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**AL-FURAT AL-AWSAT TECHNICAL UNIVERSITY**

**ENGINEERING TECHNICAL COLLEGE- NAJAF**

# Vehicle Speed Control Based on IoT

A THESIS

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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR

THE MASTER DEGREE

IN COMMUNICATION TECHNIQUES ENGINEERING

BY

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Supervised by

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بِسۡمِ ٱللَّهِ ٱلرَّحۡمَٰنِ ٱلرَّحِيمِ

اللَّهُ لَا إِلَٰهَ إِلَّا هُوَ الْحَيُّ الْقَيُّومُ ۚ لَا تَأْخُذُهُ سِنَةٌ وَلَا نَوْمٌ ۚ لَّهُ مَا فِي السَّمَاوَاتِ وَمَا فِي الْأَرْضِ ۗ مَن ذَا الَّذِي يَشْفَعُ عِندَهُ إِلَّا بِإِذْنِهِ ۚ يَعْلَمُ مَا بَيْنَ أَيْدِيهِمْ وَمَا خَلْفَهُمْ ۖ وَلَا يُحِيطُونَ بِشَيْءٍ مِّنْ عِلْمِهِ إِلَّا بِمَا شَاءَ ۚ وَسِعَ كُرْسِيُّهُ السَّمَاوَاتِ وَالْأَرْضَ ۖ وَلَا يَئُودُهُ حِفْظُهُمَا ۚ وَهُوَ الْعَلِيُّ الْعَظِيمُ

صدق الله العلي العظيم

{سورة البقرة/ الآية 255 }

# الاهداء

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# Supervisor Certification

I certify that this thesis entitled “Vehicle **Speed Control Based on IoT**" submitted by “**Ali Fadhel Ahab**” has been prepared under my supervision at the Engineering Technical College-Najaf, AL-Furat Al-Awsat Technical University, in partial fulfillment of the requirements for the degree of Master in Communication Techniques Engineering.

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Date: / / 2020

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We certify that we have read this thesis titled "**Vehicle Speed Control Based on IoT**" which is being submitted by **Ali Fadhel Athab** and as Examining Committee, examined the student in its contents. In our opinion, the thesis is adequate for award of degree of Master of Technical in Communication Engineering.

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# Abstract

Keeping vehicle speed under control according to the speed limit is considered as the main key to the traffic departments in the world to reduce vehicle accidents. This thesis presents a valuable idea to control vehicle speed automatically according to the types of roads that the vehicle passes through without human intervention. The Micro-controller unit is interfaced with the RF receiver at the prototype, also with the RF's transmitters that deployed along the hypothetical pathway. The results show a valuable response for controlling a vehicle's speed according to the speed limit of different types of roads.

In addition, an alert system is investigated to increase safety when the accidents occurred due to exceeding the speed limit. It can be accomplished by designing a vehicle alarm system to alert others to reduce speed and inform the emergency center when the accident happens. However, the vehicle speed is controlled according to the road speed limit, where it reduces dynamically based on IoT. The monitoring results have been stored in the cloud server, which gives the vehicle capability to connect with its surroundings via having the internet.

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# Abbreviations

| Symbol | Description |
|---|---|
| ADAS | Advanced Driver Assistance Systems |
| APP | Accelerator’s Pedal position |
| CAN | Control Area Network |
| D2D | Device to Device communication |
| DBMS | Database Management software DBMS |
| ECU | Engine Control Unit |
| GID | Global Identity Document |
| GIS | Geographic Information System |
| GPS | Global Positioning System |
| GSM | Global System for Mobile |
| ID | Identity Document |
| IDE | Integrated Development Environment |
| IoE | Internet of every things |
| IoT | Internet of Things |
| IoV | Internet of Vehicle |
| LED | Light Emitting Diode |
| M2N | Machine To Network |
| MAC address | Media Access Control address |
| MISO | Master In Slave Out |
| MOSI | Master Out Slave In |
| MQTT | Message Queing telemetry transport |
| MySQL | Michael Widenius's SQL Structured Query Language |
| Node MCU | Node Micro Controller Unit |

| | |
|---|---|
| NRF | Nordic Radio frequency |
| PWM | Pulse Width Modulation |
| RF | Radio Frequency |
| RFID | Radio-frequency identification |
| SCIK | Signal Clock |
| SD | Secure Digital |
| SDC | Smart Display Controller |
| SPI | Serial Peripheral Interface |
| SS | Slave Select |
| UIoV | Universal Internet of Vehicle |
| V2D | Vehicle to Device communication |
| V2G | Vehicle to Grid communication |
| V2H | Vehicle to House communication |
| V2I | Vehicle to infrastructure communication |
| V2P | vehicle To Pedestrian Communication |
| V2R | Vehicle to Road communication |
| V2S | Vehicle to Sensor communication |
| V2V | Vehicle to vehicle communication |
| V2X | Vehicle to Everything communication |
| VANET | Vehicular Ad hoc Networks |
| Wi-Fi | Wireless Fidelity |

# Chapter One

# Introduction

# Chapter One

# Introduction

## 1.1 Introduction

The Internet of things (IoT) describes the network of physical objects "things" that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet. It gave us capability to control and store the data that initialized from these devices by controlling the special sensors attached to the devices. This technology overcomes the geographical boundaries of connecting devices together and provides flexibility of controlling it remotely [1].

The IoT has evolved for a widespread phenomenon on the horizon, and with the transition to more internet systems used in our lives as shown in Fig.1.1. It has led to effective and simple traffic management control. It is also facilitated the confrontation of challenges the increase in vehicle problems due to the increase in their numbers. Therefore, the increase in the number of vehicles and the growth of their problems at an exponential rate led to an increase in the rate of utilization of (IoT) [2].


Fig .1.1: Internet of Things architecture [1]

Table-1.1 shows the increase in the percentage of the use of IoT in different segment of our daily life, it measures by million units in three years [3].

Table- 1.1: IoT endpoints growth in the world [3]

| Segment | 2018 | 2019 | 2020 |
|---|---|---|---|
| Utilities | 0.98 | 1.17 | 1.37 |
| Government | 0.40 | 0.53 | 0.70 |
| Building Automation | 0.23 | 0.31 | 0.44 |
| Physical Security | 0.83 | 0.95 | 1.09 |
| Manufacturing & Natural Resources | 0.33 | 0.40 | 0.49 |
| Automotive | 0.27 | 0.36 | 0.47 |
| Healthcare Providers | 0.21 | 0.28 | 0.36 |
| Retail & Wholesale Trade | 0.29 | 0.36 | 0.44 |
| Information | 0.37 | 0.37 | 0.37 |
| Transportation | 0.06 | 0.07 | 0.08 |
| Total | 3.96 | 4.81 | 5.81 |

Through the widespread use of modern technology and the networking of devices with the internet, vehicles' companies have sought to develop their industry for modern vehicles. The modern vehicles are connected to the Internet networks, or what is known as the internet of the vehicle (IoV), where this branch represents about 28% of the IoT as shown in Fig.1.2 [4].

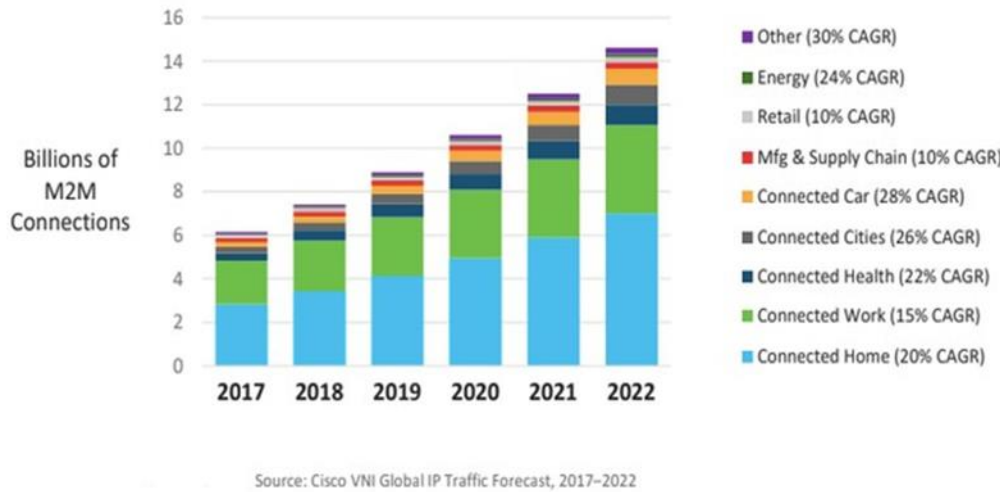


Fig. 1.2: Grow IoT and IoV [4]

IoV is classified into three types of vehicles connected (in this thesis). The first one is the vehicle-to-vehicle (V2V) connected. The second one is vehicle to pedestrian (V2P) communication, and the last one is the vehicle to infrastructure (V2I) connection, which is linking the vehicle with devices installed around it, that are mostly installed on the street[5]. However, the good internet service is required in this type of communication for high performance during the vehicle drive.

IoT has been employed to solve and control several issues, such as; smart home, smart city, smart grid, and so on. Control of connected vehicles to the internet will simply reducing the number of vehicle accidents, which include fatal accidents. Recent studies have indicated that a third of fatal accidents were due to excessive and inappropriate speed [6].

Control some of vehicle fatal accidents can be achieved through forcing vehicles to slow down according to restrictions that authorities set depending on different regions. For example, the areas where schools, hospitals, and government departments are located [7]. Using IoT can achieve this faster than smart. However, vehicle accidents are not only caused fatal for people, but also it is seriously caused injured peoples , who they suffer from the loss of blood and require immediate first aid and transfer to hospitals for treatment [8].

Finally, with the increase of technologies that used in the automotive industry, logistical matters have been added to vehicle, as well as look and luxuries, as many sensors have been implemented both inside and outside vehicle to increase safety. Sensors send specific signals to the engine control unit (ECU) via special protocols [9, 10]. It informs them on defects in vehicle and turns read and analyze errors, then the ECU take appropriate measures to direct attention to the driver, the cloud server, or others.

## 1.2 Motivation

The fatal accidents roads have been increased drastically during the last decade. According to rule of the Association for Safe International Road Travel (ASIRT), road accidents affect the gross domestic product in nations from 1-2% yearly. Fig. 1.3 shows the percentage of the most accidents registered in most countries around the world [11].

However, when the accidents happen, the traffic jam will appear and cause a difficult situation to be handling in a short period [12].

## 1.3 Objectives

In each country, each road is specified in a speed limit via traffic authorities. From the literature, the vehicle speed reduction requires human intervention. Therefore, reducing the vehicle speed automatically without human intervention is considered a big challenge technically.

The main objectives of this thesis are:

1. To design a smart system in which the vehicle speed can

be reduced when the vehicle exceeds the speed limit.

2. In addition, to report accidents when it happens in record time. To make routes safer for everybody.
3. As well as to find the location, time, vehicle identifier, and reports of the rest of the vehicles that are on the side of the accident, which is a necessary indication for other vehicles to avoid series of accidents through reducing its speed.

