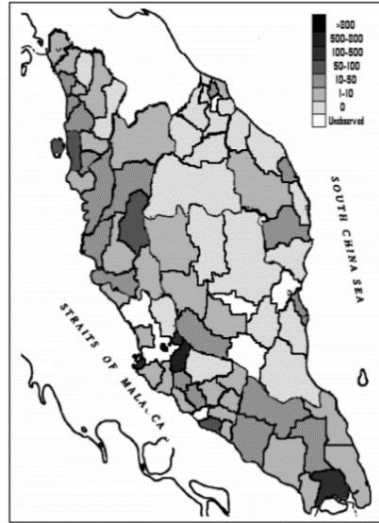
Figure 1: Map of Vehicle Theft in Peninsular Malaysia

The Figure 1 shows a map consisting of vehicle theft analytic map calculated based on negative binomial regression model by several researchers from University Utara Malaysia and University Kebangsaan Malaysia. The results constructed are displayed in the map with the likelihood of vehicle theft rated by color darkness, according to the researchers whereby the darkest area indicates the high rate of vehicle theft namely Klang Valley, Johor Bahru and Penang.

Figure 2: Existing Application Illustration

The purpose of this project is to provide vehicle safety alert which are specifically post-crash safety and financial safety of vehicle owner, the system will also provide ability to track location of the vehicle. Compare to the existing application system as illustrated in the figure above, which is solely accident detection and notification through SMS, the author's system will standout where there are more features such as Interfaces, Vehicle Theft Detection and Manual Vehicle Tracking. The fundamental concern of this project is to improve the safety and security functionality of what the average car manufacturer did not yet integrate into their builds. In this project, the author will be using sensors to communicate with the system, which are vibration sensor, crash collision sensor, load cell.

GPS module and Internet gateway module will also be needed to send location and notification. During an event of vehicle collision, safety alert will trigger notification to the next of kin or emergency contacts. In case of a foreign driver detected, a similar trigger notification will be sent to the owner of the vehicle which could indicate potential hijack. To allow this propose system to be achievable, the author will be combining Internet of Things technologies such as the usage of embedded sensors, modules, microcontrollers, Internet router, and personal computer. The implementation of Internet of Things will also allow the author to take advantage to access Cloud technology as well to provide remote monitoring and remote accessing with Internet. The proposed system will be able to mitigate injuries severity of a post-crash accident or better yet to avoid death by reducing the time interval of crash and help arrival. Besides, the proposed system will also avoid monetary loses of vehicle owner by alerting them if there is any potential hijack. As an icing on the cake, the proposed system shall allow tracking of the vehicle even if the vehicle is hijacked. The author of the proposed system aimed to strengthen the vehicle safety for the community and hopefully save lives.

Methodology

Though knowing that there is existing problem to be solved and the ideas were there, acquiring the majorities' opinion are still needed as a fundamental guide and thoughts which acts as a preview of the feasibility if the idea was to be realized. Author did the exact measures by first conducting requirement definitions and analysis, which 2 fact-finding techniques have been used by the author for this research. The first fact-finding technique used was through questionnaires, series of questions were made convenient for the public to answer. Series of questions such as background information, vehicle safety concerns, and their opinion and expectations regarding the proposed system ideas were included in the questionnaires, all of which related to the project in the aim to enhance the project. The outcome from the questionnaire were able to help the author to construct analysis diagrams to highlight and pin point the majority thoughts for the ease of analyzing and to reflect on the initial ideas. The next fact-finding technique that the author has used was Interview; which is the bread and butter technique for having an in depth thought of someone closed-up. The author has interviewed two traffic police officers from the Nilai PDRM Headquarters, as they are more experience than the average people in relations to this topic. The interview session went really well and the author had a great chat with the two Police Officers up close and able to get insights for real facts and feasibility level of the author's idea in the related field. All of the facts collected from the research techniques were then carefully recorded and detail analysis were made. The author then has illustrated a series of diagrams such as pictorial diagrams, use case and sequence diagram to map out the overall flow of the systems and its features.
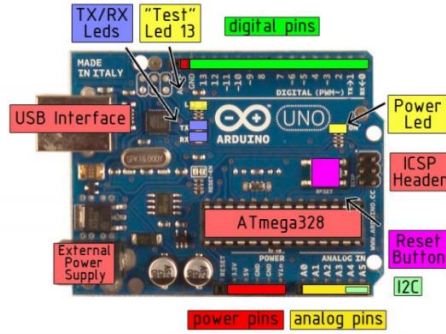
Figure 3: Arduino Uno R3 Pinout

