UNIVERSITY of RWANDA
College of Science and Technology
Website: https://aceiot.ur.ac.rw/

ACEIoT
AFRICAN CENTER OF EXCELLENCE IN INTERNET OF THINGS
Email: aceiot@ur.ac.rw

COLLEGE OF SCIENCE AND TECHNOLOGY

AFRICAN CENTER OF EXCELLENCE IN INTERNET OF THINGS

EMBEDDED COMPUTING SYSTEM

P.O.BOX: 3900 Kigali, Rwanda

MASTERS PROJECT THESIS

"IoT based intelligent traffic management system"

A dissertation submitted in partial fulfillment of the requirements for the degree of

MASTERS DEGREE IN INTERNET OF THINGS- EMBEDDED COMPUTING SYSTEM

(MSC in IoT-ECS)

Submitted by

UWIMANA Josephine (RN: 215026137)

January 2022

CERTIFICATION

This is to certify that the project work entitled "IoT **based intelligent traffic management system**" Is a record of the original work done by **Josephine UWIMANA (215026137)** in partial

Fulfillment of the requirement for the award masters of Science in internet of thongs at College of Science and Technology, University of Rwanda during the academic year 2020-2021.

This work has been submitted under the guidance of **Dr.** Philibert NSENGIYUMVA and **Dr. Eng.** Omar GATERA.

Main supervisor: Dr. Philibert NSENGIYUMVA

Signature:

Co-supervisor: Dr . Eng. Omar GATERA

Signature:

Head of Master's studies: **Dr**.James RWIGEMA

Signature:

DECLARATION

I declare that this dissertation contains my work and that it is original work. I also declare that, as required by rules I have fully cited and referenced all material and results that are not original to this work.

Student name and Registration Number

UWIMANA Josephine

215026137

Date: 06th January 2022

DEDICATION

I dedicate this dissertation….

To Almighty GOD

To my husband and my children

To family members

To my supervisors, lecturers, and close friend, who supported me a lot during my master's studies!

ACKNOWLEDGEMENTS

I am deeply intended to almighty God who has guided me through the whole period of my studies. I am very grateful to my family for their support and advice.

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My sincere thanks are due to friends and colleagues who helped us in one way or another.

Finally, I express my gratitude to each one who directly and indirectly contributed to make my studies successful today.

LIST OF ABBREVIATIONS

IoT: Internet of Things

VIP: Very important Person

RSU: Roadside units

RFID: Radio Frequency Identification

IR: InfraRed

RTDA: Rwanda Transport Development Agency

MININFRA: Ministry of Infrastructure

RURA: Rwanda Utilities Regulatory Agency

PIC: Peripheral Interface Controller

WSN: Wireless Sensor Network

Wi-Fi: Wireless Fidelity

PC: Person Computer

RAM: Random-Access Memory

USB: Universal Serial Bus

SOC: System on a chip

GPU: Graphics Processing unit

CPU: Central processing unit

OS: Operating System

GPIO: General-Purpose Input/Output

HDMI: High-Definition Multimedia Interface

ROM: Read-only Memory

MySQL: My Structured Query Language

PHP: Hypertext Preprocessor

HTTP: Hypertext Transfer protocol

IBITTMS: IoT based Intelligent Traffic Management System

DB: BataBase

UML: Unified Modeling Language

TCP/IP: Transmission Control Protocol/Internet Protocol

HTTP/HTTPS: Hypertext transfer Protocol Secure

Abstract

Nowadays, there has been a large growth in population, which causes the number of private and public cars also to increase. As a result, traffic congestion, road accidents, increased pollution levels and traffic violations are some of the prevalent characteristics seen in modern cities. This trend is likely to continue in the future. To better estimate the extent of the problem now and in the near future, a projection model was developed to predict the number of vehicles in the next ten years based on data from the last 20 years. The projected number of 576793 vehicles in 2030 suggests that more traffic congestion is to be expected if no appropriate measures are taken. It is in that respect that the present project is developed. This project proposes an IoT based intelligent traffic management solution for decreasing the effects of traffic congestion. The system to be designed would control traffic signals based on the density of traffic on each side of the intersection, and also it is a road traffic jam control system to examine road priorities of three directions using the latest technology of sensors and microcontrollers.

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CHAPTER 1

1.1 Introduction

Traffic management is the planning, monitoring, and controlling or influencing traffic. Or it is a process of adjusting or adapting the existing road network to improve traffic operations without major construction. One of the main issues for traffic management is congestion. Proper traffic management can prevent congestion or reduce the consequence of congestion. It is occurs when there is an inefficient use of the roads capacity. Budget-wise, in our developing countries it is almost unfeasible to build new roads, or even expand those that are available to catch up with the cities' growth. Devising new and innovative traffic management systems remains the most effective solution to this issue.

Congestion can result from the improper use of available road capacity due to the lack of information on the side of road users (i.e., drivers) for example, when some road sections are congested while the alternative routes are completely free. Solutions are therefore reducing the traffic demand or increasing the road capacity, or else implementing better traffic management systems based on accurate information sharing. This traffic management system will attempt to increase the efficiency of using the available road capacity.

Congestion has negative effects on safety and security since the probability of an accident is higher in or near congestion (for example, approaching the tail end of a traffic jam causes a higher risk of an accident) and travel times to particular destinations will be longer. In our country, existing police are in charge of the traffic system; in general, the fundamental disadvantage of the traffic police-controlled system is that it is not intelligent enough to deal with traffic jam. The traffic police officer can either block a road for a longer period of time or let vehicles on another road to pass; in other words, the decision making process may not be as intelligent as it should be, and it is entirely dependent on the officer's judgment.

Moreover, even if a traffic signal is employed, the time interval during which the vehicles will receive a green or red signal is set. As a result, it may not be able to solve the traffic problem.

If there is traffic management on the road, drivers will have less time to wait on the road. This will also help in the reduction of traffic congestion. This is done with the help of an intelligent traffic control system based on IoT.

1.2 Background and Motivation

Reports given by international economic magazines such as Frobes[1] indicate that developing countries have the issue of work hours partition methods. Statistically, an average citizen spends only 7out of 24 hours of a day working. The impact of city traffic congestion to this redundancy lag assumptive value goes up to 18% of the whole day's loss of time. The economic implications of this issue are off the charts.

Internet of Things is a technological trend nowadays. It provides a way of engineering many technical, social solutions. IoT helps us collect and analyze information from different source points instantaneously, and very accurately. As a student of Master of Science in IoT, I experience day-to-day advantages of this new technology. The skills I have acquired so far have given me the confidence to address the issue of traffic congestion in Rwanda. The fact that the desired system would require the collection of data from multiple points on the road throughout the city compels the solution to be designed using IoT platforms.

The government of Rwanda has adopted digital solutions as the leading tool to fighting poverty in all aspects of life. Many programs have been put in place to enhance the economy of the population by adopting new technological innovations. This has been done in the agriculture sector, government services, and so on. Now the transport sector where my research is based is coming up. Having seen those economic implications of traffic congestions, and seeing the government's support towards digital innovations, I have decided to devise an IoT-based intelligent traffic management system that could tremendously reduce the congestion issue in towns and cities of our country.

1.3 Problem Statement

Since the wide utilization of automobiles, traffic congestion has been one of the most serious concerns affecting modern cities. It occurs when the capacity of the roads is insufficient to fulfill the demand. There are a lot of reasons for traffic congestion, including road maintenance, broken down vehicles, insufficient traffic police, VIP movement, and a lack of strict enforcement of traffic rules, in addition to a high density of vehicles on the road. Traffic congestion issues include incremental delays, vehicle operating costs such as fuel consumption, pollution emissions, stress, and frustration caused by vehicle interference in the traffic stream, which can result in a number of injuries and fatalities. Table below presents respondents' views on the causes of traffic jams in Kigali City.

Table 1.Causes of Traffic Jam in Kigali City [2]

	Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Vald Traffic rule violation	13	21	21	21
Unplanned city	7	11.3	11.3	32.3
Different Speed vehicle	3	4.8	4.8	37.1
Overpopulation	8	12.9	12.9	50
Insufficient road	5	8.1	8.1	58.1
Unplanned parking	6	9.7	9.7	67.7
Increase private cars	13	21	21	88.7
Other various causes	7	11.3	11.3	100
Total	62	100.1	100.1	454.9

Source: Field data May 2017

As presented in the table above, 21% of respondents argued that the traffic jam in Kigali is caused by traffic rule violations. 11.3% of respondents said that an unplanned city is one of the causes of traffic jams while 4.8% of respondents said that different speed vehicles end up causing a traffic jam. Additionally, 8.1% responded that insufficient roads are the reason behind traffic jams in Kigali whereas 12.9% of respondents uttered that overpopulation is another factor that contributes to traffic congestion in Kigali. Furthermore, 21% said that the increase of private cars in Kigali also result in a traffic jam, while 9.7% said that unplanned parking also causes traffic jam and finally 11.3% of respondents said other various causes of traffic jam in Kigali City. Referring to the respondent's viewpoints previously clarified a big number of respondents equivalent of 21% supported that traffic rules violations and increase of private cars are major causes of traffic jam in Kigali city.

The number of vehicles over 20 past years shows an increase of vehicles. For simplicity of cars statistics, we are choosing the year of 2000 , 2010, 2020 and we show the respective number of cars based on indicated years. In 2000, the number of vehicles was 54755 cars, in 2010, this number changed to 97319, and finally 2020 has 241213. The change over 10 first years (2000-2010) is 42561 and between 10 last years (2010-2020) there are 143894. The number of cars in the last 10 years is around 3 times the number of cars in the 10 first years. While this number of vehicles is increasing into multiples times and nothing is done on the roads; this will create traffic congestion. For the projection over the next 10 years; this number of cars will become too high and the traffic congestion will become high. The description of an increase of vehicles with respect to the population and yearly basis is given by figure 1 and 2.

Analysis of the last 20 years also done by the number of cars on the basis of the population and time period (year). The experiment is assessing the association of the three variables (Population, number of car and time period in years).

1. Number of Cars vs Population

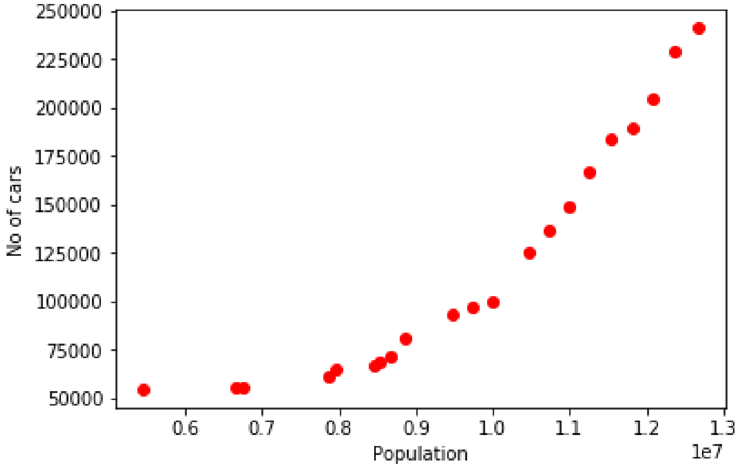

Figure 1.Car versus population

The scatter plot Figure 1 indicates the number of cars versus the population. The results indicate how the number of cars is linked with the total population. This scatter plot on the figure 1 also shows that the association of cars and population is an exponential function between the two measurements.