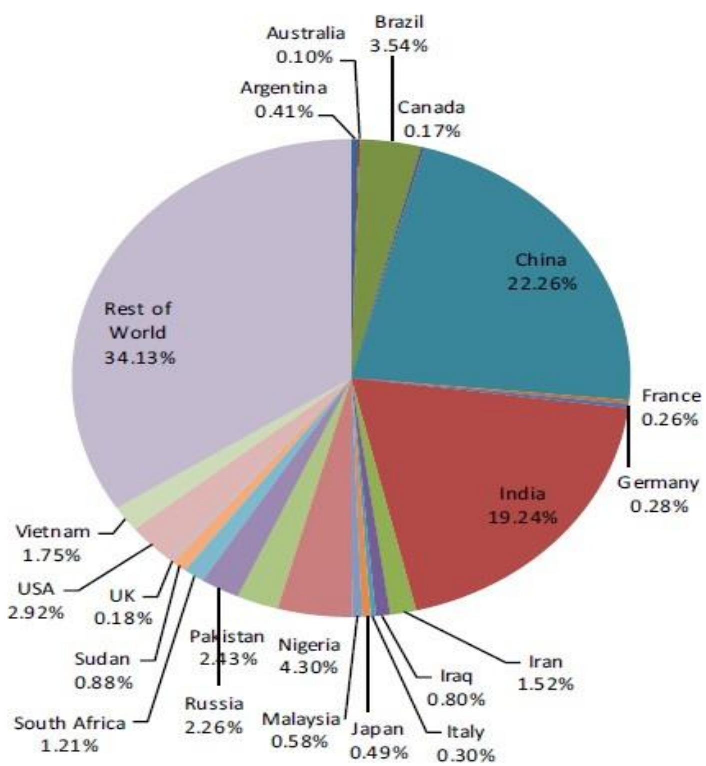


Fig.1.3: The Rate of Fatal Road Accidents to Countries Annually [11]

## 1.4 Contribution

Basically, there is a standardization for the vehicle’s speed according to the zones or types of roads that vehicles pass through. However, from the literature, the reduction of vehicle speed requires human intervention. Therefore, controlling the vehicle speed automatically without human intervention is technically considered a big challenge. The prevention of vehicles exceeding the limit speed that is specified to each road is the main contribution of this thesis. A control system is developed to reduce the vehicle speed based on IoT. It also an alert accident system is suggested and tested to help and save people's lives through monitoring vehicles.

## 1.5 Thesis Layout

This thesis contains five chapters as follows:

In chapter one, the motivation and some challenges vehicle speed control are discussed. The main contributions of this thesis are summarized, and the structure of this thesis is presented.

In Chapter 2, a general background of control Vehicles, sensors, some protocols, and literature review are presented.

In Chapter 3, the methodology of the proposed system to reduce the speeds of vehicles and to detect of accidents is explained.

Chapter 4 highlights the obtained results for the different cases.

In Chapter 5, the conclusions of this thesis are drawn, and possible future work is discussed.

# Chapter Two Theoretical Background and Literature Review

# Chapter Two

# Theoretical Background and Literature Review

## 2.1 Introduction

Vehicle accidents are considered as a serious issue that needs to be addressed in our societies. Excessive speeding is one of the main causes of fatalities of traffic crashes. However, the vehicle speed is one of factors in determining the severity of the accident, which means that setting the correct speed limit for vehicles is an important factor in road safety [13].

Legislators set statutory speed limits for different road types (e.g., urban streets, Interstates, rural highways) which can vary from country to another. In this thesis, a prototype device has been designed to automatically reduce the vehicles' speed when the drivers exceed the speed limits. Examples of statutory speed limits include 70 mph in major interstate highways, 55 mph in rural highways, and 25 mph in suburban or school districts. [14]

In this thesis, a prototype model has been used to emulate a real situation. For this, an Arduino microcontroller has been used to control a vehicle's speed.

## 2.2 Controller Device

Arduino is an open-source hardware and software company, project and user community that designs and manufactures single-board microcontrollers and microcontroller kits for building digital devices.

Arduino platform was designed to supply a cheap and simple way for hobbyists, professionals, and students to make devices that react with their environment using sensors and actuators [15]. It established on easy microcontroller boards, which utilized for constructing and programming electronic devices. It has capable of sending and receiving information over the internet with the help of different Arduino shields. However, Arduino uses hardware known as the Arduino development board and software for developing the code known as the Arduino Integrated Development Environment (Arduino IDE) [16].

Arduino IDE supply a simplified integrated platform that can run on uniform personal computers. It allows users to write their programs for Arduino using C or C++. With so many Arduino boards existed in the market; selecting a special development board needs an assortment of the survey done concerning their specifications and abilities, which can be used for the project execution according to its fixed implementation[17].

Researchers use several methods to change the engine speed, especially those running on DC. The most important technical methods; their advantages, disadvantages, and how the methods are followed are listed in the following items:-

- Series Resistor: This can be done through adding an extra effort to reduce the engine torque. It leads to consume a large amount of energy and current and that may cause a sudden stop.

- Mechanistic Gears: This can be done by instructing one gear to interfere and reduce the speed that is depending on the situation. This method may cause friction in those gears, which leads to a high temperature and erosion of its parts.

- Pulse Width Modulation (PWM): In this method, the speed of the engine is controlled through the width of the pulse. Therefore, by sending a short pulse, the engine runs at low speed, while sending a long pulse, the engine increases its speed [18].

In this thesis, a PWM is used in which the message encoded and instructing the engine to work at the required speed. Figure 2.1 shows the instruction of PWM used to control the speed engine. The instruction (digital Write) is replaced with (analog Write), where the code numbers are from (0) to (255). (0) represents the engine off, while (255) means the engine is running at full capacity.

It can benefits to PWM by reduce the engine speed [19] by choosing a value between (0) and (255), to determine the speed at which the vehicle operates.

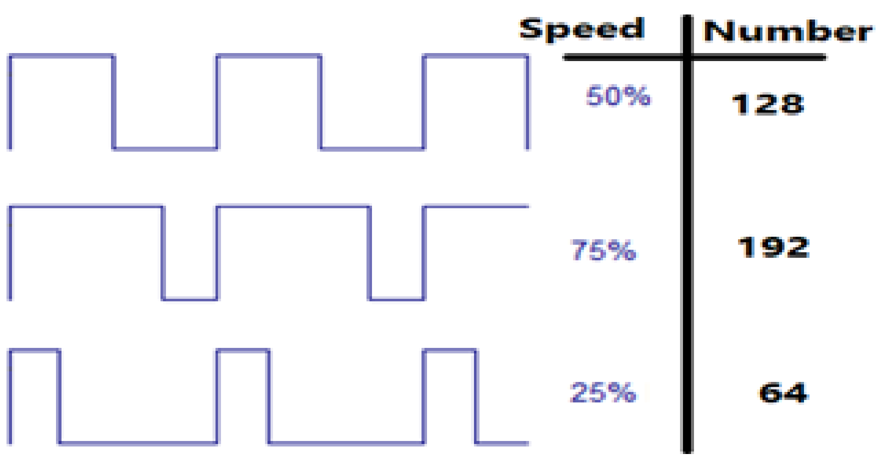


Fig.2.1: variable pulse width

An example of the Arduino Auno contains (6) outputs of PWM can be seen by looking at the ports (3, 5, 6,9,10 and 11) in Fig 2.2.

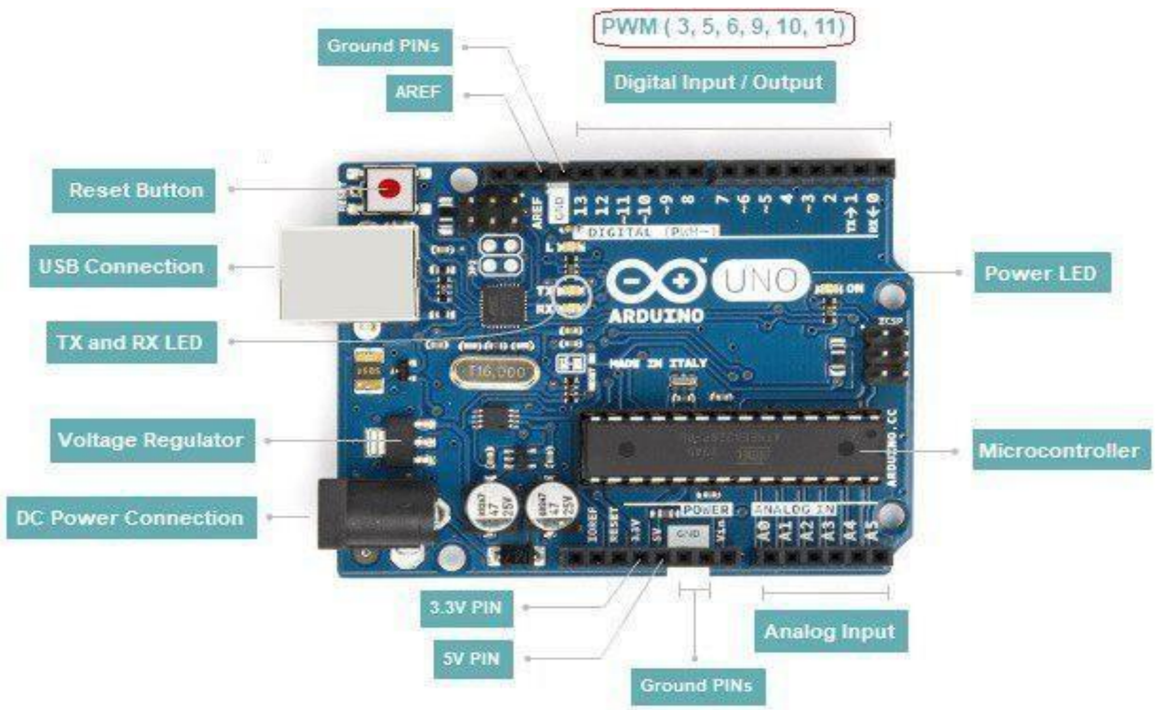


Fig.2.2: Arduino UNO Components [20]

## 2.3 Vehicle Sensors

Sensors in the vehicle are connected through a bus connector. Where the bus has very high data transfer speed, enabling high-priority communication such as prioritizing AIRBAG or crash sensors. This system uses a protocol called controller area network (CAN) [ 21][22], that has a printed circuit that allows data transfer speed of 500 kilobits per second as shown in Fig 2.3. This chip is widely used because its speed that exceeds the speed of other printed circuits, and it is working with two layers; the physical and data layer.

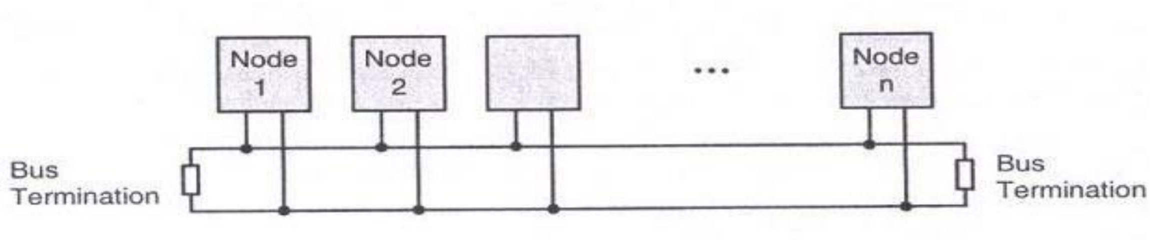


Fig.2.3: CAN Protocol [23]

CAN protocol is used immediately to report of accidents. It sends signals to the rest of vehicles to reduce speed, as it communicates directly with the sensors without going through ECU.

Message Queuing Telemetry Transport (MQTT) publish/subscribe is another protocol used to track vehicle speed [24].

The vehicle published the information of coordinates of its position and time within the network based on IoT. The server collect, register and store the information in the database center after comparing the vehicle data with road details (road limits) as shown in Fig .2.4.