The proposed system prototype is developed by using the IOT technology. For hardware side as shown in figure above, the author has used an Arduino Uno R3 microcontroller as the main control board. The reason why Arduino Uno R3 has been chosen by author is because it is very affordable, and it has enough processing power and pins to accommodate the size of the project. As seen from above figure, the author used SW420 vibration sensor and crash sensor for collision detection, HX711 weight module and load cell, to be acted as a car seat driver detection, Neo7N GPS module to provide GPS related data, an Internet Router for providing budget friendly Internet Gateway which suitable to create local subnetting for the prototype.
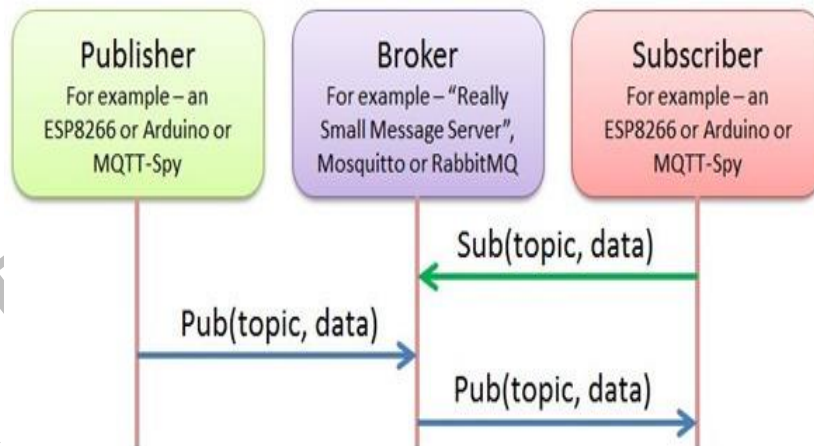

Figure 4: MQTT Protocol Concept Illustration

The author has used MQTT protocol as illustrated in figure above as the main communicating medium between basically everything such as the sensors, servers and clients. MQTT protocol works on a principle of Pub/Sub to allow transmission of messages. MQTT Client are essentially device such as microcontrollers with sensors data embedded, these devices would need MQTT library to run and operate in order to communicate with the MQTT Broker. However, an Internet Gateway module such as Wi-Fi module ESP8266 or Ethernet module would be needed on the microcontroller for this to work. Clients can subscribe or publish on topics, which these topics adhered the routing information for the sending broker. Speaking of broker, a MQTT broker job is primarily in charge of filter every message it received and to decide who is interested in that message then send them to the subscribed clients. Topics and data are forwarded from the publisher to the subscriber with the help of broker usage. (Arnoys,L., 2014) The author also has used

OpenHab platform to construct different rulesets for the alert triggering process which works in conjunction with Telegram, OpenHab also allowed the author to create a simple GUI for the monitoring of the system, especially the sensors' condition. The author has also used an Open Sourced Cloud Service which made remote access, and mobile access to work efficiently. Of course, finally is the Arduino IDE which is an environment for the author to write the programs to be run on the Arduino UNO microcontroller. The code written will tell what the Arduino UNO to do with the sensors data and translate them into MQTT protocol message to be delivered to the server via Internet Gateway for more meaningful usages like creating alert notifications when specific conditions have met. The overall big picture of the process is illustrated as shown in the figure below.
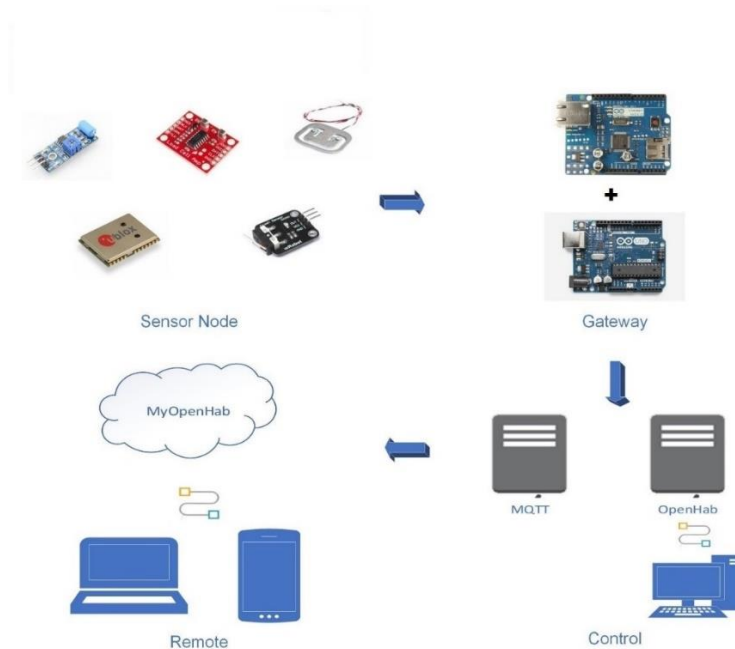

Figure 5: Overall System Pictorial Diagram

After the system prototype has been constructed which occupied majority of the timeline, the author then performed numeral testing on the system, ranging from unit testing where individual system or component were tested, integration testing where several parts of system were tested together for specific goals, and lastly system test which tests the overall system functionality. After the tests, the author's system luckily was able to pass all expected results with no problems whatsoever. The author had pictured about several future enhancements that could level up the system even more providing budget is not an issue. The future enhancement will be able to elevate the prototype to be final market ready product and to translate the prototype to suit the real-life application by using the same concept with just slight different components.