2. Number of cars versus time period in years

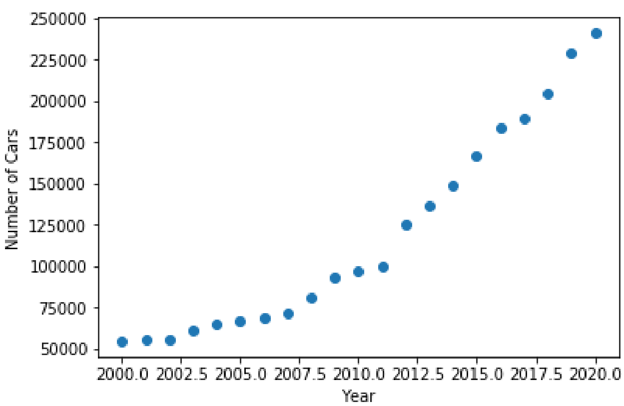

Figure 2. Car versus year

The scatter plot on figure 2 indicates the number of cars versus the time period in years. The results indicate that number of cars is linked with the year on the exponential distribution. As the year increases also the car increases.
These two above plots (Fig 1 and Fig 2) show that car has a relationship with Population and time period (year) by an exponential relation. Therefore, we fit the data using exponential regression and linear regression.

While developing the linear regression model, we choose 30% of the data (Population and the number of cars) for testing and 70% for training the model.

Table 2. Dataset

	Year	Total Population	No_cars
0	2000.0	5462641	54755.0
1	2001.0	6654641	55731.0
2	2002.0	6755741	55827.0
3	2003.0	7865741	61480.0
4	2004.0	7965681	65066.0
5	2005.0	8455681	66517.0
6	2006.0	8522641	68587.0
7	2007.0	8676771	71699.0
8	2008.0	8856891	81161.0
9	2009.0	9482641	93319.0
10	2010.0	9736771	97319.0

Table 5 shows the final dataset combining past 20 years ago versus their population, and past 20 years ago versus the number of cars. The table has only shown 10 first observations in 20 total observations available. This dataset serves as the input of model construction for the exponential regression and linear regression.

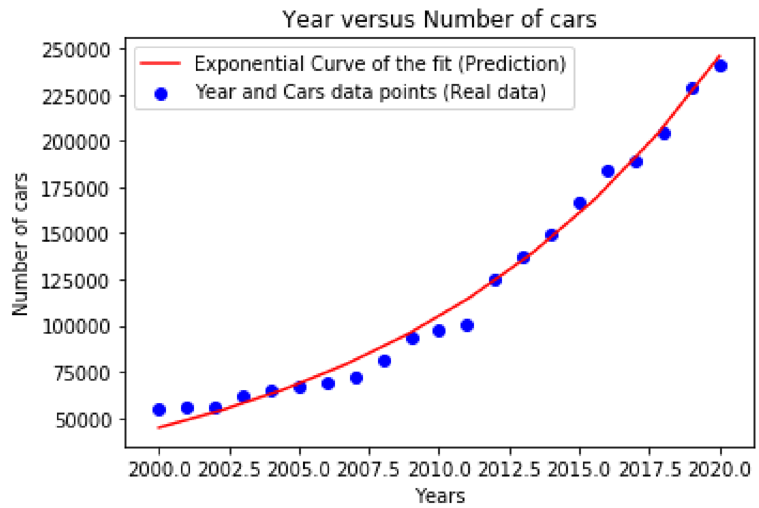

Figure 3. Time period (years) versus the number of cars

As seen from the above paragraph defining the relationship between years and number of cars which are exponential function (blue color points). After fitting the data an exponential function with mean of 1 (lambda=1); the red color curve (figure 3) is constructed with the parameters given by the fit of data and the overall results show a good fit of the curve to the data (year versus number of cars). These parameters are the coefficient *a* of 0.0852 and the constant c of -159.71.

The final formula of the number of cars *Y* on the yearly basis is as follow:

$$Y = e^{ax+c} = e^{0.0852*x-159.71}$$

$$Y = e^{0.0852*x-159.71}$$

The variable x represents the years.

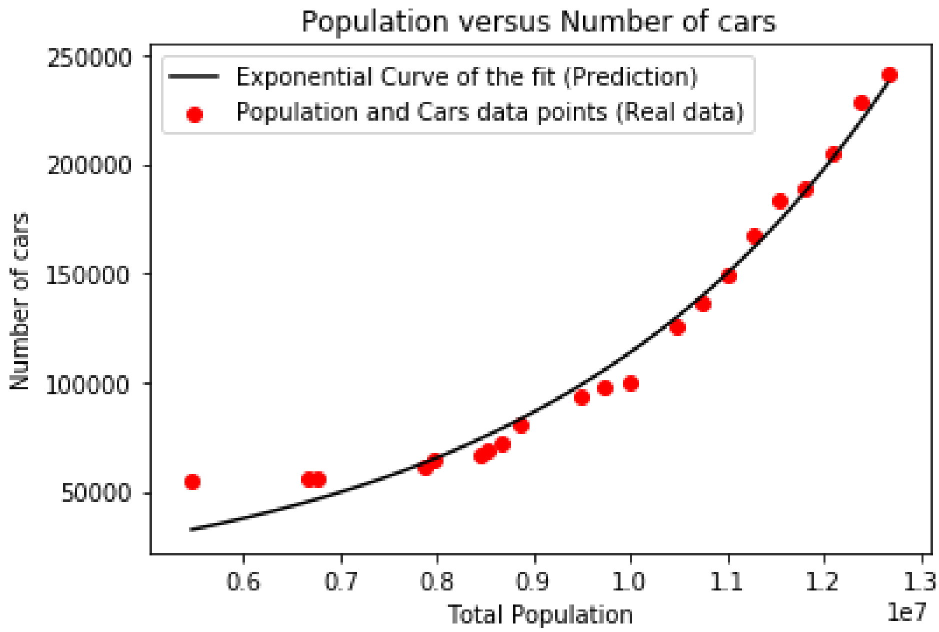

Figure 4 . Population versus number of cars

As seen from the above paragraph defining the relationship between population and number of cars which are exponential function (red color points). After fitting the data an exponential function with mean of 1 (lambda=1); the black color curve (figure 4) is constructed with the parameters given by the fit of data and the overall results show a good fit of the curve to the data (population versus number of cars). Apart from using exponential regression, we used also the linear regression algorithm and the fit has given the r2 score of 95.5% and the testing of 88.6%.

After analyzing the all above data, we conclude that Kigali City's population has been growing at a phenomenal rate, and private car ownership has been growing at a quick rate as well, causing more and more traffic congestion. It is in that respect that the present project is developed for resolving the problem of congestion by assignment of priorities based on the number of vehicles on each lane.

1.4 Study objectives

The objectives of this research are divided into two categories based on their broadness and implantation steps: General objectives and specific objectives.

1.4.4 General objective

The main objective of this project is to develop an IoT based intelligent traffic management system that is expected to reduce traffic congestion in Kigali City.

1.4.2 Specific objectives

The following are specific objectives of the project:

(i) To model an optimal sensor placement for roadsides

(ii) To design a control system for traffic monitoring and notification using Raspberry Pi

(iii) To provide proper directions to vehicles for effective usage of roads.

(iv) To design a data dashboard for traffic management and monitoring

(v) To perform an analytical model for traffic- decision and prediction

1.6 Study Scope

General purpose of my study is to develop IoT Based intelligent traffic management to manage traffic in Kigali. My study will focus on traffic management in Nyarugenge District particularly on the Road with 3 directions. The duration of my study is 1 year, including the research, data collection, prototype design, and implementation.

1.7 Significance of the study

The conclusions of this research are extremely valuable to Rwandan society as whole, Rwanda National Police, RTDA, MININFRA, RURA, and law enforcers in particular. To reduce traffic jam, ensure road safety, road accidents reduction, improve transport infrastructure including roads, walkways, and improve traffic management. The ramification of this project will go up to many economic development impacts for the society at large. It will also be a way of developing the knowledge of students at level of master's degree and will become a valuable resource of documentation, tool of specialization to other researchers or academicians to the interconnected subject matter.

1.8 Organization of the study

The rest of this thesis is organized as follows:

Chapter1: presents introduction, which includes the background and motivation of the study, problem statement, general objective, specific objectives, hypothesis, scope, significance, and the organization of the study.

Chapter 2: presents a literature review, which covers what others research and several documents in relation to the topic.

Chapter 3: states the methodology used, which consists in research. Explanation of the methods used in the implementation of my projects.

Chapter 4: presents the system analysis , Design of an IoT based intelligent traffic management system, and how it works.

Chapter 5: is Results and Analysis which found and explain the graphs of the results

Finally, Chapter 6 is the summary of findings and recommendations.

CHAPTER 2: RATIONALE AND LITERATURE REVIEW

The main objective of this work is to develop an IoT based intelligent traffic management system which is expected to reduce the traffic congestion in Kigali City. Several researchers have worked on similar topics. The present chapter will review some of their work showing their relationship to our own work. In addition, this chapter will review the main concepts that will be used to find a gap in the literature and the need for this research

2.1 Related Review:

According to Sadhukhan, P., & Gazi, F. proposed the system for reducing traffic congestion delays at road crossing using dynamic traffic signal management.The proposed congestion control system uses a unique technique for assessing traffic congestion density by using ultrasonic sensor nodes (USN). to dynamically set signal operation time depending on estimated values of traffic congestion density .the only component of the proposed system that is being presented is the design part.There are no experimental findings to back up the usefulness of the proposed system. [3]

According to Fu, G., & Yang, Z. (2015, October). They talked about how to improve traffic signal timing and offered architecture for a new generation of intelligent transportation systems based on the internet of things. They have only discussed the theory and technology of the Internet of things in the context of intelligent transportation and have run simulations to see what happens. [4]

According to Pyykönen, P., Laitinen, J., Viitanen, J., Eloranta, P., & Korhonen, T. (2013, September) presented a method for collection sensor data from stationary roadside unit (RSU) or moving cars and storing it in a database. The rest results show that the proposed friction monitoring system (IcOR) is capable of accurately distinguishing between the various road weather categories (ice, snow, wet and dry asphalt). [5]

According to Harshini Vijetha H1, Dr. Nataraj K R2 (2017, May) proposed a system that may be operated both automatically and manually. When a lost car is found, an email will be sent to the owner. For the rescue operation, an accident alarm message has been sent. [6]

According to Saleh, A., Adeshina, S. A., Galadima, A., & Ugweje, O. (2017, November). They Work has proved the theory of density-based traffic light management systems as well as the use of red light cameras to catch red light runners. Controlling income by linking with government traffic regulating bodies [7].

According to Md.Rokebul Islam, Nafis Ibn Shahid, Dewan Tanzim ul Karim, Abdullah A Mamun, Dr. Md. Khalilur Rhaman, The author propose a real time video processing technique based on road traffic density measurements. Using object detection, the traffic density is computed by examining video sequences from a camera. The predicted vehicle density is compared to other lanes in the route in order to intelligently operate the traffic light. To assure law enforcement, the system employs RFID sensors. As a result, every car that violates the traffic laws will be immediately detected. Therefore, the purpose of this article was to present chang in the existing manual traffic control system [8].

According to Tousif Osman, Shahreen Shahjahan Psyche, J. M. Shafi Ferdous, Hasan Zaman, They used a density-based traffic control method in this work. It collects data using an infrared sensor. These sensors count the number of cars on the road and communicate the information to an embedded system. The algorithm determines the approximate amount of time for red and green signals green signals based on this data. This article also considered automatic traffic management systems with predetermined red and green signal timing [9].

According to Bilal Ghazal, Khaled ElKhati(2016, April). They presented a system based on a PIC microcontroller that uses IR sensors to assess traffic congestion and implements dynamic time slots of varying intensities. The device can assess traffic density by using infrared sensors positioned on both sides of roadways. Based on this information, green light period will either be extended to allow a considerable flow of automobiles in the event of a traffic jam or reduced to avoid unnecessary wait time when no cars are present on the opposite route [10].

According to Viswanathan, V. and Santhanam, V. (2013) they suggested a method that involves using WSN to detect the presence of traffic near intersections and then routing traffic in the desired direction based on traffic density.

Because this system does not require any car systems, it can be easily deployed in any traffic system. This system detects automobiles using WSN and manages traffic using a microcontroller-based routing algorithm [11].