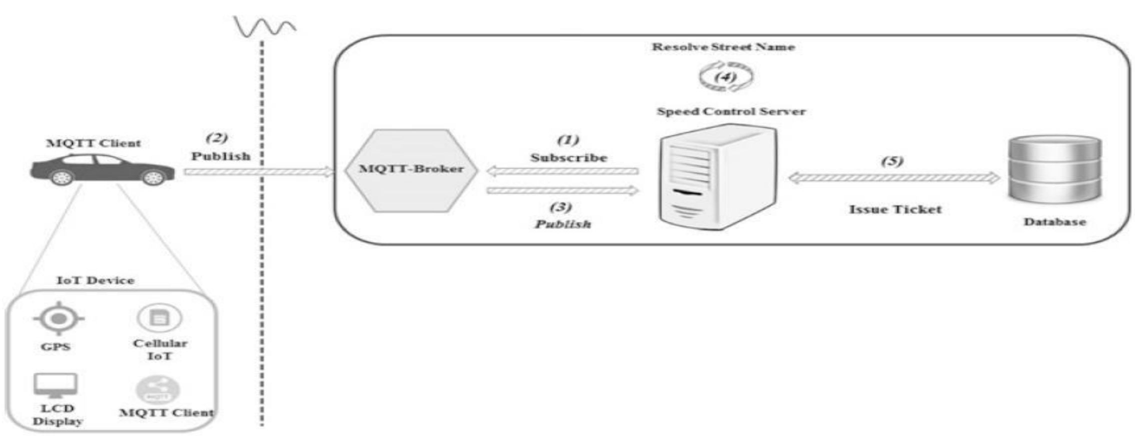


Fig.2.4: MQTT Software design [25]

## 2.4 Radio Frequency (RF) Device

RF device is an electromagnetic signal device that sends the signal wirelessly through an antenna for communication between two devices. It works at a specific frequency range from 3kHz to 300GHz, as shown in Fig .2.5. It also does not require transmitting the signal in the line of sight (LOS) [26].

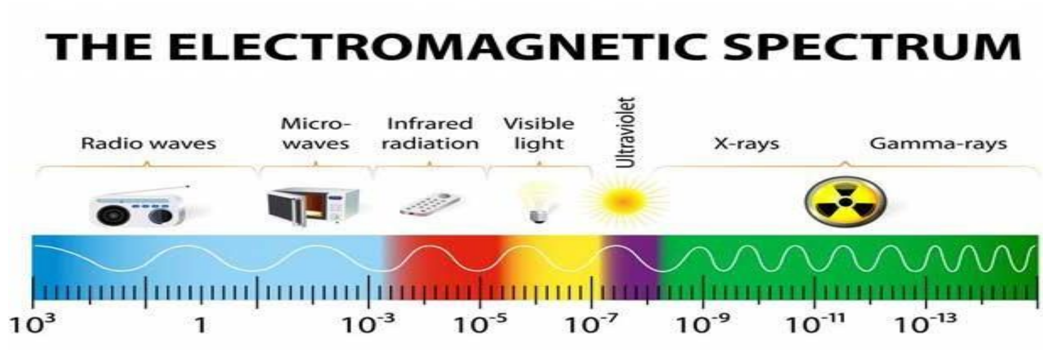


Fig.2.5: Electromagnetic Spectrum [27]

There are several types of RF devices, for example, RF434MHz and NRF24L01. In this thesis, the NRF24L01 is used for several reasons. Its facilities include of cheap price, current consumption is less than 13.5 mAh, Data Rate 25 Mbps, the ability of communicate with more than one receiver, full-duplex, high receive sensitivity, withstand high temperature and it is using the Serial Peripheral Interface (SPI) protocol.

SPI is a very easy serial protocol. The master sends a clock signal (SCLK), and upon each clock pulse; it shifts one bit out to the slave and one bit in, coming from the slave.

By using Slave Select (SS) signals, the master can control more than one slave on the bus. There are two ways to connect multiple slave devices to one master, one is mentioned above i.e. using slave select, as shown in the Fig. 2.6 [28] and the other is daisy chaining. It uses fewer hardware pins (select lines), but software gets complicated.

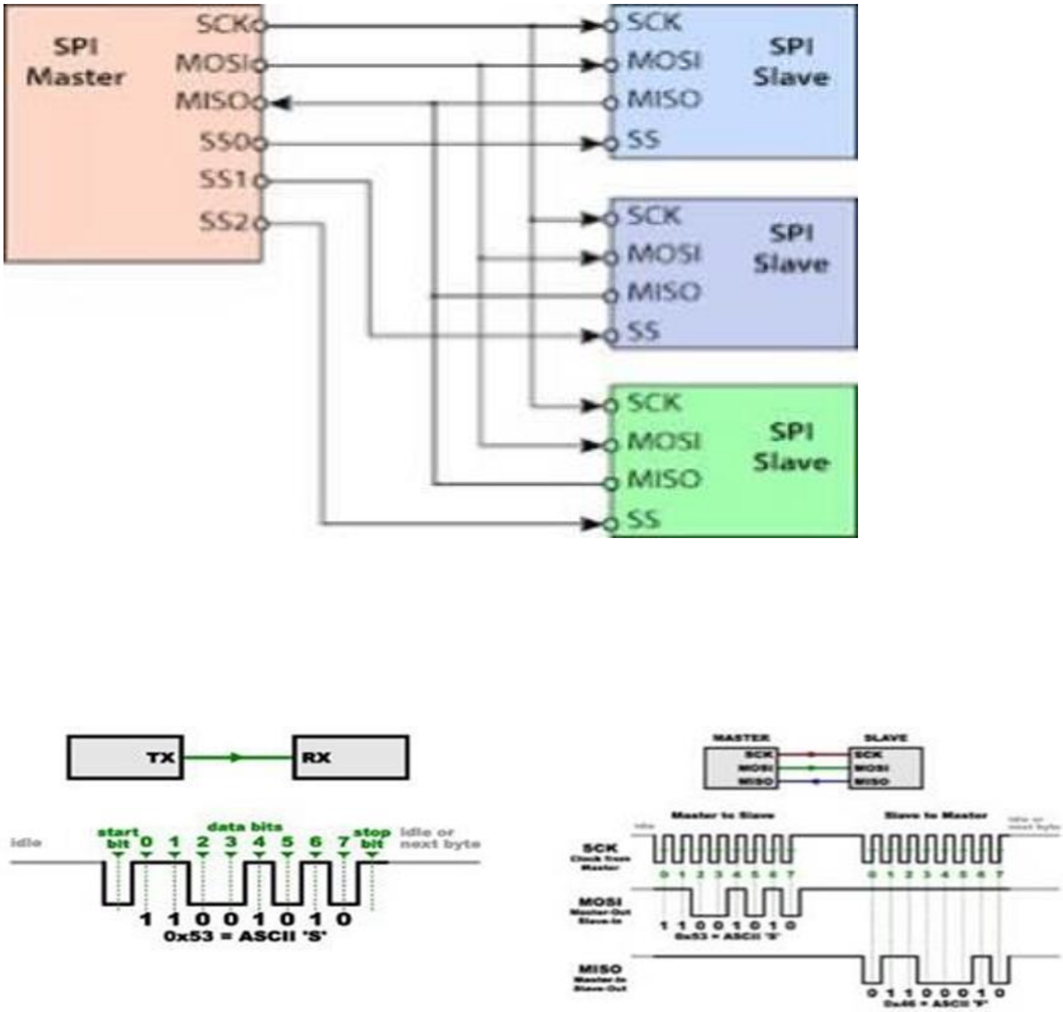


Fig.2.6: SPI connection [28]

Several parts chooses to be daisy-chained with each other, with the Master input Slave Output (MISO) of one going to the Master Output Slave Input (MOSI) of the next. In this case, a single SS line goes to all the slaves. Once all the data is sent, the SS line is raised, which causes all the chips to be activated together. This is often used for daisy-chained shift registers and addressable LED drivers. Note that; for this layout; data overflow from one slave to the next, so to send data to anyone's slave, it will need to transmit enough data to reach all of them. Also, keep in mind that the first part of the data you transmit will end up in the last slave as shown in the Fig.2.7.

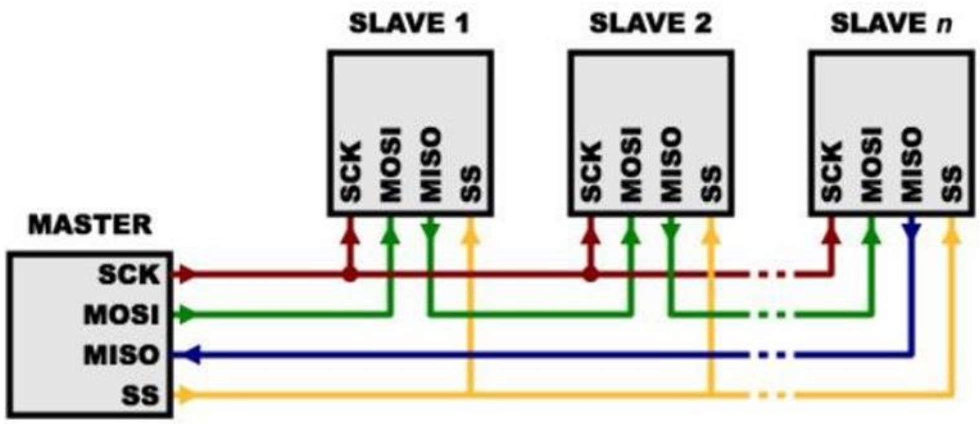


Fig.2.7: SPI Daisy-Chained [28]

SPI is used in this thesis; because it has high data rates transfer, single master, and full duplex. Therefore, it can benefit from the advantage of this protocol in our work due to one device is used as a transceiver (full duplex) [29]. Taking into consideration the configuration of an identifying library for the protocol used at the beginning of writing the IDE code.

## 2.5 Literature Review

This section presents briefly the previous studies, which have, in way or another, relevance to the current study. The smart roads are considered as a promising way for a modern transport infrastructure, where it combines artificial intelligence and big data with physical infrastructures such as sensors and solar panels [30]. Further, roads can be connected to the internet of things (IoT) to collect traffic and weather data, where it can be utilized from this type of connectivity to improve safety and traffic management, etc. In general, several researchers have made suggestions to limit overruns to reduce traffic accidents.

**In 2013, Singh, Narendar *et.al*** [31], have been designed a smart display and controller (SDC) to alert the driver when the speed limit zone is exceeded, where the information is displayed on the vehicle. The author suggested placing a Radio-frequency identification (RFID) tag in different zones. When the information is received from the RFID zones, the message of the speed limit zone will appear on the smart display to alerts the driver with an alarm. If the driver does not reduce the speed in the speed limit zone, the SDC unit will automatically send a message through the global system for mobile communications (GSM) includes the details of the vehicle and speed limit zone to the traffic police system.

**In 2014, Qiao *et.al*** [32], the author suggested deploying radio frequency (RF) devices along with the work areas (construction areas) and maintenance areas, which send a voice message to the vehicle driver to reduce speed, stop or otherwise. The driver can hear that message through the radio channel or receiver device.

**In 2016, K. Kumarmanas *et.al*** [33], sensors were installed in the vehicle to broadcast the collected data, such as vehicle registration plate, vehicle speed, and vehicle speed limit monitoring. The broadcasted data gathered and analyzed by the RF devices deployed along the streets, and the analyzed data would be sent to the traffic department through a special router.

**In 2016, H. Gupta *et.al*** [11], the author suggested to set up a Microcontroller with the vehicle system to receive a message from the traffic authorities to reduce the speed when the driver exceeded the speed limit. If the driver does not respond to the message, the microcontroller will turn off the vehicle engine within 10 seconds without reducing the vehicle speed [34].

**In 2016, Kochar *et.al*** [35], a method to send a warning message through a protocol Zigbee was considered. The vehicle is tracking through a global position system (GPS), and the warning message would be received from the driver via protocol Zigbee to reduce the vehicle speed.