Results and Discussion

Project Objectives:
1. To study and analyze the strength & weakness of vehicle safety alert and tracking system.
2. To study and utilize the relevant tools and technologies.

3. To implement cloud technology into the project.
4. Conduct relevant testing and user evaluation for the system.

From all these four objectives, the author is proud to say that they are all achieved now at the near end of the project which mostly been discussed in the detail in the author's Project Report. When the author discussed about the Target Audience which is in the author's Project Report's Chapter 1.4, the author has mentioned the strength of the proposed system and its usefulness. In author's Project Report's Chapter 2.6 where author compared his system with similar existing system, the author has mentioned the system's strength & weakness which means the first objective has been achieved.

1.4 Target Audience

The main audience is basically whoever owns a vehicle. Most of the mid to low-end vehicle owners could really benefit with this system. Vehicle accident has drawn many lives every year, especially those that happened in a time zone or area where there were no one around there, which ambulance or police authority could not even detect if there is no one knowing and thus report the incident. With the system, this risk can be reduced. Another possible audience is those who have expensive vehicle or living in an unsafe area from thievery, the system could help them in the case of foreign driver which is potential hijacking by notifying them and allow them to manually track their vehicle location. This project aims to provide a system which a regular family member can use this for their loved ones, and in case of inevitable situations, they could have first-hand informative notification about the incident.

Figure 6: Evidence of Objective 1 Achievement 1

2.6 Comparative Analysis of Similar Existing System

Similar Existed System's Title	Author	Features				
		Accident Detection	Potential Hijack Alert	Manual Tracking	Notification	Remote Monitoring
Arduino GPS Tracker Using GPS and WiFi Module	Saddam	No	No	Yes	No	No
Vehicle Tracking and Accident Alert System	Kommineni Rakesh	Yes	No	No	Yes	No
Vehicle Safety Alert and Tracking System	Jason Fong (Author)	Yes	Yes	Yes	Yes	Yes

Table 2. 1 Comparison table of Existing System and Proposed System

Figure 7: Evidence of Objective 1 Achievement 2

The second objective has been achieved throughout the Chapter 2 to Chapter 4 where the author continuously studies and utilize the relevant tools and technologies to conduct the system prototype. The figure below shows the outcome of the studies and achievement of objective 2.
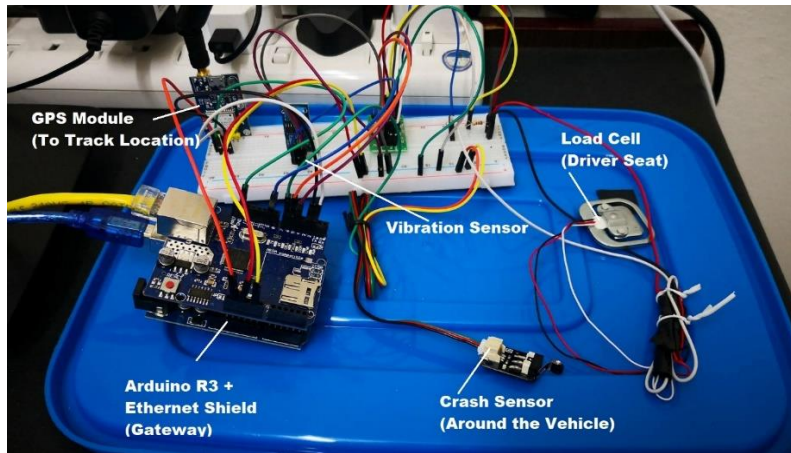
Figure 8: Evidence of Objective 2 Achievement