According to P. Prema, Dr. A. Murugan(August, 2015) They suggest a system that employs Wireless Sensor Networks (WSN) at roadside intersections and assigns a fundamental quantity to each light's illumination. The interval changes depending on the amount of traffic at the intersections. The sensors at the intersections will constantly monitor the vehicles and send out signals to avoid traffic jams. They also advocated designating specific numbers for emergency vehicles such as ambulances, fire trucks, and VIP vehicles. This system is primarily intended to reduce traffic congestion at intersections by giving emergency vehicles more priority. For both single and numerous junctions, these approaches are dynamically adapted [12].

CHAPTER 3: RESEARCH METHODOLOGY

3.1 INTRODUCTION

The research methodologies that will be used throughout the study are outlined in this section. It emphasizes the processes and procedures employed throughout the project, as well as how the analyzed results were presented. Although the majority of research methods are scientific, data analysis is a part of this study, so both qualitative and quantitative approaches are rarely used. This research approach is categorized as scientific research methods, which implies that scientific research methods are only used to clarify matters.

3.2 Development Research Approaches

This part describes the overview of the research approaches and the steps involved in system development from the step of gathering the idea to the final step of prototype and getting the result.

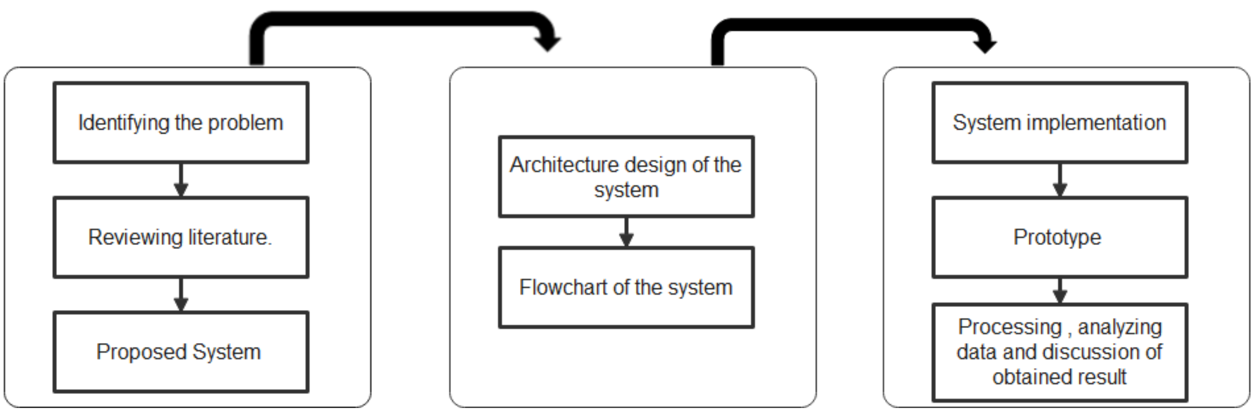

Figure 5 . Block which shows development of research approaches

3.2.1 Scientific research approach

This study was conducted using a variety of scientific methodologies. Existing schemes were discovered through qualitative research approaches, and an experimental approach was employed for design, analysis, and simulation. We started with a jumble of ideas and worked our way up to objectives, a problem statement, and a solution proposal. This helped in the creation of knowledge regarding research ideas in the existing projects. To be more precise, a quantitative technique was used to assess how other existing schemes function, as well as their weaknesses, in order to determine what should be done to improve their performance.

3.2.2 Experimental approach

First and foremost, the idea of this project came with the objectives, a description of the problem statement, and its solution based on the IoT application. My project was done and based not on simulation but on experimentation. An experiment is a scientific procedure for confirming, refuting, or proving the validity of an idea. Experiments explain what happens when a given factor is changed, showing cause and effect relationships.

3.3 Data collection method

Traffic jam is due to high number of cars, to assess jam of cars the collection of the data from the sensors on roads with 3 directions were used, the setup of the sensors configuration can be applied to any road with 3 directions.

From the previous paragraph of the research there is a point explaining that the traffic jam is linked to the high number of cars, therefore we need to assess the variation of the cars entering in the country together with population and time period in years. We use 2 datasets for the analysis (population on yearly basis and car entries on yearly basis).

	Projections Year	Total Population
0	2000	5462641
1	2001	6654641
2	2002	6755741
3	2003	7865741
4	2004	7965681
5	2005	8455681
6	2006	8522641
7	2007	8676771
8	2008	8856891
9	2009	9482641
10	2010	9736771
11	2011	9996891
12	2012	10482641
13	2013	10736771
14	2014	10996891
15	2015	11262564
16	2016	11533445
17	2017	11809300
18	2018	12089721
19	2019	12374397
20	2020	12663116

A

	Year	No_cars
0	2000.0	54755.0
1	2001.0	55731.0
2	2002.0	55827.0
3	2003.0	61480.0
4	2004.0	65066.0
5	2005.0	66517.0
6	2006.0	68587.0
7	2007.0	71699.0
8	2008.0	81161.0
9	2009.0	93319.0
10	2010.0	97319.0
11	2011.0	100244.0
12	2012.0	125159.0
13	2013.0	136824.0
14	2014.0	149012.0
15	2015.0	166893.0
16	2016.0	183703.0
17	2017.0	189105.0
18	2018.0	204612.0
19	2019.0	228934.0
20	2020.0	241213.0

B

Table 3. A is the number of population based on year and B is the number of car entries based on the year

Source: National Institute of Statistics of Rwanda (NISR) 2020

Table A is the data showing how the population is increasing with year, and table B is the data showing how the number of cars is increasing with year; here, this data will really help us know that As the population grows, so does the number of cars also increase. This would also help us to really know as the number of vehicles increases, there are not enough traffic roads, causing traffic jams.

3.4 Documents analysis

Analysis of different documents we used to analyze my project is books and other documents from different websites and the ideas from my supervisor.

3.5 Methodology

IoT based intelligent management system consist of three main parts. The first is IoT hardware component that build the entire circuit. This part involves sensing components, data processing component and Traffic display components. The second part consists of programming to make system hardware operational. The last part is data processing and analytics which will be done using Python programming, machine leaning technique for prediction analysis and will be visualized on graph.

3.6 Proposed system requirements

3.6.1 Hardware Components

1. NodeMCU (ESP8266 12F)

ESP8236 is a microcontroller for expressive system. ESP8236 is a solution for Wi-Fi networks from existing microcontrollers to Wi-Fi and is also capable of running standalone applications. Connection with PC using the micro USB cable and there are 17GPOI, with a consumed current of 10uA~170mA and RAM of 32K+80K [13]. It's made for wireless location-aware devices, communications from wireless positioning systems, and industrial wireless control, among other things. The ESP8236 is used to process and send data to a web server for analysis.

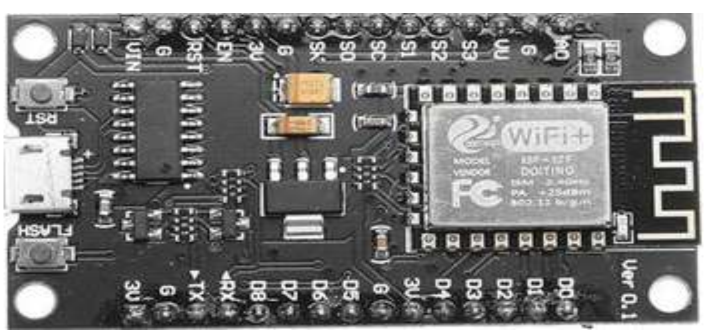

Figure 6: NodeMCU (ESP8266 12F)

2. Ultrasonic sensor HCSR04

Ultrasonic sensors use sound to determine the distance between the sensor and the closest object in its path. Ultrasonic sensors act in similar way to sound sensors, but at frequency greater than human hearing. This module has a range of 2cm to 4m. The sensor produces a sound wave with a specific frequency. The computer then listens for the sound wave to bounce off something and return. The sensor maintains track of time between sending and receiving sound waves. [14]

Figure 7: Ultrasonic sensor HC¬SR04

3. Raspberry pi v3

Raspberry Pi is a series of small single board computer. There are three generations in Raspberry Pi i.e. Raspberry Pi 1.2 and 3 with different models like model A, B. This board also in built memory such an ROM to store the application, which is used to process the data and make some decision. The basic Raspberry Pi did not have Wi-Fi and Bluetooth in it, later it was added. Raspberry Pi 3 is used in our system. It has Broadcom SOC and GPU.CPU’s speed is 700MHz-1.2Ghz.RAM has 256MB-1GB memory.SD card sore OS in it. There are 4 USB slots. Raspberry Pi also has video or audio jack. And it has 40 GPIO pins. For monitor connection it has HDMI port. [15]

Figure 8: Raspberry Pi-3

4. Jumpers wire: It is used to link the various components together.

Figure 9: Jumpers wire

5. LED: LEDs are utilized to signal traffic conditions based on the current traffic situation.

.

Figure 10 : Light emitting Diode (LED)

6. Resistor:

Resistors are used for current limiting

Figure 11 : Resistors

The decision to use these particular components was entirely based on the cost efficiency and availability of devices on a local market.

3.6.2 Software requirement

1. Arduino Ide:

The Arduino Integrated Development Environment (IDE) is developed in Java and is programmed in C/C++. It is based on the processing project from creating and uploading code to the Atmega chip in Arduino. It is software that may be used to program with certain modules, such as ESP. [16]

2. Xampp: xampp is an abbreviation where X stands for cross-platform,A stands for Apache,M stands for mysql,and the Ps stand for PHP and Perl,respectively.It is an open source package of web solutions that includes Apache distribution for many servers and command line executables along with modules such as Apache server ,MariaDB,PHP and Perl XAMPP help a local host or server to test website and clients via computers and laptops before releasing it to the main server. It is a platform that furnishes a suitable environment to test and verify the working of projects based on Apache,Perl,MySQL database, and PHP through the system of the host itself.[17]

3. Sublime: Sublime Text editor is a full-featured text editor that can be used to edit local files or a code base. It has a number of tools for editing code based that aid developers in keeping track of change. [18]

4. Web server: A web server is a software or hardware that responds to client requests via the World Wide Web using http (hypertext transfer protocol) and other protocols. A web server's primary responsibility is to show website content by storing, processing, and distributing WebPages to users. Web servers provide smtp (simple mail transfer protocol) and ftp (file transfer protocol) for email, file transmission, and storage, in addition to http. Web server hardware connects to the internet and allows data to be transferred with other connected devices, while web server software regulates how users' access hosted content. The web server is an example of the client/server model in action. On all machines that host websites, web server software is necessary. [19]

3.6 System Block Diagram and System architecture

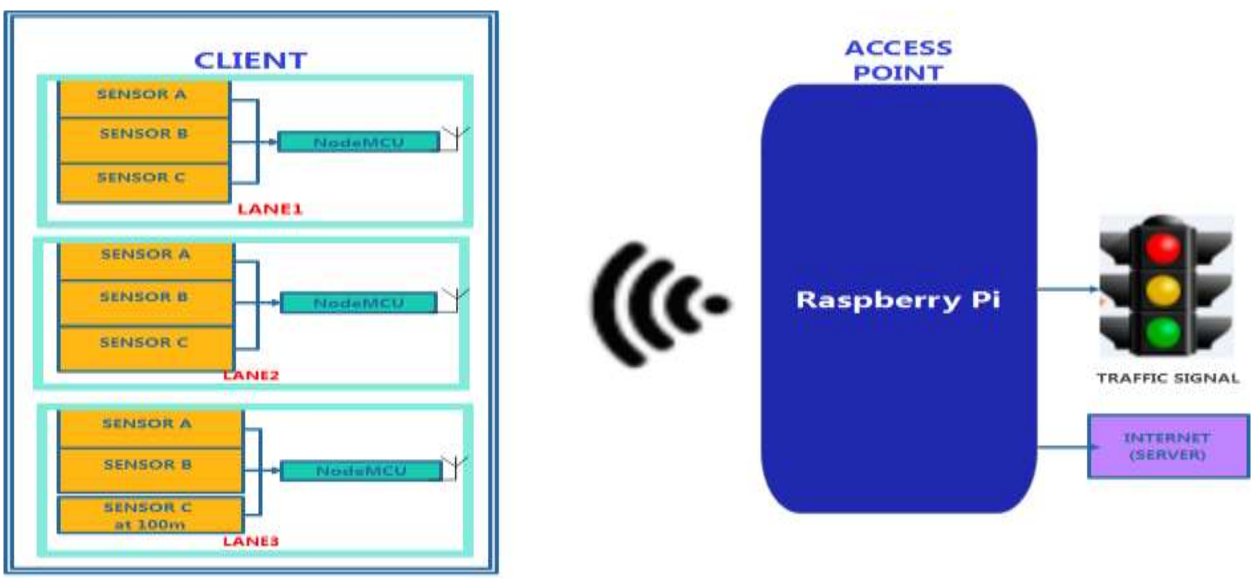

Figure 12 :block diagram

The figure 12 approximately overall architecture of the IoT based intelligent management system. The The system is categorized into two types of modules: hardware and software. In hardware module, utilized ultrasonic sensors (HC-SR04),NodeMCU (ESP8266 12F).