**In 2014, K. N. Goh *et.al*** [36] the authors designed a system based on an algorithm to find the closest hospital to the accident. It is depending on the geographical coordinates and maps.

**In 2016, E. Nasr *et.al*** [37] the authors designed an accident avoidance system with the aid of the IoT and they were able to connect it to the network. They used ultrasonic sensors to detect the hazard.

**In 2018, Ni, Fei, Jianxiang Wei *et.al*** [38] designed a system to protect children and the elderly sitting in the vehicle during its stoppage and their relatives forget them during rest periods or shopping, that is by establishing a system for monitoring life and warning about weather conditions.

The controls of vehicle speed that depend on the standardization of speed limits are more complicated and have not been addressed in the literature. An investigated unique method in relation to a gap found in the literature is needed to be declared, which is the main contribution of this thesis.

In this thesis, a prototype model has been applied to rival vehicle accident recognition and remote alarm system based on IoT. Consequently, a low-cost Arduino microcontroller has been used to control vehicle speed automatically. A PWM is used to encode the control message to determine the speed at which the vehicle operates. MQTT protocol is used to track vehicle speed based on IoT using MySQL database storage software for GPS to track the speed and the time consumed.

# Chapter Three

# Methodology

# Chapter Three

# Methodology

In this chapter, the architectures of the proposed system for vehicle speed reduction and accident based on IoT are presented.

The theoretical framework used in this thesis relied on IoT, where IoV is one of IoT branches that have already evolved to become more comprehensive; therefore, it is called Universal IoV (UIoV) [39]. Fig .3.1 and Fig.3.2 show vehicle were connected via the internet from several aspects.

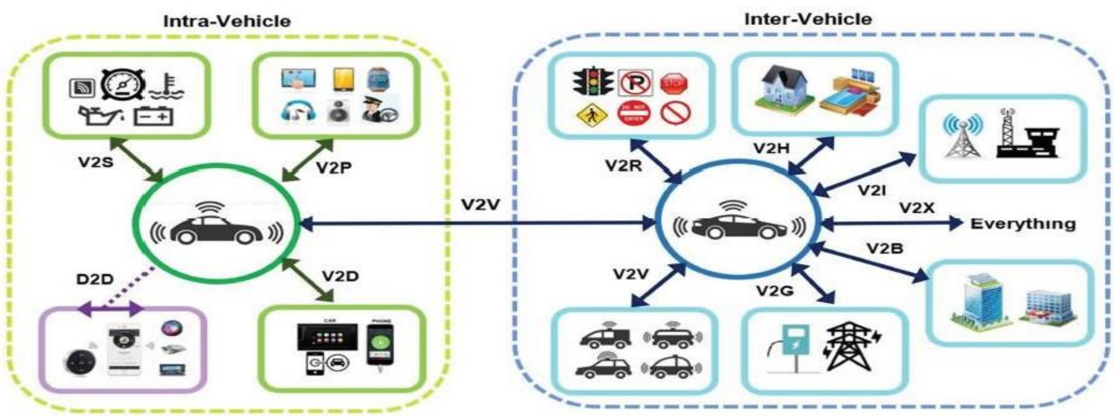


Fig .3.1: Models IoV [39]

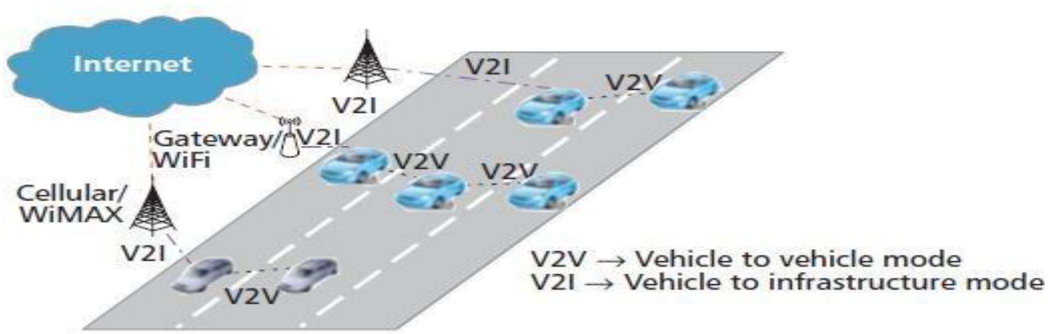


Fig .3.2: IoT Structural [40]

## 3.1 Vehicle Speed Control

Previously, the vehicle fuel consumption is controlled mechanically through a metal drawing wire attached between the fuel pedal and throttle valve. This traditional method was replaced by an electronic control system [41].

Generally, the speed of the motor vehicle can be changed by setting the accelerator pedal position (APP), where the variation in the APP is forwarded to the Electronic Control Unit (ECU) [42]. Depending on APP, and the data received from different sensors, the ECU has controlled the gate of the throttle [43].

In this thesis, Micro-controller is setting as linked between the ECU and APP as shown in Fig. 3.3. It gathers the data speed of a vehicle from APP. According to the data collected from the APP unit, the Micro-controller will analyze and compare it with the data that is saved. Then the Micro-controller will decide to stay at the same speed or decrease the vehicle's speed and send its decision to the ECU unit. Depending on the decision of the Microcontroller, the ECU will turn to decrease or not the amount of spent fuel that affects the vehicle to reduce or stay at the same speed (see Fig 3.4).

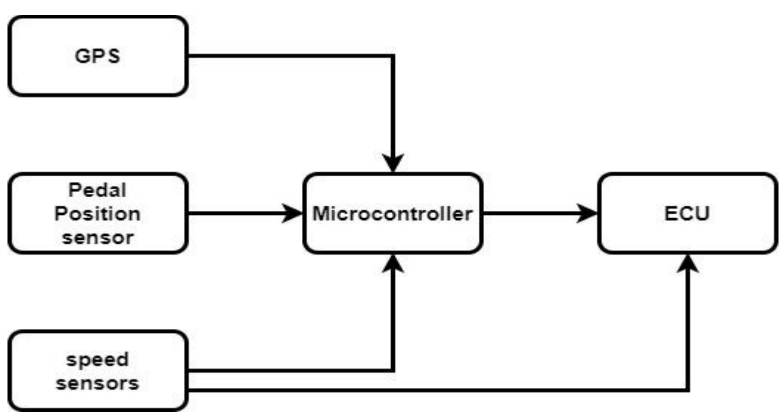


Fig .3.3: Engine speed control architecture

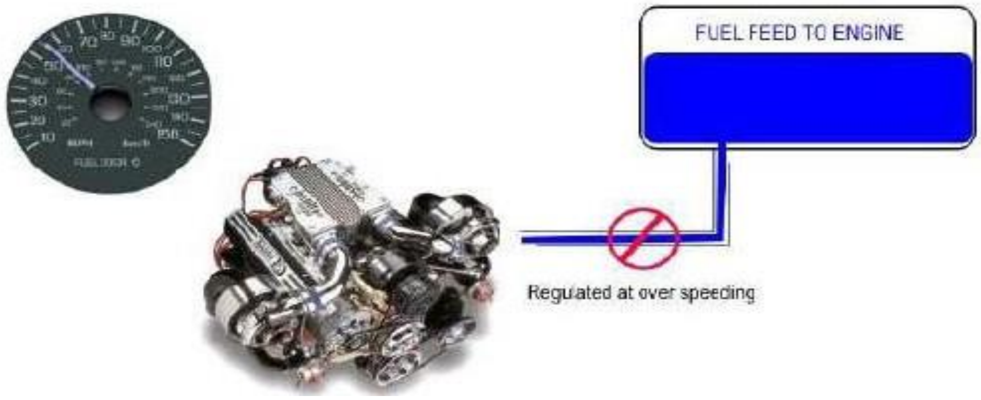


Fig.3.4: Description of the function of the road speed Limiter [44]

The methods used to define the areas where speed needs to be reduced are programmed with GPS coordinate via GIS maps. If this is not possible due to the lack of maps or its financial cost in some regions, this will be replaced by deploying RF stations that transmit the radio signal to the vehicle to control and reduce the speed when exceeding the speed limit.

The RF stations are placed next to the main road on the lighting poles, electricity pole, and traffic lights. It either is fed from electricity sources on the road or via DC battery connected with a solar cell since it needs stable source power [45].

### 3.2.1 Modes of processes

In the utilized design, the vehicle has two statuses: passive and active mode.

**A-Passive Mode:-**

The Microcontroller receives the data from the pedal position sensor and compare it with the data from the speed sensor, then its transfer the data to the ECU unit. In this mode, the vehicle's speed will not be changed since it is below the allowed maximum speed.

## B - Active Mode:-

In this mode, the vehicle's speed data is always passed to the Micro-controller unit. According to the received data from the RF transmitters, which are specified for each road, the Micro-controller would compare the data with that received from the APP unit. After that, if the driver exceeds the maximum speed limit, the Microcontroller will decide to reduce vehicle's speed and pass this information to the ECU unit. Figure 3.5 shows the flow chart of both normal and active modes.

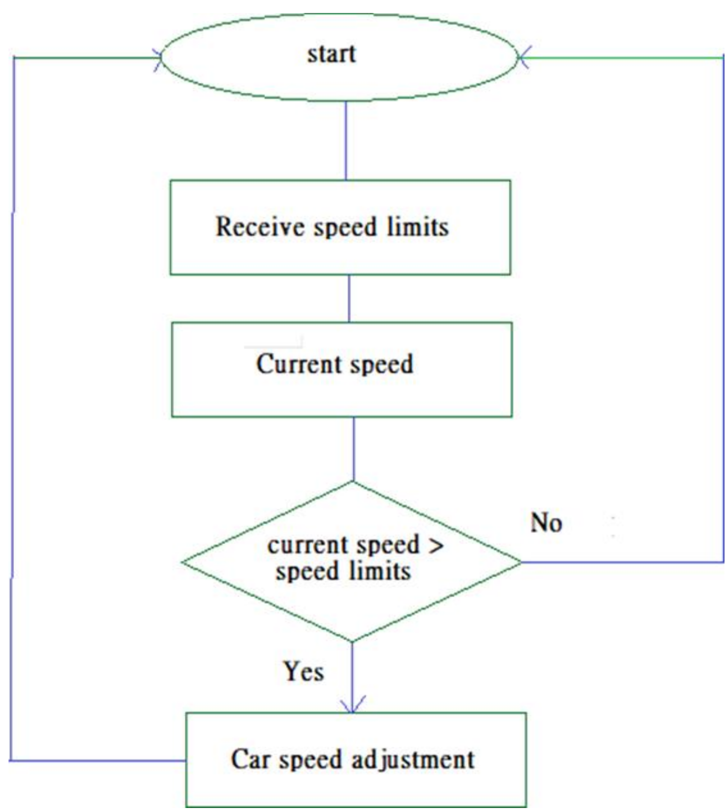


Fig. 3.5 Flow Chart on Passive and Active Model

### 3.2.2 Vehicle Speed Control

In this thesis, GPS coordinate device always tracks the vehicle as shown in Fig 3.6. The Micro-controller receives the data of the vehicle position and decides to reduce the speed level or stay at the same level depending on the specific speed that belongs to the type of street that the vehicle passes through. In addition, the authorities can receive the information about the vehicle's status from the internet cloud server via a Wi-Fi, which will help them monitor the vehicle when an accident happens.


Fig.3.6: GPS in a vehicle

An Ethernet shield or Wi-Fi is used between the RF devices installed along the roads and the cloud for tracking and saving the data collected from the vehicle as shown in Fig 3.7.