The third objective has been achieved when the author demonstrates how the implementation of cloud technology is done as discussed in author's Project Report's Chapter 4.2.4.6. Figure below shows evidence of cloud service being used to display the interface of the system.
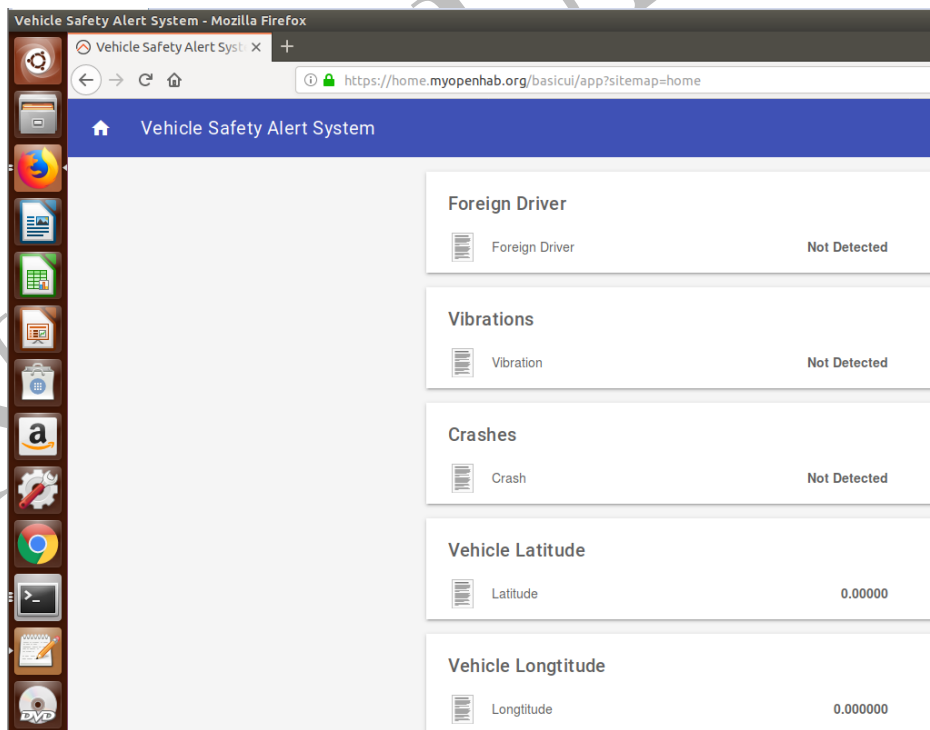

Figure 9: Evidence of Objective 3 Achievement

Finally, the forth objective has been achieved when the author conducted testing and evaluation which discussed in detail in chapter 5 whereby the system are tested thoroughly.

System Testing: Generate Notifications from OpenHab to Mobile Phone through Telegram			
Test Objectives	Test Description	Expectation	Result
To verify if the author is able to receive Notifications after the conditions to generate them are met	The author tries to trigger notifications to his mobile phone by triggering the sensors that meet the Rule conditions in OpenHab	Telegram App should receive notifications sent by the Bot	Working as Expected
Evidence			

Table 5. 11 Sensor Node to Notification Complete System Testing

Figure 10: Evidence of Objective 4 Achievement

Conclusions

In conclusion, the author has completed his project and the objectives are met. The author really hoped that the ideas conveyed through the author's system proposal would inspire more authorities to look into the related concerns and mitigate the problems which could be beneficial to the public or perhaps even save many lives if done right. The outcome of the project is a fully functional and working prototype that met its meant functionalities. In this project, the author's system prototype has showcased several functionalities, however, the prototype can be improved to be more suitable for real life encounters. The author will discuss the future enhancements that can be made, project budget, and the objective achievement in this chapter.

The limitations for the project is firstly the server location is held in the author's laptop, this can be improved in future enhancement where a smaller and more compact microcomputer such as Raspberry Pi can be used for overall cheaper and portable solution. The second limitation of the project prototype is network portability is limited due to the usage of building ISP as chosen network solution since it is a prototype as the author wanted had limited budget. This also can be enhanced in the future if budget is not an issue with the usage of Telecommunication Service Provider (TSP) Internet solution and portable router to provide network portability. The next limitation of the project prototype is the power source selection, the author has used power source from USB of author's laptop, in future enhancement, where the prototype will be placed in a vehicle, can be powered up by modifying the vehicle power outlet to suit the prototype power needs. The last limitation for the project prototype is that the system showing the real-time location

only in the GUI, hence the user cannot construct a history mapping of the vehicle, although this is not a requirement for the project, but it would be nice to have an enhancement for this feature, to accomplish this, a local database has to be implemented in the future to retain the acquired coordinates from the GPS module. Upon the completion of this project, the author has grown a lot throughout the project as it teaches the author to be independent and enhance the problem-solving skills of the author. The author would like to thank Ms. Sarasvathi, the lead supervisor of this project for her guidance and motivations throughout the project, and Mr. Kannan for sharing ideas and giving support. Without these two important person, this project could never be done, the author ends his writing here with a hope of the project ideas being useful for the society and community.

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