Raspberry Pi, traffic signal, server etc. And in software used arduino ide, xampp, sublime / vc code studio and web server for saving the database.

3.7 System Block Diagram Description

The preliminary analysis and the basic understanding of the working principles of the components the project will be made up with dictate that the system proposes 9 sensors at 3 lane equipped at roadside starting with the traffic signal on the road, first sensors node is kept at (10) meters distance, second sensors node at (50) meters and third sensors node at (100) meters distance, placing them at different distances also helps to detect the presence of a long line of vehicles. Those sensor senses vehicles and determine the traffic level in each lane, allowing traffic levels to be managed. Such levels are low (only first sensor output is high), medium(means that 2nd and 3rd sensors are high) and high (all these sensors will give output which is high) which mounted at the particular distance gap.

Table 4.Traffic density states by 3 ultrasonic sensors

	SENSORS			
CONDITION	**1**	**2**	**3**	**STATUS**
1	1	0	0	**LOW**
2	1	1	0	**MEDIUM**
3	1	1	1	**HIGH**

Each sensor’s reading is 1 or 0(either that particular sensors detects the vehicle or not)

- If only the first sensor output is high, the 'traffic density is low,' and the system is operating normally. As a result, the green light is only turned on for 30 seconds.

- It says 'traffic is medium' if the 2nd and 3rd sensors are both high. The green light will then turn on for 45 seconds.

- When traffic is heavy, all of these sensors will produce a high output, indicating that "traffic density is high," and the green light will turn on for 60 seconds.

Each lane has three ultrasonic sensors which correct data individual and send it to the NodeMCU.NodeMCU will take data from sensor and send it to the local server which is raspberry Pi by using wifi mqtt communication which used mqtt protocol. Every NodeMCU has its own Static IP Address So that We can monitor the devices and their Connections properly. The data from sensors are continuously sent to controller (raspberry Pi) for processing and comparison of traffic congestion levels and a lane with high congestion is assigned a high priority, priority are assigned once every minute and no lane can be assigned more than two consecutive high priorities to serve all the directions of crossing roads. Raspberry Pi is connected with the traffic light. The result from raspberry Pi will be send to the traffic light, when there is a lot of traffic, all of these sensors will provide high output which means those large number of vehicles will give first priority and if a low traffic level is detected, the controller (Raspberry Pi) adjusts the signal timing in that lane, allowing a vehicle to pass in less time. If there is no congestion the system will back to normal traffic light and also the data from this central server will be stored for analysis. Data Analytics will also be performed which will help in future traffic planning and analysis.

Table 5.Traffic density states by 9 ultrasonic sensors

SITUATION	3 SENSORS'S RESULT FOR ROAD 1	3 SENSORS'S RESULT FOR ROAD 2	3 SENSORS'S RESULT FOR ROAD 3	ACTION	THE SEQUENCE OF LANES
	ROAD 1	ROAD 2	ROAD 3		
1	HIGH	HIGH	LOW	PRIORITY given to ROAD 1 AFTER ROAD 2	123
2	HIGH	HIGH	MEDIUM	PRIORITY given to ROAD 1 AFTER ROAD 2	123
3	HIGH	HIGH	HIGH	NORMAL	123
4	HIGH	LOW	LOW	PRIORITY given to ROAD 1	123
5	HIGH	LOW	MEDIUM	PRIORITY given to ROAD 1	132
6	HIGH	LOW	HIGH	PRIORITY given to ROAD 1 AFTER ROAD 3	132
7	HIGH	MEDIUM	LOW	PRIORITY given to ROAD 1	123
8	HIGH	MEDIUM	MEDIUM	PRIORITY given to ROAD 1	123
9	HIGH	MEDIUM	HIGH	PRIORITY given to ROAD 1 AFTER ROAD 3	132
10	MEDIUM	LOW	LOW	PRIORITY given to ROAD 1	123
11	MEDIUM	LOW	MEDIUM	PRIORITY given to LANE 1	132
12	MEDIUM	LOW	HIGH	PRIORITY given to ROAD 3	312
13	MEDIUM	MEDIUM	LOW	PRIORITY given to ROAD 1	123
14	MEDIUM	MEDIUM	MEDIUM	NORMAL	123
15	MEDIUM	MEDIUM	HIGH	PRIORITY given to ROAD 3	312
16	MEDIUM	HIGH	LOW	PRIORITY given to ROAD 2	213
17	MEDIUM	HIGH	MEDIUM	PRIORITY given to ROAD 2	213

18	MEDIUM	HIGH	HIGH	PRIORITY given to ROAD 2 AFTER ROAD 3	231
19	LOW	LOW	LOW	NORMAL	123
20	LOW	LOW	MEDIUM	PRIORITY given to ROAD3	312
21	LOW	LOW	HIGH	PRIORITY given to ROAD 3	312
22	LOW	MEDIUM	LOW	PRIORITY given to ROAD 2	213
23	LOW	MEDIUM	MEDIUM	PRIORITY given to ROAD 2	231
24	LOW	MEDIUM	HIGH	PRIORITY given to ROAD 3	321
25	LOW	HIGH	LOW	PRIORITY given to ROAD 2	213
26	LOW	HIGH	MEDIUM	PRIORITY given to ROAD 2	231
27	LOW	HIGH	HIGH	PRIORITY given to ROAD 2 AFTER ROAD 3	321

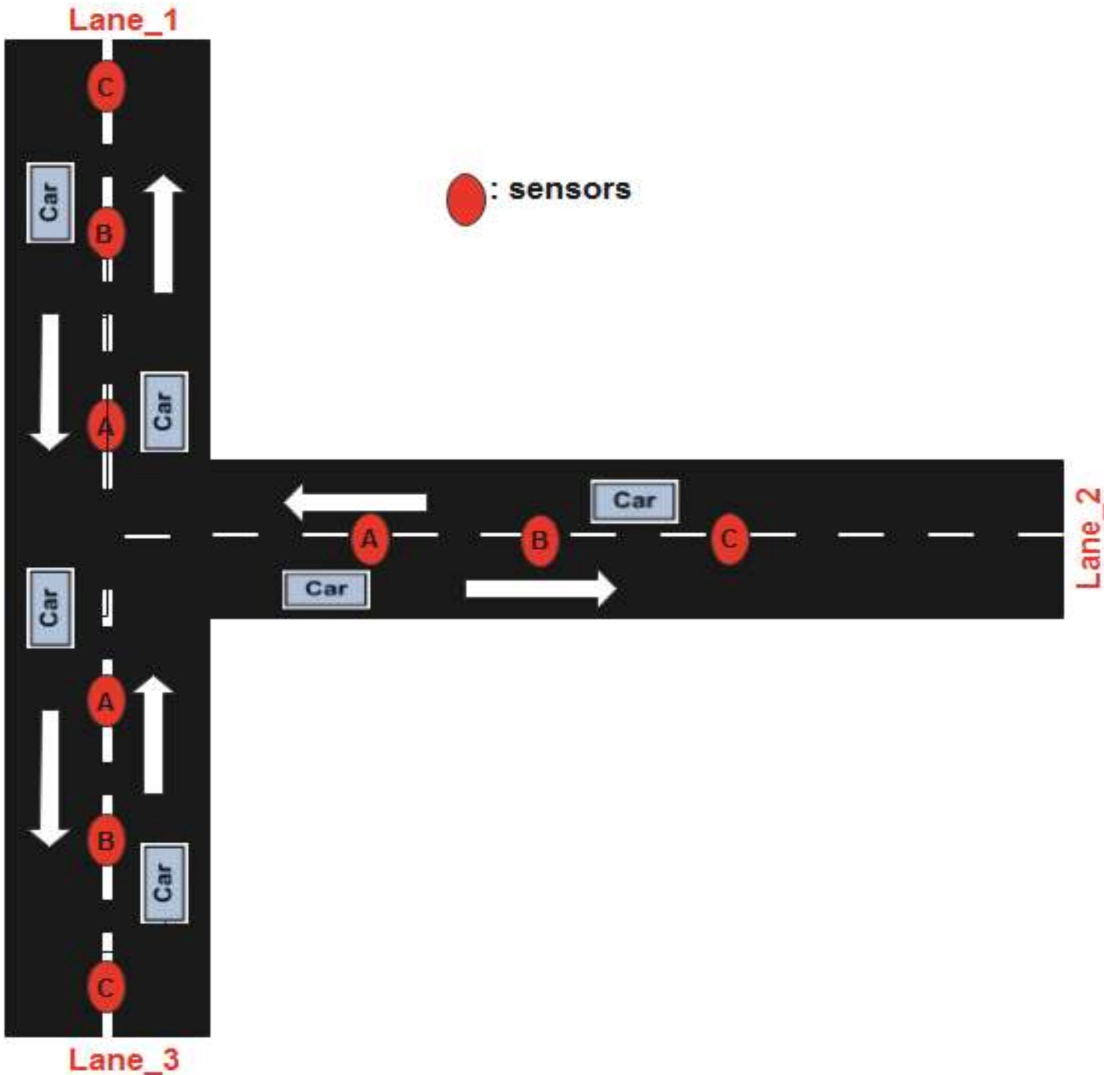

Figure 13: System architecture

Figure 13 is a Design of the system which contains three roads (lane 1, lane2, and lane 3) were equipped with three sensors at a set distance from the traffic signals. A is the first sensor, B is the second, and C is the third. All sensors are place at roadside.

3.9 System Algorithm

The flowchart below shows that there are a number of vehicles on the road which are sensed by the sensors. Here, we have used sensor networks, and the results from those sensor networks are sent to the roadside unit. The roadside unit contains a raspberry pi, and it takes the input from the sensor network for comparing the density from different roads. Congestion measurement is done through the raspberry pi. Then decision-making takes place and check in which road traffic congestion is more, traffic signal time will be adjusted on that road. Time of traffic lights will be reduced for that road so that traffic congestion problem will be reduced. If there is no more vehicles on the road then traffic lights will be the same. All the data from Raspberry are sent to the cloud and that data is displayed on the dashboard.