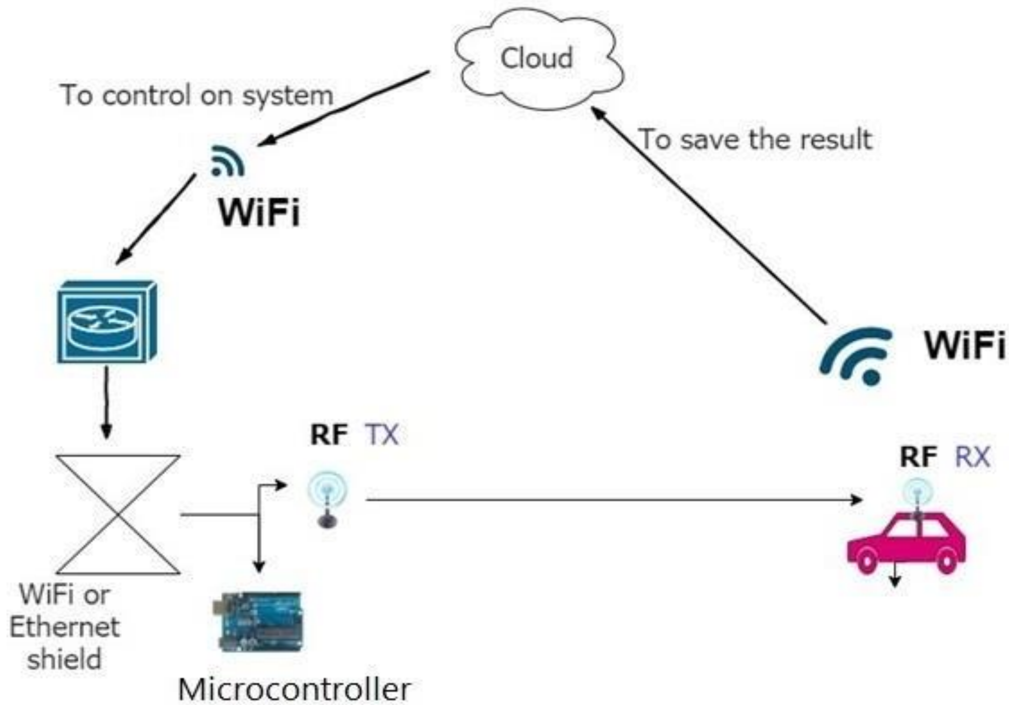


Fig.3.7: Cloud Data Storage for Vehicle Control

In addition to the speed reduction system, it has been proposed an additional accident system alert to assist in saving peoples when the accident happens. It sends a message for asking help in two ways as shown in Fig.3.8. Firstly, the accident sensor sends a message through an application in the mobile device. Then the mobile device will send an alarm message to the emergency center via GSM. In a second way, the sensor will send an alarm message using a Wi-Fi connection to the server that will pass it to the emergency center also. These two ways are setting simultaneously, to ensure that the alarm message is forwarded to the emergency center when the accident happens. In addition, there is an alert message broadcasting to all vehicles on the street from the vehicle that exposed to a traffic accident.

A collision sensor is added to the system, which is a signal-conducting switch. It sends an electrical signal of a traffic accident to the microcontroller in order to take action and reduce speed. This sensor is placed on the outer hull of the vehicle or under it with a depth of 5 cm.

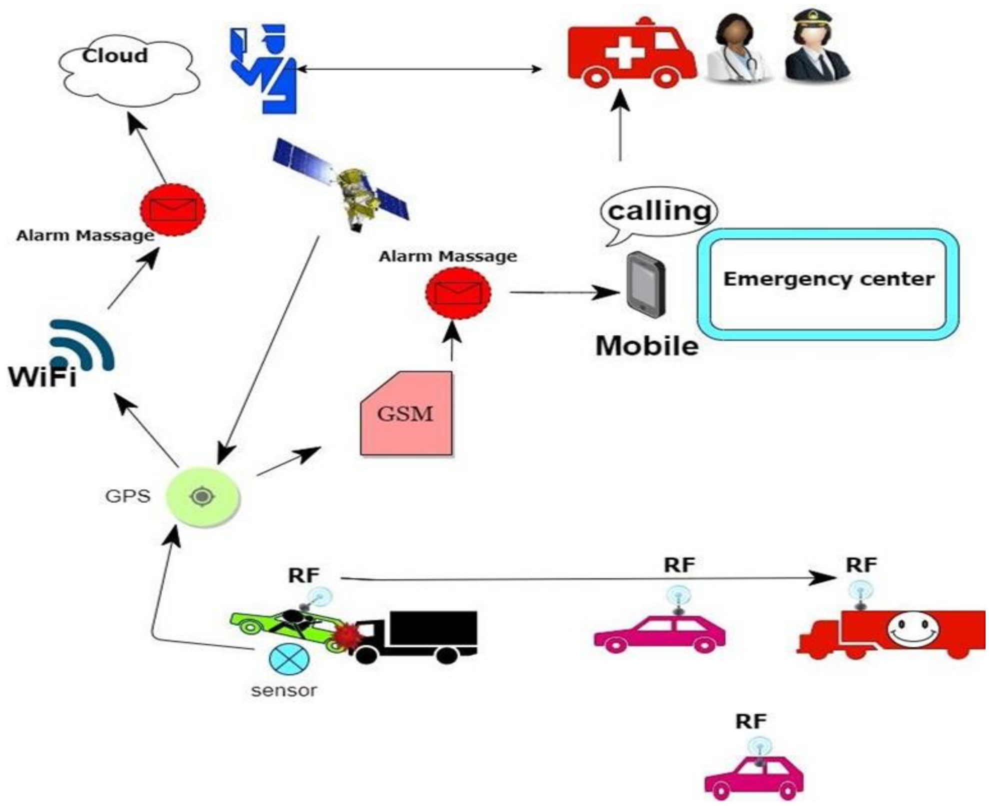


Fig.3.8: Accident Detection System

Figure .3.9 depicts the proposed accident system. First, a sensor senses the action and sends an electrical signal to start an early warning process of the accident to Microcontroller. The sensor works to conduct the electrical signal to the system when contact occurs on the principle of the Push - Button switch. The alert systems start and the Microcontroller sends the location of the accident coordinate, which depends on the GPS system. The accident coordinate will be send in parallel through two-technology simultaneously, Wi-Fi and GSM. Through the Wi-Fi path, the Microcontroller sends the data to the cloud server directly via Wi-Fi technology. In the RF path, the Microcontroller sends an accident signal to the RF device that will broadcast an alert signal for others to reduce their speed. Finally, in the GSM path, the message is sent to the emergency center to inform it about the accident.

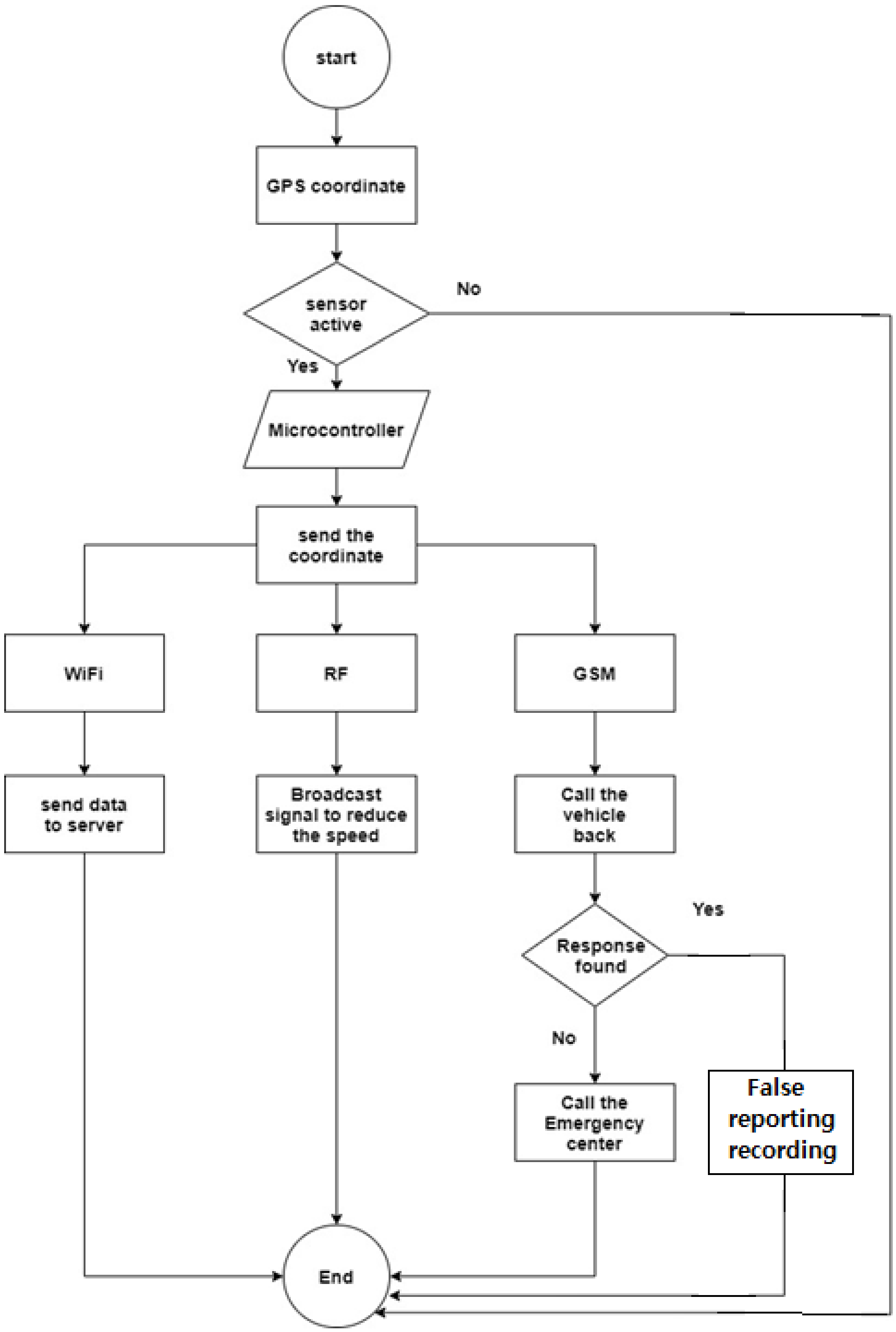


Fig.3.9: Flowchart of the proposed emergency system

The technologies used in the alert system are explained in the following sections.

### A- Global Position System

Global position system (GPS) helps to identify the position of vehicle. It helps to send the exact location to the emergency center when the accident happens. It was found that 67% of people are not able to explain the situation to the paramedics about the location where they are [36]. Therefore, from the GPS, it is easy to identify the accident location and the nearest hospital from that accident.

The navigation system works by operation a GPS device to choose four satellites out of 24 satellites that specified in length, width, height and speed to send this information to the rest of the other means of communication [46].

### B- Cellular Communication (GSM)

The proposed emergency system is connected with the vehicle through the GSM to report the ambulance and the police when the accident is taken place. The message contains the vehicle’s identity, coordinates, and time. The assistant is send to the vehicle according to the information provided. This happens when the emergency center calls the vehicle driver to confirm the accident. If the driver of the vehicle is not responding to the emergency center, the accident will be confirmed [47].

### C- Wi-Fi Connection

The WiFi connection is secured to the nearest base station (LTE or Mobile station) to store the information about the vehicle and the driver, which is previously recorded (for example, blood type, diseases, and home phone number) [48]. It used to send the information of the vehicle such as current speed to the cloud server for monitoring. The monitoring process continues to show the results of a vehicle accident or malfunction and to send the geographic coordinate to cloud computing.

Vehicle Ad-Hoc network (VANET) technology can be used to exchange information between vehicles when the vehicle cannot be able to obtain the information via radio of GPS due to the obstacles [49]. It also sends an alert signal to the neighboring vehicles during a rush hour.

The (MQTT) protocol transmits messages between the server and the client in a (publisher/subscriber) mode, as the open-source protocol consists of three main parts:

- Broker
- Publisher
- Subscriber

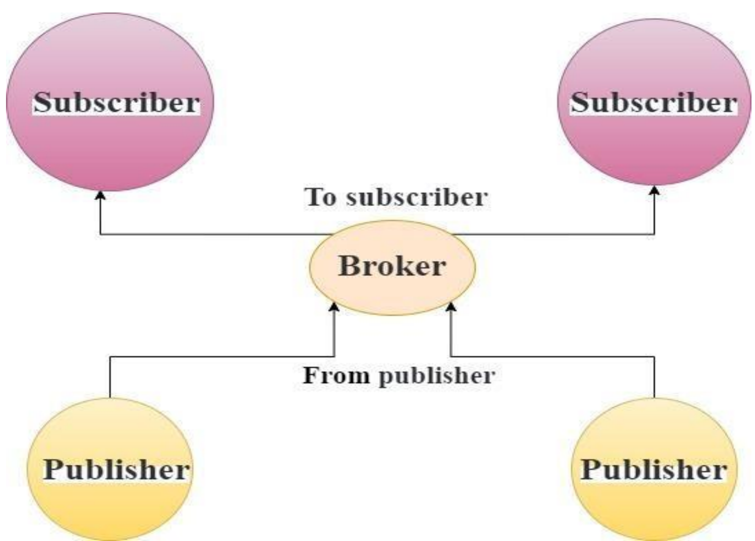


Fig.3.10: MQTT Protocol Stage

The vehicle publishes its information to the broker via messages, where the broker manages the network and sends the information to the server, which it acts as an intermediary between the publisher and the customers by relying on TCP / IP to determine the specific customer to whom the message is delivered to, as shown in the Fig 3.10

### D-Radio Communication

An RF device is placed in each vehicle. It works to receive signals from the RF's devices that deploying alongside the road, as well as to receive signals from other vehicles.

## 3.2.2 Prototype components

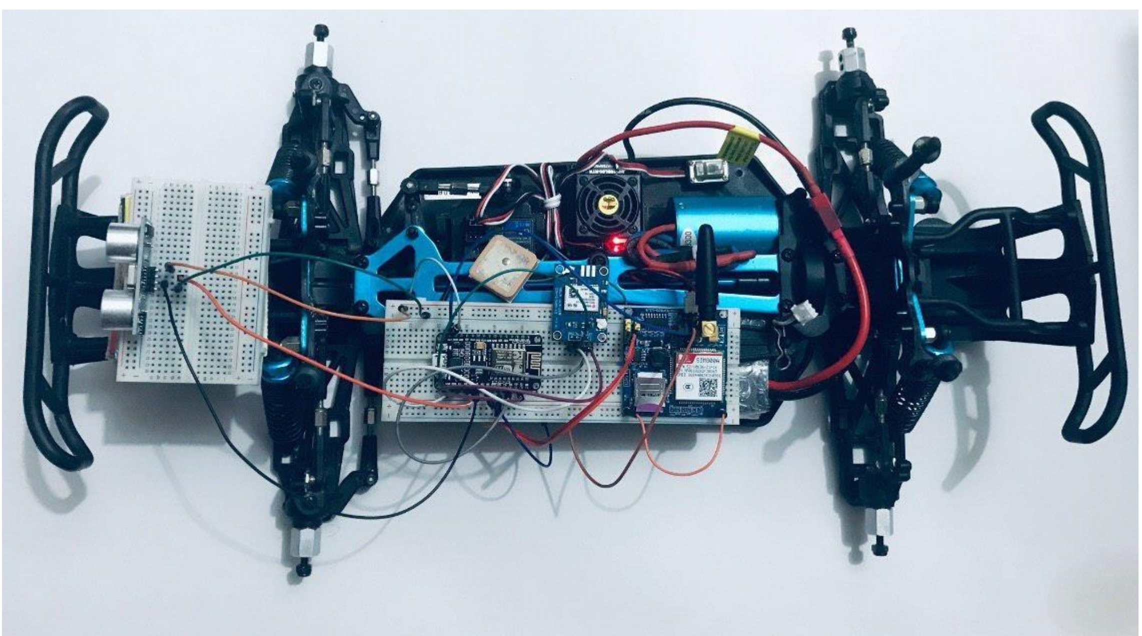

Fig.3.11: Prototype Vehicle of Speed of 60 km / h

The IoT is used to control speed limits, store data in the cloud server and use the same technology to report early traffic accidents that will help to protect the lives of passengers. Figure (3.11) shows the components that added to the vehicle prototype, which used in this thesis.

The prototype of the suggested system is designed and implemented. A system component is consisting of two parts. The first part consists of the NRF-24l01 transmitter, the dc power source (battery) or solar cell and the microcontroller type Arduino pro mini (ATmega328) because of its tolerance of temperature around from -40 to 80 degrees Celsius degrees.

This equipment are placed in a plastic box as shown in Fig.3.12. This part is set in a roadside and customized according to the types of the road through programming the microcontroller. In the second part, the same aforementioned in the first part is compact with the vehicle pattern as shown in Fig.3.13.

However, the NRF-24l01 is used as a transceiver since it has the advantage of a fast connection recipient using the serial peripheral interface (SPI) protocol [50]. In addition, the Arduino pro mini is used in this project due to its small size. Therefore, it can be easy use with the small vehicle's prototype.

The microcontroller (Arduino pro mini) can be replaced with a Node MCU that has a WiFi unit (ESP8266) to control RF stations remotely without programming manually. Therefore, the Node MCU has been chosen and used in this thesis due to it has a microcontroller and WiFi at the same time (See Fig. 3.14). It allows us to change the conditions of speed remotely according to speed variables.

Fig.3.12: Transmitter Unit

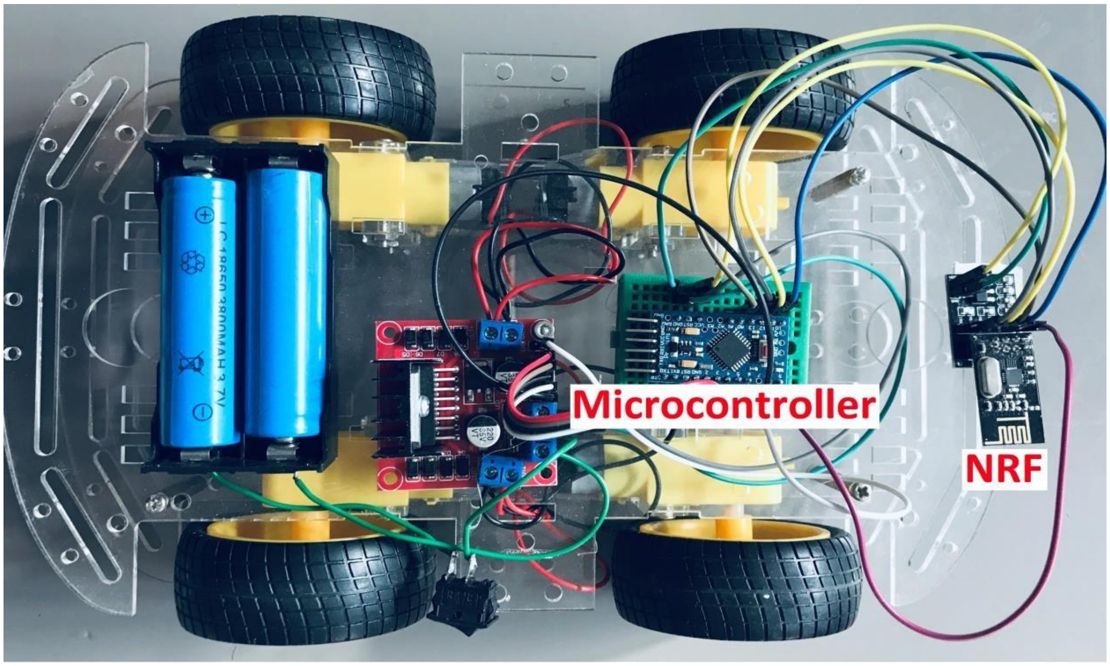


Fig.3.13: Prototype vehicle with Receiver Unit

Fig. 3.14: Transmitter Unit with Node MCU

A group of transmitting stations can link to a single station that is controlled via a particular server or directly from a switch in the Main Station, as shown in the Fig. 3.15.


Fig. 3.15: The Main control statin

# Chapter Four

# Results and Discussion

# Chapter Four

# Results and Discussion

In this chapter, the results of this work are shown and discussed.

## 4.1 Control the Speed of Vehicle

As explained chapter three, the system controls the speed of vehicles by installing RF radio stations alongside the road. It will send a message to the vehicle for the purpose of speed reduction. Practically, the thesis tested different NRF and RF stations for knowing the coverage ranges by these stations. This helps us in the calculation of the number of stations that installed alongside the road in order to accurate test the model.

The RF device used in this work has a standard transmission range of 100 meters. The experiment was conducted in a rural area as shown in Fig. 4.1. The RF transmission station was set at a height of 2 meters, where a maximum transmission distances of a radio signal according to equation (4.1) [51].

Fig.4.1: Prototype of Zone Test

$$d_T = \frac{2\pi h_T h_R}{\lambda} \qquad (4.1) \quad [51]$$

where $\lambda$ is a wavelength to RF signal , $h_T$ transmitter height, $h_R$ is a receiver height and $d_T$ is a maximum distance.

If the speed is required for long distances, it is possible to install more than one station or install devices with a broadcast antenna with a standard range of 1000 meters, as shown in Fig.4.2.

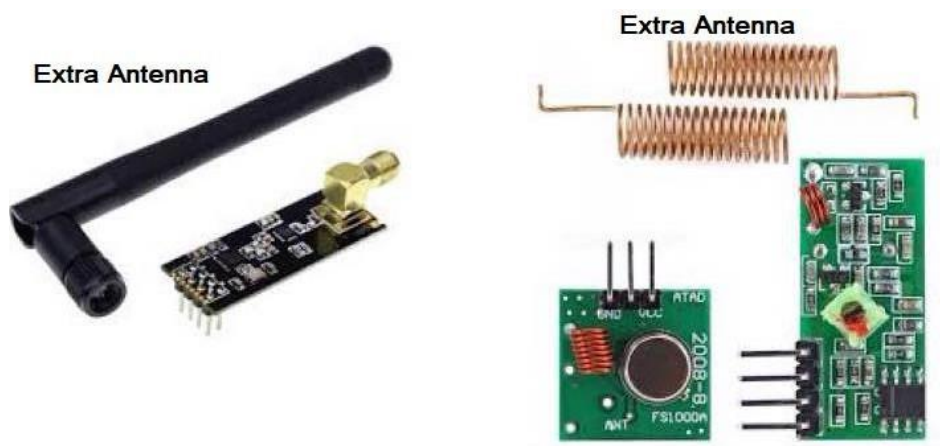


Fig .4.2 RF with Extra Antenna

The prototype vehicle is tested along the path of 500 meters, where the path is divided into different regions to emulate the real streets. The transmission unit defined as an identifier, for example, C, D, etc. A Microcontroller is programmed by the open-source Arduino Software (IDE) version Arduino 1.8.12 for the transmitting and receiving units, where each station is specified for a limited speed.

As shown in Fig.4.3, the vehicle is started to increase its speed gradually from the zero point up to 42 Km/h during the period from 0 to 4 seconds (s) since the maximum speed in the first path is set to 45 Km/h. After that, the vehicle speed dropped in the second region to 20Km/h and stay almost stable at that speed of a period from 5.8 s to 14.2 s, where the vehicle is entered the restricted region that set to 20 Km/h maximum speed. When the vehicle passes the restricted area, it has returned to increase its normal speed with the region of 45Km/h. The stations (NRF) were used in the experiment.