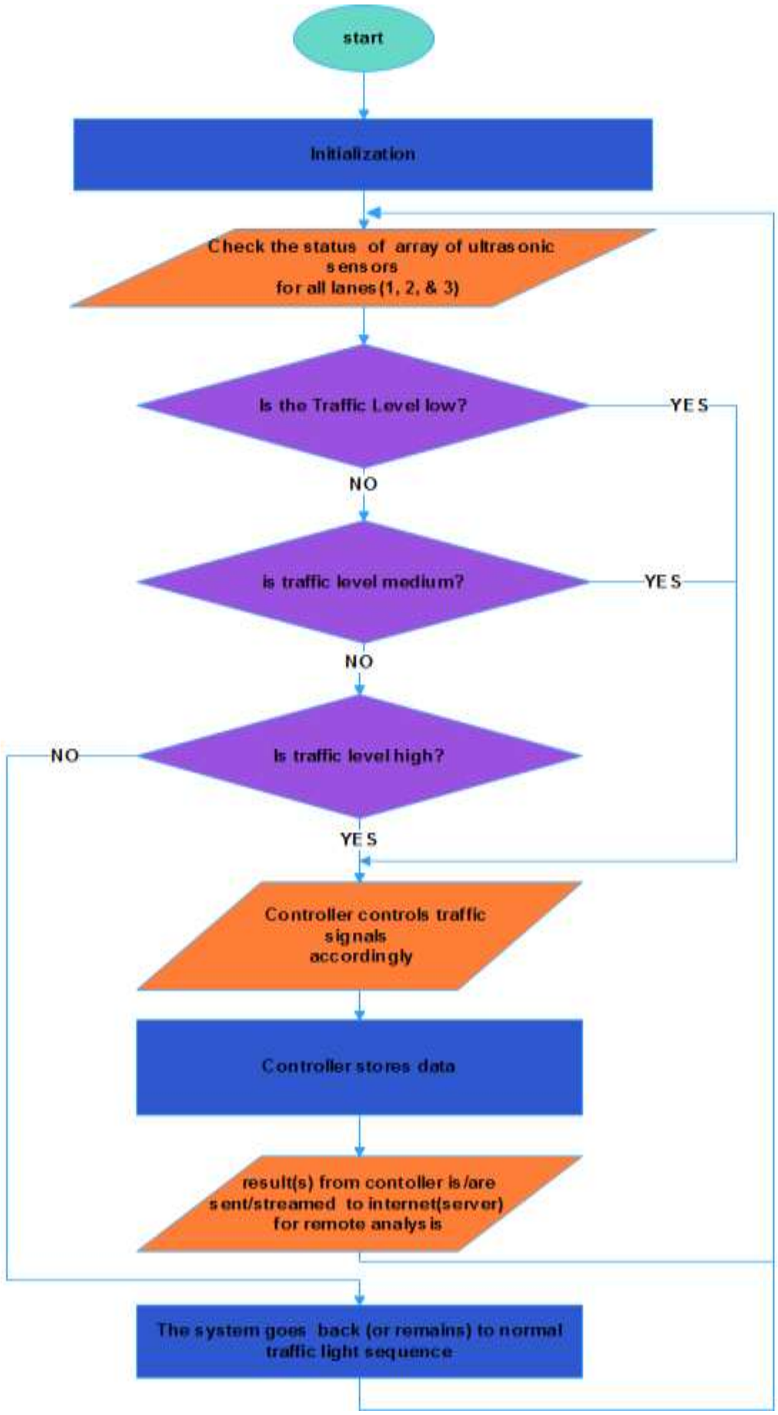

Figure 14: Flow chart

CHAPTER 4: SYSTEM ANALYSIS AND DESIGN

4.1 DESIGN OF THE SYSTEM

4.1.1 Introduction

In this chapter, we present the designed IoT based intelligent traffic management system. How it works. The developed hardware equivalent circuit, software program and also a brief explanation about the circuit used.

4.1.2 IoT architecture

In the context of internet of things, the architecture is a framework that defined the physical components, the functional organization and configuration of the network ,operational procedures and the data formats to be used [20].To design the IoT based intelligent traffic management system the IoT architecture model was adopted.

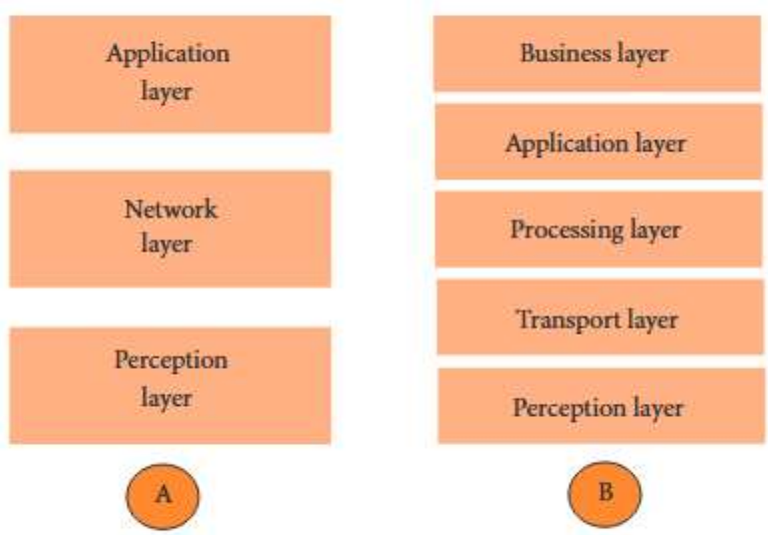

Figure 15 : Architecture of IoT (A: three layers) (B: five layers)

4.1.3 Three-Layer and five layer architectures.

Three layer constructions as seen in figure 15, is the most basic [21–23]. It was firs employed in the early stages of study in this sector. Perception, network, and application are the three layers that make up this system.

i) The perception layer is a physical layer, which has sensors for detecting and gathering information about environment. It. recognizes other smart things in the proximity or senses certain physical variables.

(ii) The network layer is in charge of connecting other smart things, network devices, and serves. Its capabilities are also used for sensor data transfer and processing.

(iii) The application layer is responsible for providing application specific services to the user. It discusses a variety of Internet of things applications, including smart homes, smart cities, and smart health. Perception, transport processing, application, and business are five levels (see Figure 15 B).The perception and application levels provide the same purpose as the three layer design. The remaining three levels' functions are listed below.

(i) The perception layer sends sensor data to the processing layer via transport layer. Other wireless and/or wired technologies that could be used include UTP-LAN, Bluetooth, RFID, WiFi, NFC, and others. [24].

(ii) The processing layer is also known as the middleware layer. It stores, analyzes, and processes massive amounts of data from the transport layer. The processing may employ various storage and computing models and technologies, such as cloud computing, web services, big data, database system, etc. [24].

The processing layer is also known as the middleware layer. It stores, analyzes, and processes massive amounts of data from the transport layer. The processing may employ various storage and computing models and technologies, such as cloud computing, web services, big data, database systems, etc. [24].

(iii) The business layer is in charge of the entire IoT system, including apps, business and profit models, and the privacy of users.

4.1.4 IoT based intelligent traffic management system Three Layered Architecture

According to the above mentioned Internet of Things design, the intelligent traffic management system based on the internet of things uses three-layer architecture, with the following three-layer distribution:

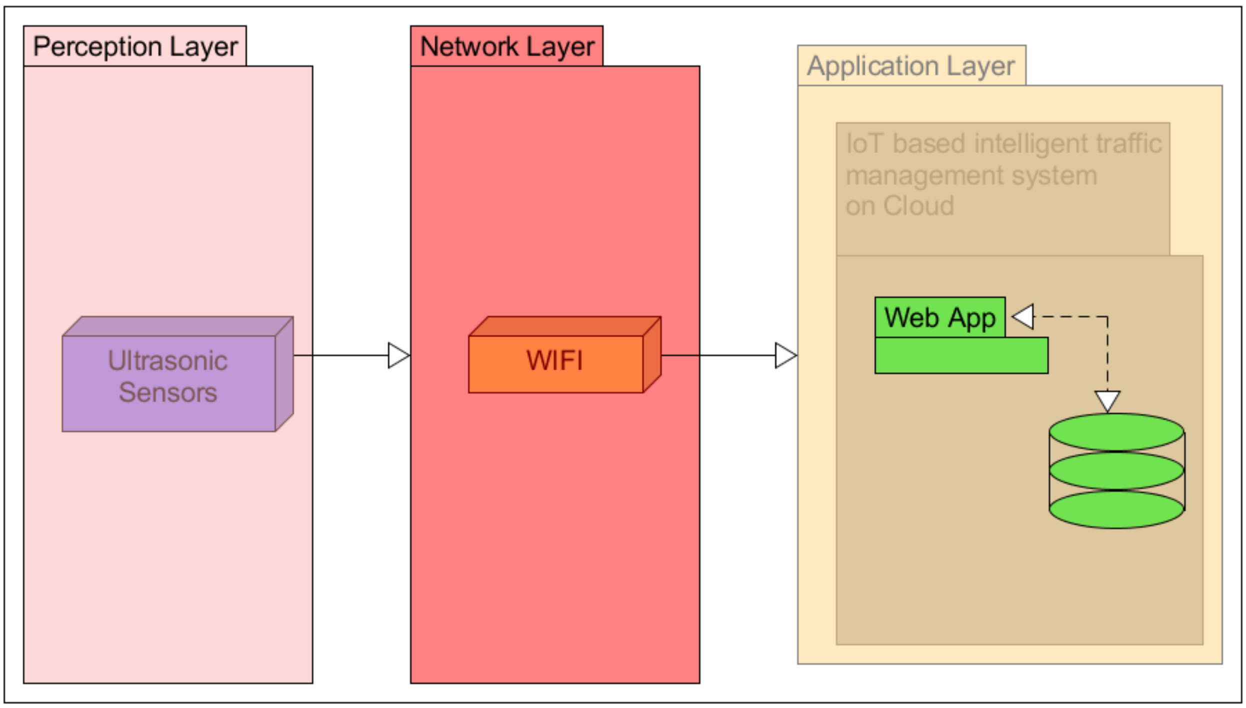

Figure 16: IBITMS Three layered architecture

4.1.5 The IBITMS System Components Model

The IBITMS System Components Model is composed of 4 main components IoT component, Admin component, traffic signal and Cloud component.

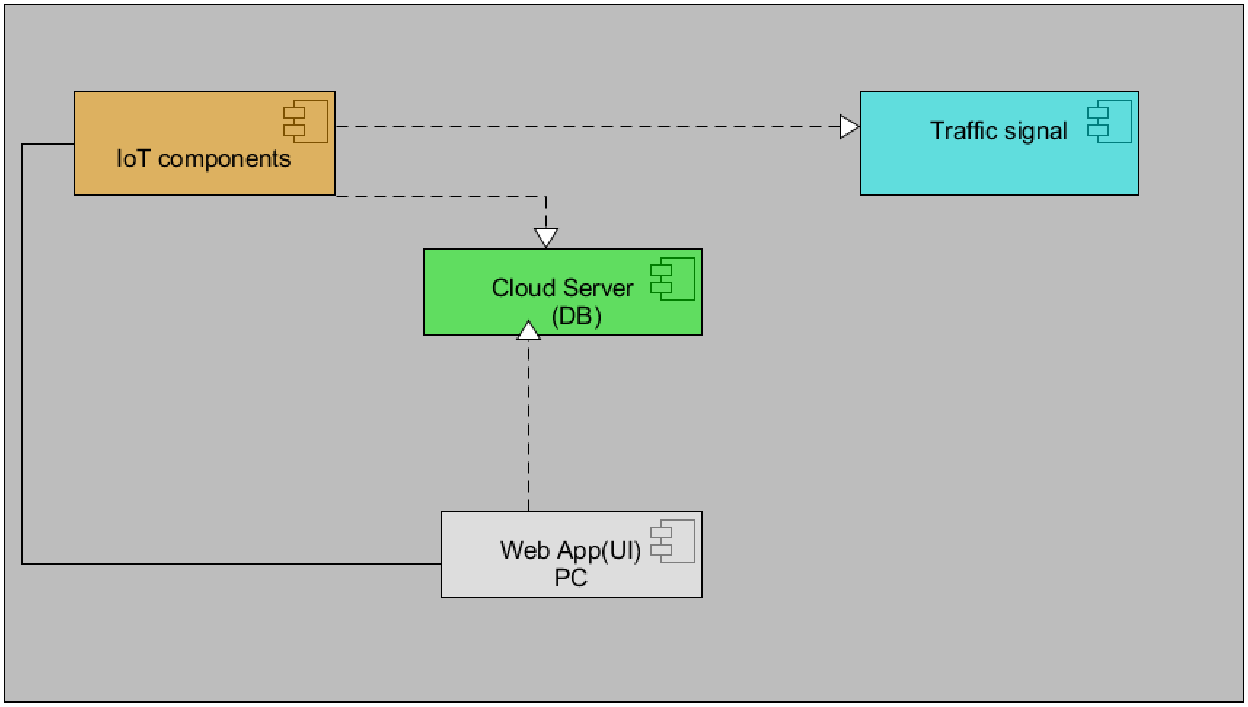

Figure 17: IBITMS System Components diagram

4.1.5.1 The IBITMS System Components Model description

1.IoT Components: this part consists of different modules with different technologies which are interconnected together to perform the main goal of this research. Raspberry pi is used as control unit, nine ultrasonic sensors used to sense traffic density at the road, and wifi module used as communication module to link the IoT components with the cloud server

2. Traffic signal: A traffic light controls vehicle traffic at the intersection of three routes, indicating whether automobiles should proceed, slow down, or stop.

3. Admin component: Web App and person computer or smart phone: This component consists of a web application interface which helps the admin to manage and monitor the system for prediction analysis. It allows the admin:

- To manage traffic on the roads
- To generate a reports

4. Cloud Component: Web server and Database server: Data engine of the system from cloud services such as data storage, security, privacy and execution of instruction

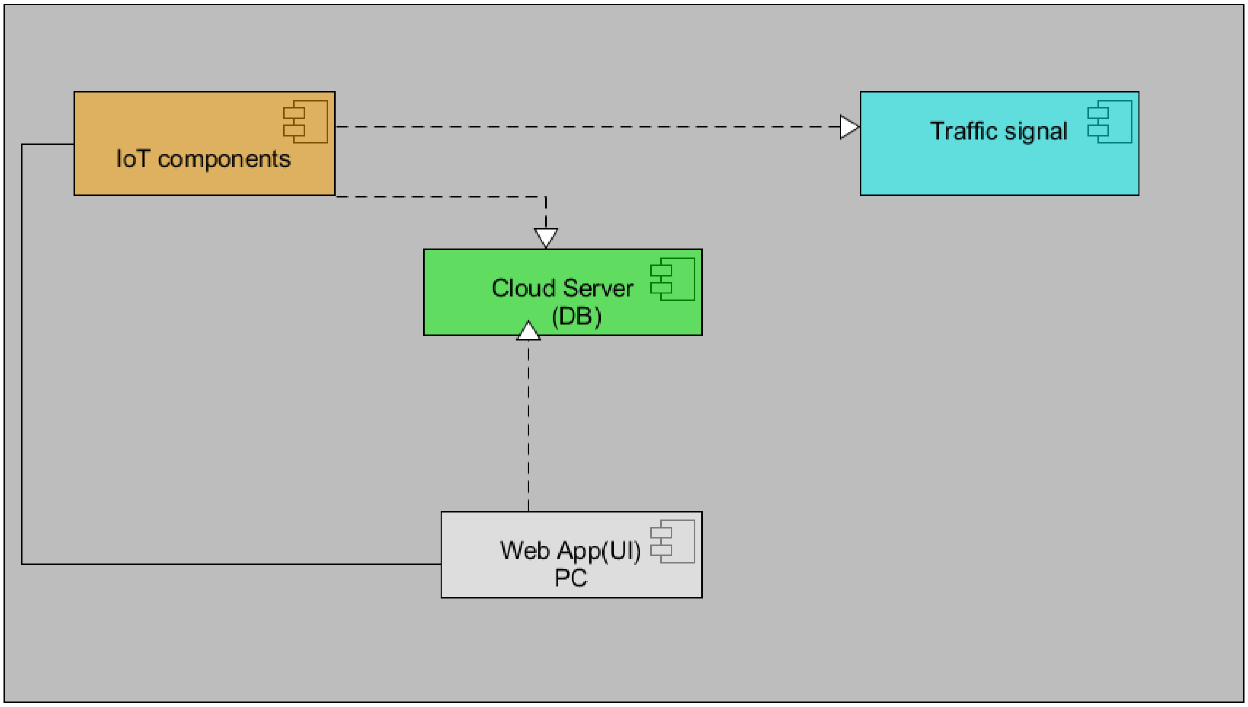

Figure 18 : IBITMS System Components diagram

4.1.6 IBITMS Layered Architecture Design Pattern

An architectural style is a set of ideas or a coarse grained pattern that provides an abstract foundation for a family of system. Architectural style describes deployment patterns, structure and design issues and communication factors [24]. In terms of structure, the IBITMS is a layered style architecture that focuses on the software's structural configuration, such as features. This means that every data request should be checked before being granted access to the data.

In terms of deployment, the layered IBITMS architecture is housed in N-tiers on the cloud and communicates with sensors through the internet.

IBITMS architecture is classified as a service-oriented architecture (SOA) application. Through the use of a communication protocol, application components provide services to other components through a network. In terms of communication, the IBITMS architecture employs a variety of protocols for data transmission.

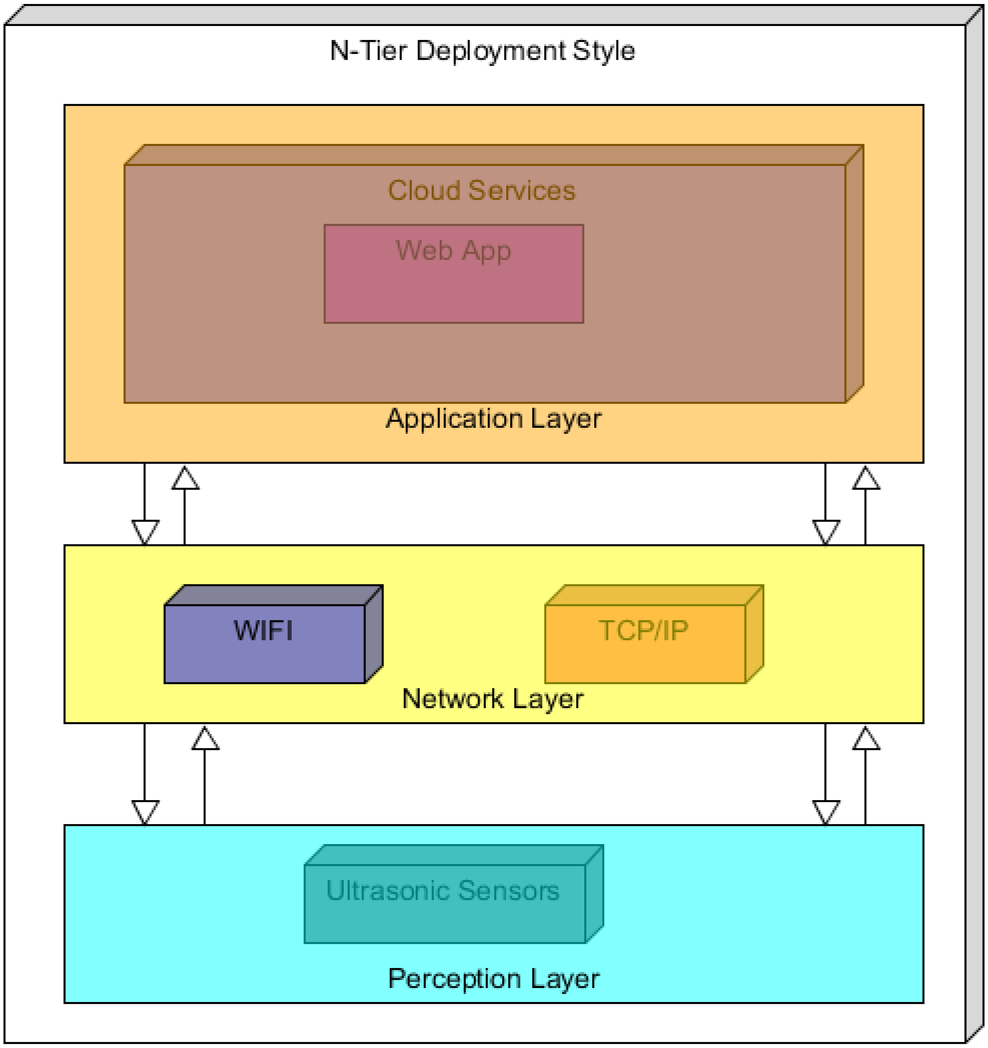

Figure 19 : N-Tier Deployment style

Specifically, the above architectural style defines the vocabulary of components and connections that can be used in instances of that architectural style, as well as a set of limits on how they can be combined. [25].Each layer's component communicates with other levels' components via well defined interfaces.

IBITMS adopted the layered architecture style due to its benefits:

- **Abstraction**: Layers enable changes to be done at the abstract level.
- **Isolation:** Allows technological changes to be isolated to particular layers, reducing risk and influence on the whole system.

- **Manageability:** Separating core concerns makes it easy to discover dependencies and breaks down the code into smaller sections.
- **Performance:** Scalability, fault tolerance, and performance can all be improved by spreading the layers across numerous physical tiers.
- **Reusability**: Roles help with reusability.
- **Testability:** This is attained as a result of decomposability Component-Based

4.1.7 IBITMS System deployment model

The transfer of support and maintenance obligations to the post deployment support organization, as well as the migration of capacity to the eventual end-user, are all part of the system deployment process. The UML This model uses a deployment diagram to illustrate a system's execution architecture, which comprises nodes like hardware or software execution environments, as well as the middleware that connects them. The actual hardware and software of a system are typically depicted using deployment diagrams.

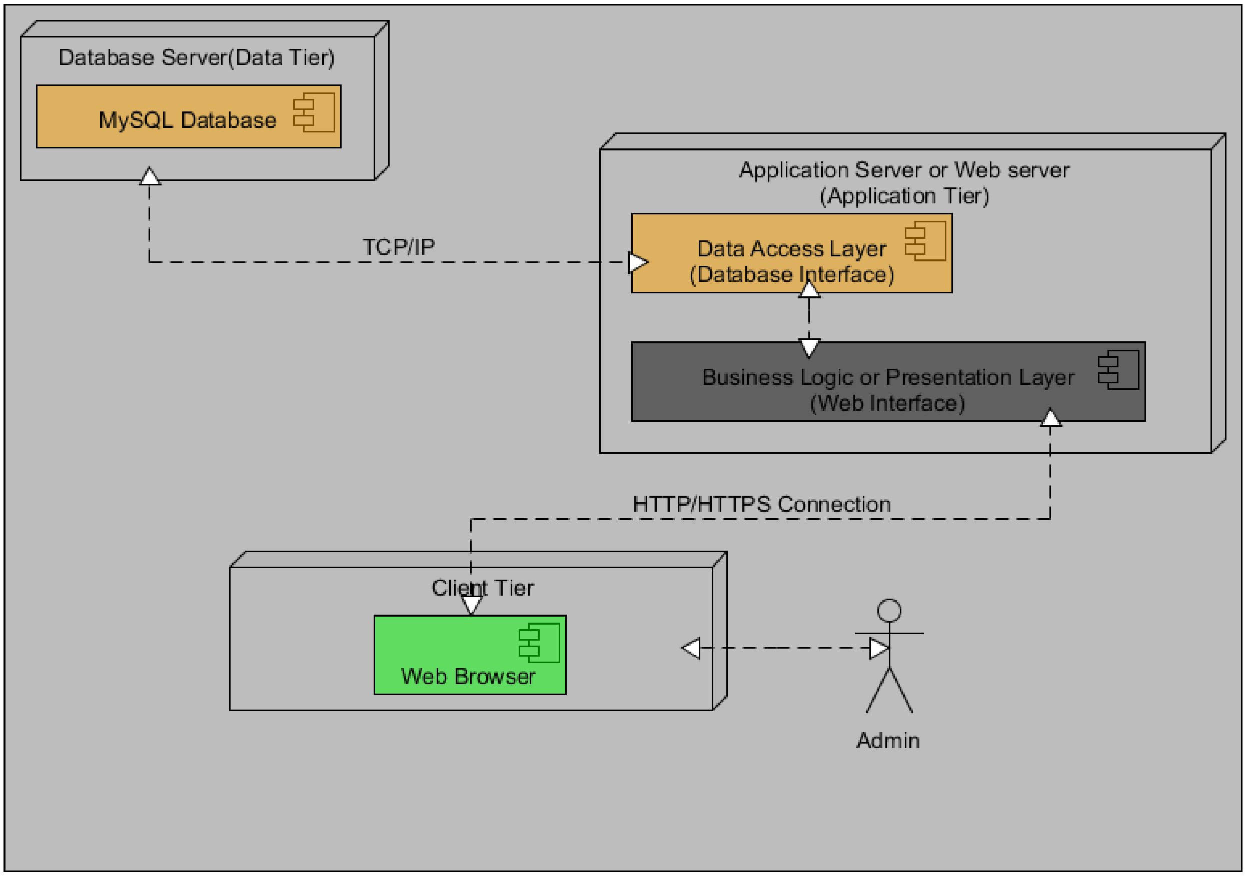

Figure 20 : System deployment diagram

4.1.8 IBITMS System use case diagram

A use case diagrams show how a user might interact with a program visually. The system's numerous use cases and various types of users are depicted in a use case diagram. The use cases are represented by circles or ellipses.