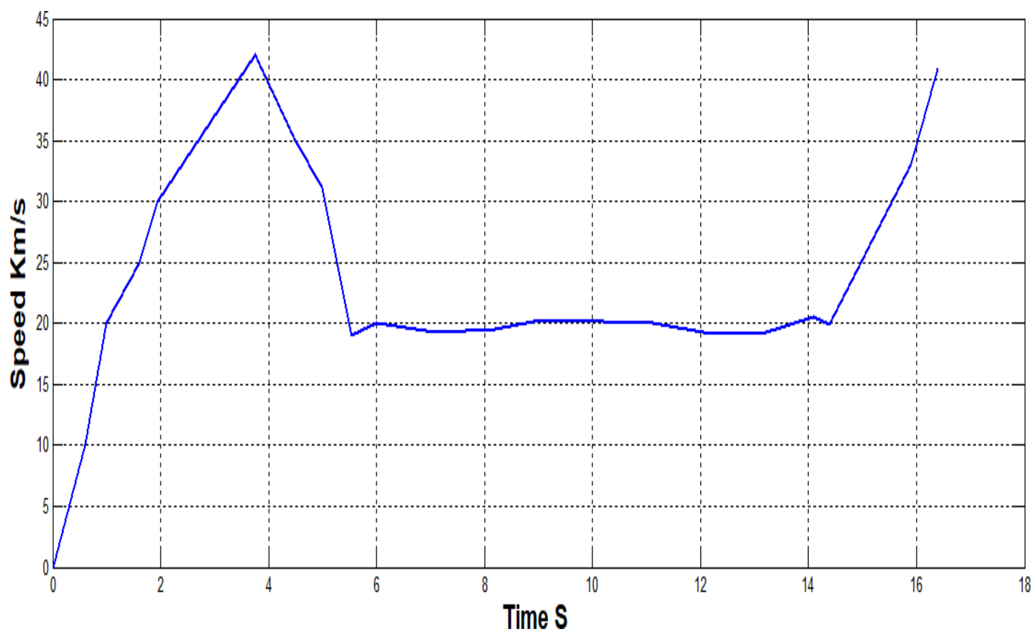


Fig.4.3: Control Speed Reduction Zone

In this thesis, the vehicle speed is measured using a GPS box, which is a multiuse tracking device [52]. The experiment has been conducted in the laboratory before it is carried out on the street through the serial window to know the time required for the vehicle to receive the notification message of reducing speed and from which station. An SD card has been added to save the information and to view a chart that displays the speed of the vehicle within the time.

Figure 4.4 illustrates the results of the second test. The road that connects Najaf- Karbala was chosen as an example of speed reduction with different limits. The section taken from point (32.1058858 N, 44.2739056 E) begins and ends with point (32.0943819 N, 44.2721370 E).

The prototype was traveling at 40 km / h, and then the speed was reduced to 30 km / h by the NRF device installed in the first region. In the second region, the speed is reduced to 20 km/h, where the vehicle took about ten seconds to cross the second region.

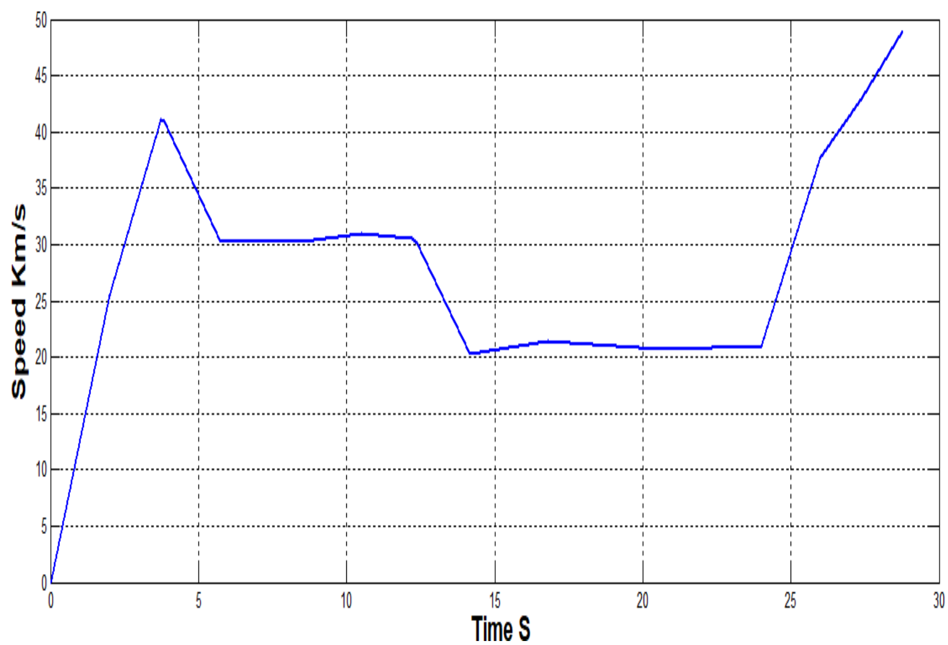


Fig.4.4: Relation between the Speed and Time

Figure 4.5 shows the results of the third experiment, as the region was divided into four sections A, B, C, and D with unequal distances. The maximum speed is set at 10, 20, 15, and 5 Km/h, respectively. From this figure, the response to speed reduction is good enough according to the speed limit.

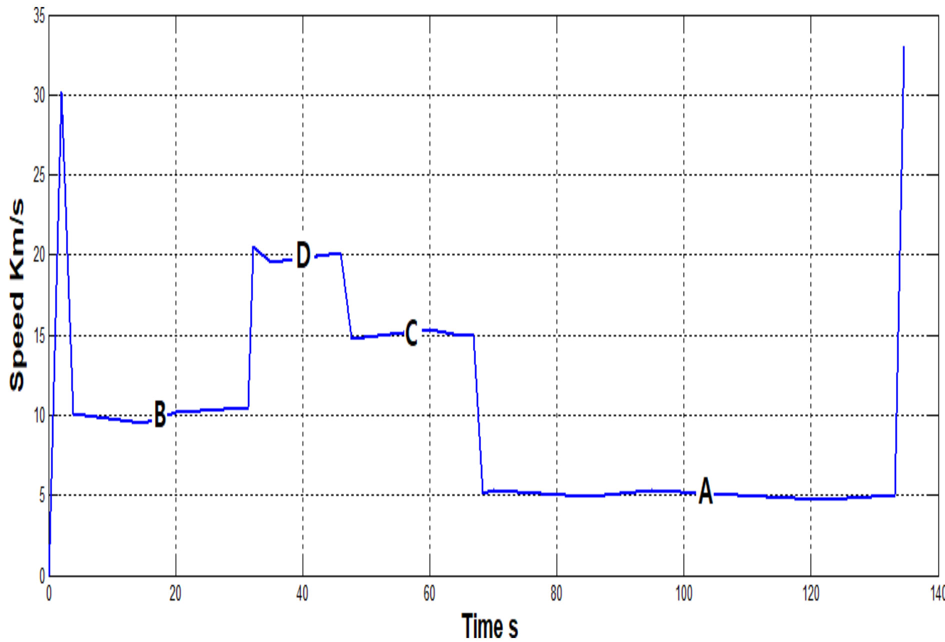


Fig.4.5 Use four stations (NRF) to reduce the speed

The Node MCU is the key to access the IoT, where the results of the sensors reviewed on paid servers, and some are almost free like Thingspeak, Remotexy, Blynk, GPRS server...etc.

Figure (4.6.A) shows how to monitor vehicle speed by connecting to the internet. It can monitor a group of vehicles through the server screen where the coordinates, time, speed, weather conditions, etc. are available. It provides the ability to monitor the quality of the speed reduction system.

Also, It can control the radio stations to make the speed change remotely by the server via setting a specific speed according to the recommendations of the traffic departments since it stipulated that the speed limits during the daylight are differing from night times (see Fig. 4.6.B)

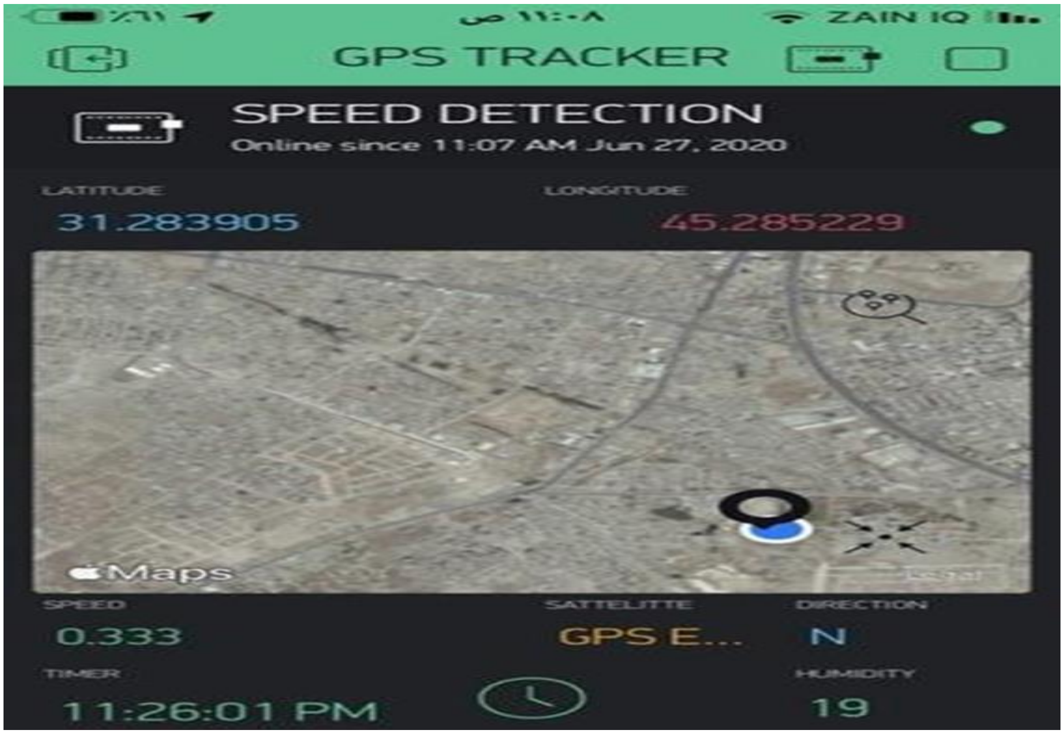


Fig.4.6.A: Shows how to Monitor Vehicle Speed and other Parameter

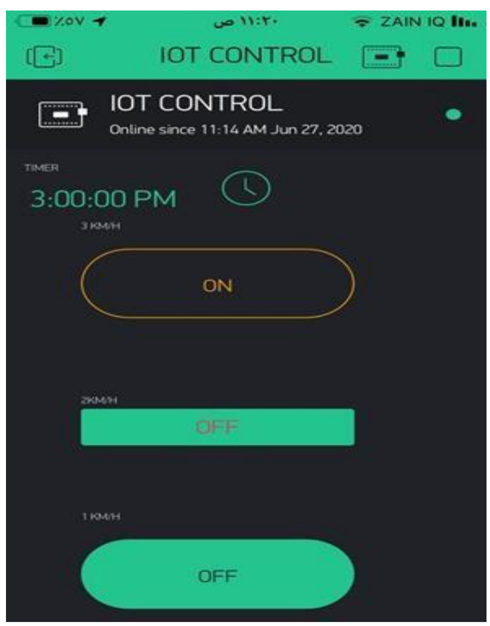


Fig.4.6.B: How to Change the Reduction Speed of a Radio Station

| Zone No | Accident detection accuracy | Location tracking accuracy | Notification sending accuracy |
|---|---|---|---|
| 1 | 100% | 94% | 100% |
| 2 | 100% | 97% | 100% |
| 3 | 100% | 95% | 100% |
| 4 | 100% | 94% | 100% |
| 5 | 100% | 99% | 100% |
| 6 | 100% | 99% | 100% |
| 7 | 100% | 94% | 100% |
| 8 | 100% | 95% | 100% |
| 9 | 100% | 93% | 100% |
| 10 | 100% | 97% | 100% |
| 11 | 100% | 93% | 100% |
| 12 | 100% | 97% | 100% |
| 13 | 100% | 97% | 100% |
| 14 | 100% | 95% | 100% |

Table 4.1 Test Accident Detection Accuracy

## 4.2 Accident Detection System

For rescue teams to reach the accident site quickly, accurate coordinates of the vehicle accident site must be obtained. Table 4.2 shows 14 experiments that conducted to check the accuracy of the accident detector, where fifteen different areas were examined to check the proposed accident system. The accuracy of the used device ranges (GPS NEO 6M) from 5 to 10 meters and is acceptable in our project to detect the vehicle accident.