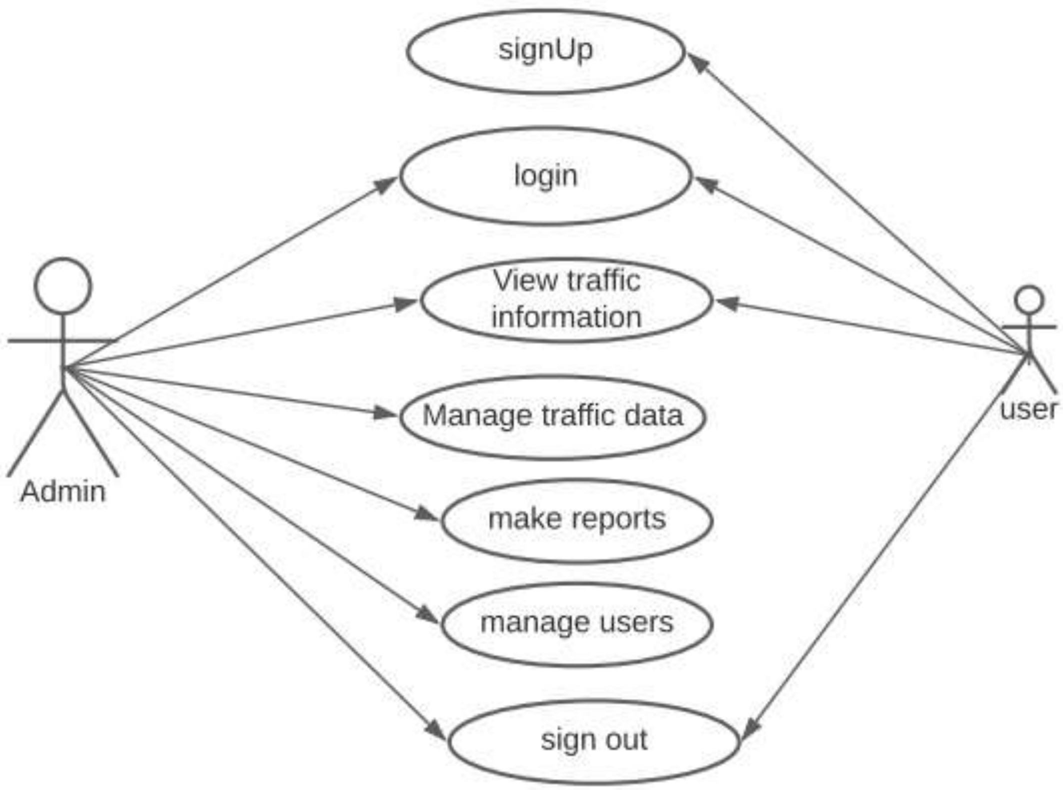

Figure 21 : IBITMS Use Case Diagram

4.1.9 IBITMS Database Model

An entity relationship diagram (ERD),often called an entity relationship model, is a graphical depiction of relationship between people ,objects, places ,concepts, or events in an information technology (IT) system Data flow diagrams (DFDs), which depict the flow of information via processes or systems, are often used in conjunction with ER diagrams.

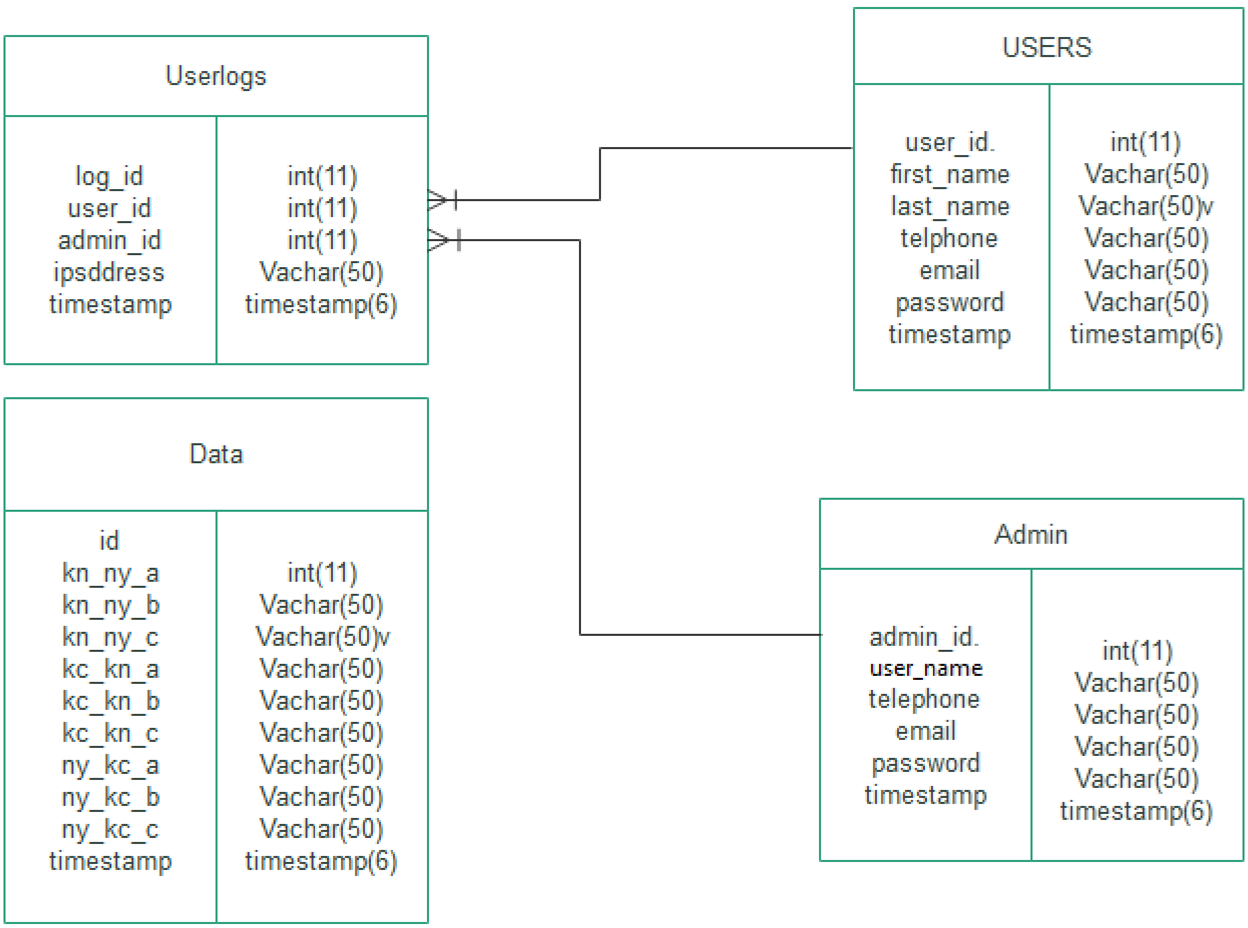

Figure 22: Database Model diagram

4.2 Prototype circuit diagram

A circuit diagram is a visual display of an electrical circuit using either basic images of parts or industry-standard symbols[26].This circuit diagram shows how all the devices come together and provide the same solution to reduce traffic congestion which is the goal of this project.