The ability of the GSM (SIM900) device to send the geographical location of the affected vehicle was determined. The identifier of that vehicle can be determined so that the vehicle can be distinguish from another vehicle through the installed GPS device since it has a MAC address. The MAC address is unique and different from the rest of the devices. Therefore, it can distinguish the affected vehicle from the other on the network, through the knowledge of the MAC address identifier. The whole information is stored in advance, as shown in Fig 4.7. It shows the location information message coming from the vehicle to the emergency service center over the phone.

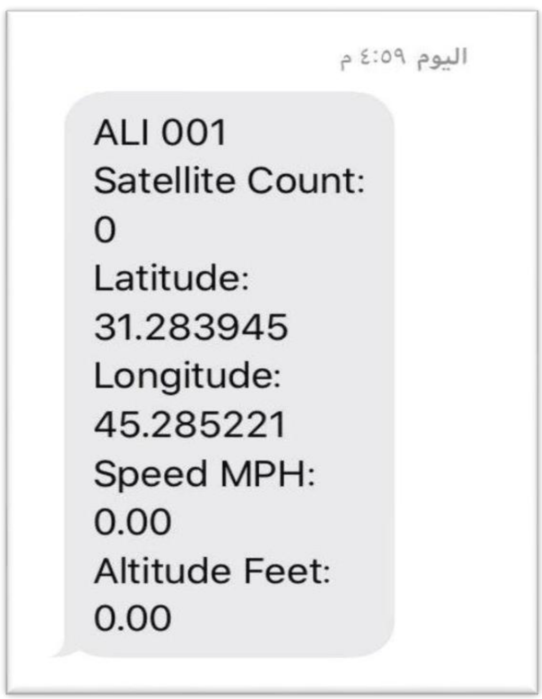


Fig.4.7: GSM emergency Message

When the vehicle accident is recorded; an alert message via Wi-Fi or GSM can be stored and displayed on the server. Therefore, the vehicle ID and its coordinates are stored on the map at the server, as shown in Fig. 4.8.

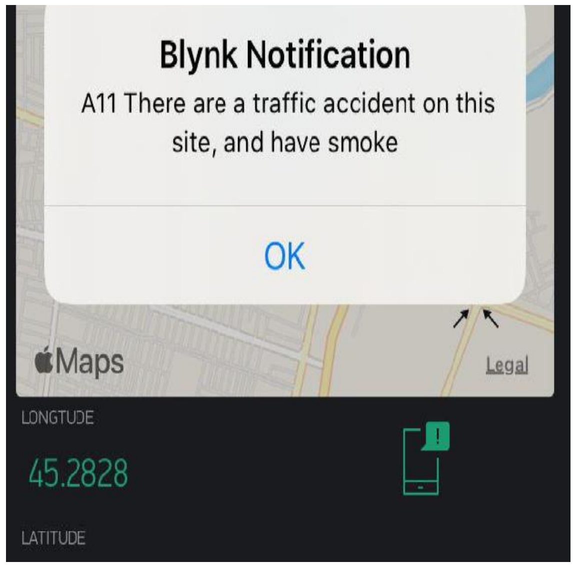


Fig.4.8: Server screen to follow up vehicle accidents

To avoid serial accidents, the transmitter of the crashed vehicle sends a speed reduction message to other vehicles on the road. It can be distinguish through the serial port in the transmitter of the vehicle crashed. Therefore, it acts as a secondary transceiver station for the rest of the vehicles on the road.

## 4.3 MySQL server

It is a database management software (DBMS). It helps users to store, organize, and find data. MySQL databases are characterize by being responsive, support different programming and this is what made most content management programs and social networks such as Word Press and Facebook dependent on it. Observers take advantage of these massive database programs to store the vehicle's private information by sending it over the internet via Wi-Fi technology. Figure 4.9 shows the MySQL data storage software for GPS to track the distance traveled and the spent time.

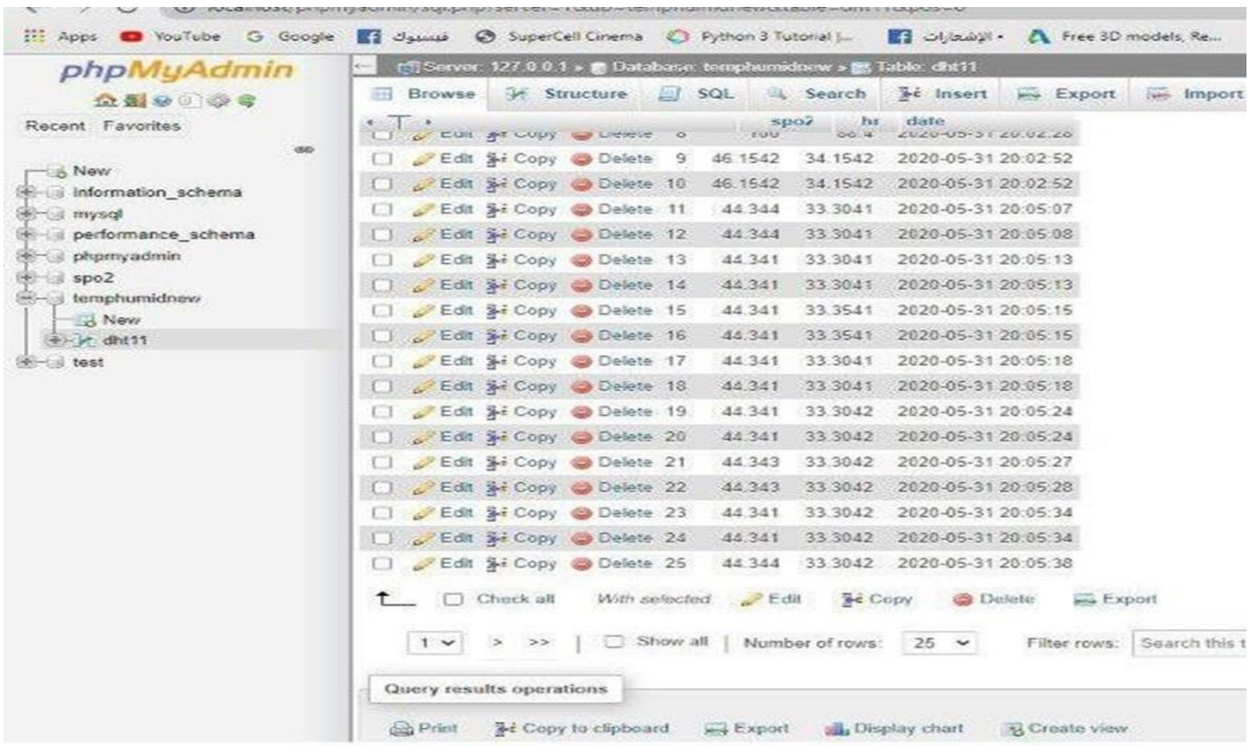


Fig.4.9: MySQL Server Screen

# CHAPTER FIVE

# Conclusion and Suggestions for Future Work

# Chapter Five

# Conclusion and Suggestions for Future Work

## 5.1 Conclusion

IoT become more popular day by day, where various devices are connected and controlled via internet.

The IoT was suggested to be used in this thesis. It used to enforce reduce the vehicle speed when the driver exceeds the speed limit. It is also used to track vehicle accidents. The GPS device was used to track the vehicle, and then to reduce the speed according to the data of the speed limit. In addition, RF devices have been deployed along the tested road. The function of the RF device is to send message information about the speed limit of the region to the vehicle to adhere to the specified speed. The new system handled cases of non-rescue of vehicles that had a traffic accident and were not assisted by setting an immediate location and informing the relevant authorities of that and broadcasting the necessary information to the rest of the vehicles.

In this thesis, the vehicle's speed was monitored via cloud server, where the server operator determines that speed. It is used to send a value of speed reduction through special transmitters in which to reduce the vehicle speed according to the speed limit. This thesis introduces a valuable idea to control vehicle speed according to the authorize standardization speed limit. It is conclude that this idea gives the best practical solution to reduce vehicles accident if the researchers know that the trend of technology in the world is to connect the internet of everything (IoE).

## 5.2 Suggestions for future work

For future work, several aspects can be studying, including, for example, analyze the effects of latency on the system response. For more reliability and security, it can add a firewall to the suggested system. It can take into consideration different circumstances during bad weather includes heavy rain, fogs, storms, and heavy dust.

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# الخلاصة

الحفاظ على سرعة السيارة تحت السيطرة وفقًا لحدود السرعة تعتبر بمثابة المفتاح الرئيسي لإدارات المرور في العالم لتقليل حوادث المركبات. تقدم هذه الدراسة نموذجًا أوليًا لفكرة جديدة للتحكم في سرعة المركبة تلقائيًا وفقًا لأنواع الطرق التي تمر بها المركبة وبدون تدخل بشري. يتم ربط وحدة التحكم الدقيق بمستلم التردد اللاسلكي في النموذج الأولي، وكذلك مع أجهزة إرسال التردد اللاسلكي المنتشرة على طول المسار الافتراضي. تظهر نتائج الاستجابة كميه التحكم في سرعة السيارة وفقًا لحدود السرعة ولأنواع من الطرق المختلفة.

بالإضافة إلى ذلك، تم اقتراح نظام تنبيه لزيادة السلامة عند وقوع الحوادث الناتجة عن تجاوز الحد الأقصى للسرعة. يمكن تحقيق ذلك من خلال تصميم نظام إنذار للسيارة لتنبيه الآخرين لخفض السرعة وإبلاغ مركز الطوارئ عند وقوع الحادث. وعلى أي حال، يتم التحكم في سرعة السيارة وفقًا لحدود سرعة الطريق، حيث يتم تقليلها ديناميكيًا استنادًا إلى إنترنت الأشياء. تم تخزين نتائج المراقبة في الخادم السحابي، مما يمنح السيارة القدرة على الاتصال بمحيطها من خلال الاتصال بالإنترنت.

**جمهورية العراق**

**وزارة التعليم العالي والبحث العلمي**

**جامعة الفرات الاوسط التقنية**

**الكلية التقنية الهندسية نجف**

# التحكم الالي في سرعة العجلات بالاعتماد على إنترنيت الأشياء

***رسالة مقدمة الى***

***قسم هندسة تقنيات الاتصالات***

***كجزء من متطلبات نيل درجة ماجستير في هندسة تقنيات الاتصالات***

***تقدم بها***

***علي فاضل عذاب***

إشراف

***د . أسعد سموم دغل***