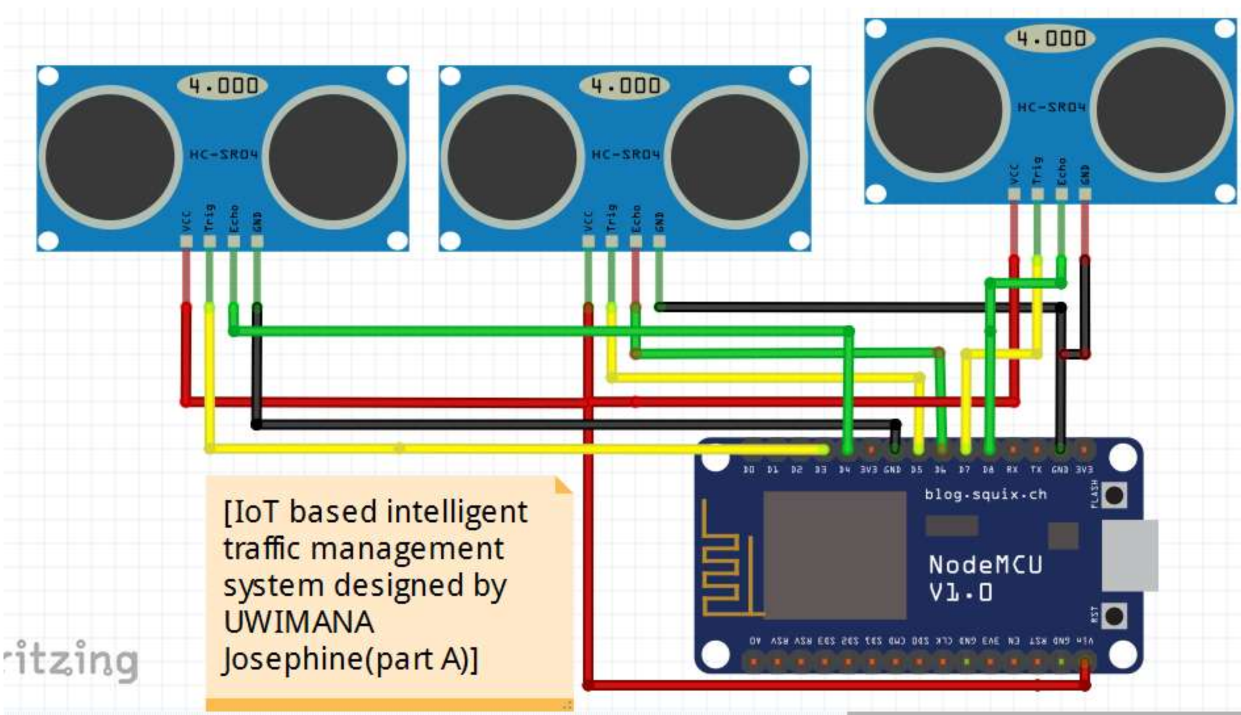

Figure 23: circuit diagramme part A

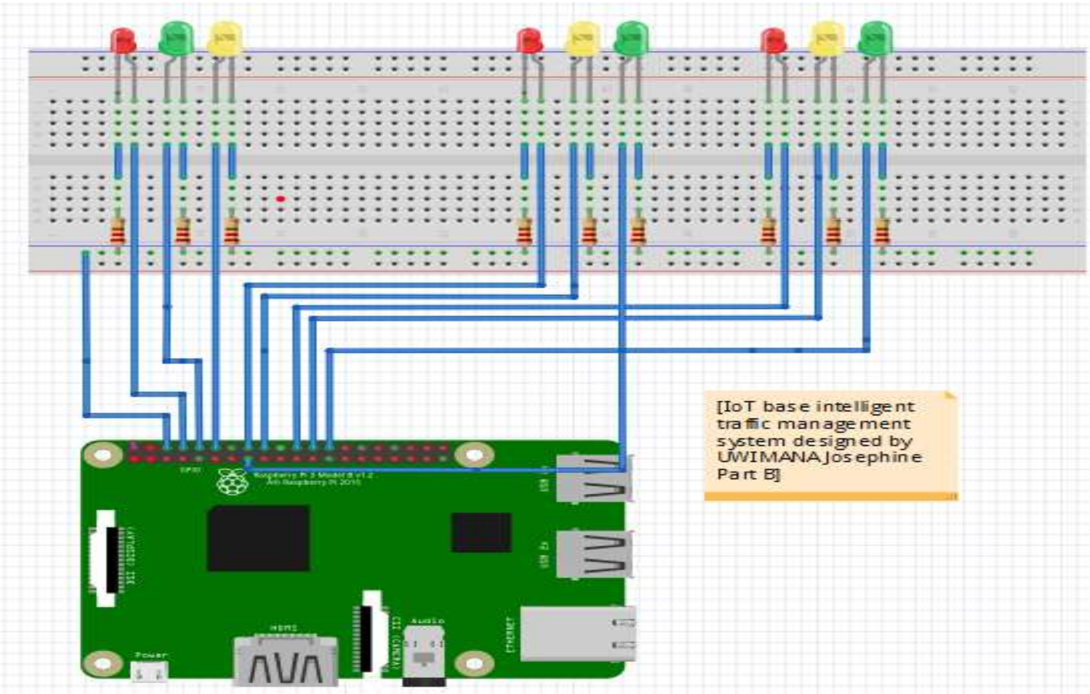

Figure 24 : circuit diagram part B

Figure 25.prototype of IBITMS

CHAPTER 5: RESULT AND ANALYSIS

After designing of the full circuit, I implemented the circuit. I did test of my prototype to check that if it is working. In addition, a web interface was created enabling the authorities to display traffic statistics data on the roads.

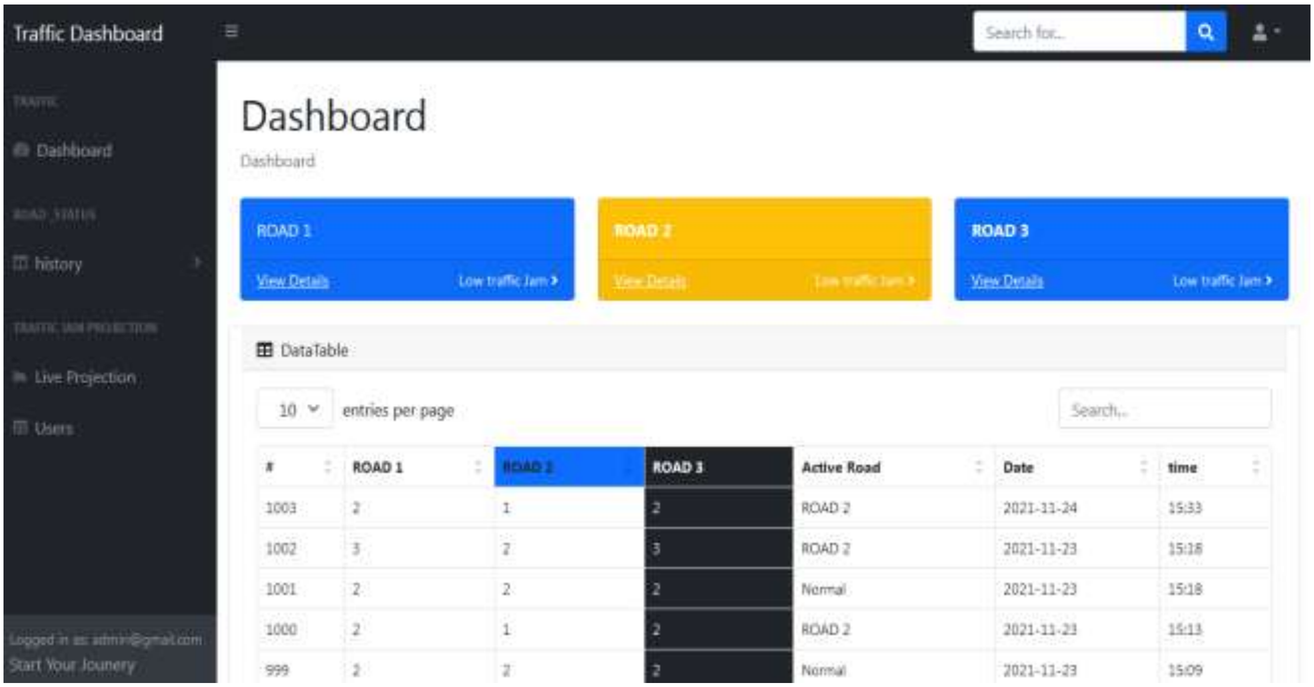

Figure 26.The statistical results obtained on dashboard after testing

As shown in figure 26, the road with the highest jam will be the first on the dashboard to be recorded as 1. The next one has a medium jam, which means that the 2 sensors at different distances are high in the dashboard, is recorded as 2, and then the road with the low jam means that the first sensor is the only one that comes up and writes 3 on the dashboard. When all the roads are high at the same time the system works as normal as the normal system does; no priority is given as long as it is low and medium. How these priorities are presented is reflected in the active road. All this data is coming from Raspberry pi to this dashboard.

Analysis of traffic jam dataset provides histogram representation of 3 choices in using 3 roads as follow:

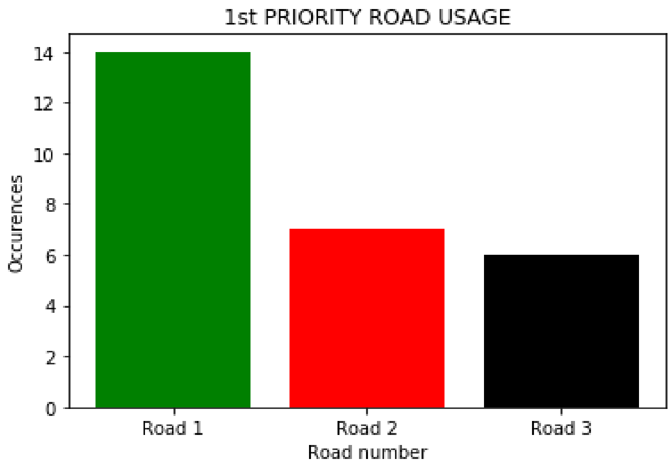

Figure 27. Roads priorities in the first choice

Figure 27 shows the usage of the 3 roads for the very first choice among the other two remaining priorities. Road 1 has occurred 14 times, road 2 with 7, and road 3 with 6 times. This means that the usage of the first road in the first choice is nearly 2 times of one of the remaining roads (road 2 or road 3). The usage of road 2 and road 3 are equally balanced in the first priority.

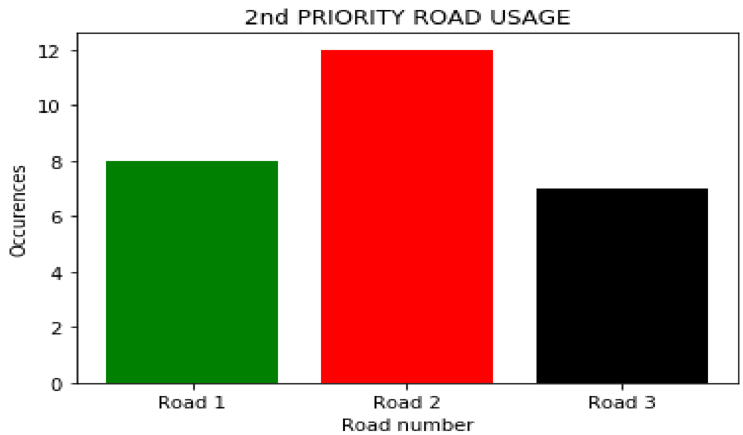

Figure 28.Road which has second priority

Similarly, Figure 28 shows the usage of the 3 roads in providing priorities for the second option. Road 2 with 12 occurrences, Road 2 with 8 occurrences, and Road 3 with 7 occurrences.

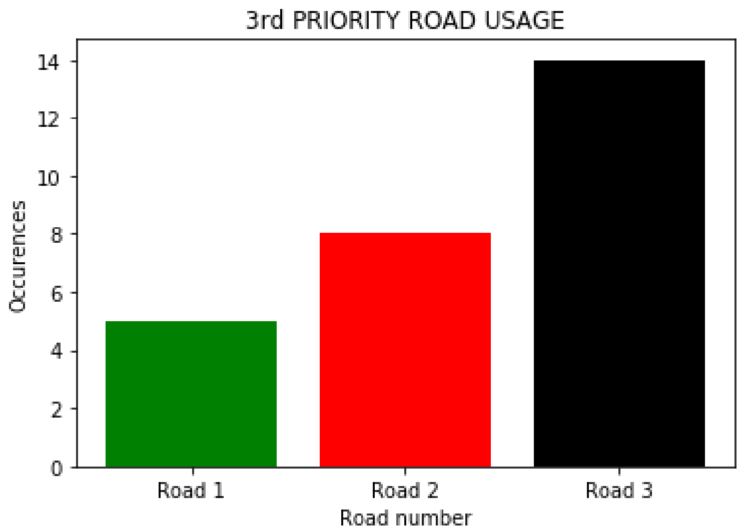

Figure 29.Road which has third priority

Figure 29 represents occurrences of the 3 roads. Road 1 with 5 occurrences, Road 2 with 8 occurrences, Road 3 with 14 occurrences.

CHAPTER 6: CONCLUSION AND RECOMANDATION

6.1 CONCLUSION

This research was IoT based traffic management system where the system used Raspberry for controlling traffic signal. The proposed system does the time management of the normal signal lights while reducing the traffic congestion problem. The system has shown success in the prototype implementation but it can be implemented in other 3 directions roads. For more than 3 directions roads, the sensors need to be increased and other hardware resources as well.

The results obtained are presented and full discussed. After carrying out the necessary test, it was observed that the aim of the work was achieved.But it was hard to access the infrastructure of the roads to allow the control of the jam for extensive time duration.The traffic signals blink in response to the amount of traffic in the lane, and the system also regulates traffic when congestion occurs by prioritizing the road with more vehicles.

Depending on where traffic signals are placed, this project could be very valuable in the future for putting the project's idea into real-life practice. To believes that this may bring more powerful solution than the existing system.

6.2 RECOMMENDATION

Based on the Design and implement IoT based intelligent traffic management system, I have been experiencing a great deal of opportunities and challenge during this process, I give the following recommendations:

- To the department of ACEIoT should set up a laboratory of IoT components equipped with enough equipments ranging from integrated circuits to computer simulation strictly reserved for final year students doing their research projects. To students should do small project in this areas from the second cohort to familiarize themselves with practical so as to acquire as much knowledge as possible from school instead of just doing project on final stage.
- I recommend, who want to improve my project to use other Raspberry pi which has high speed to process data from multiple nodes without taking much time

- The testing of the project had to be performed with prototype and with very few practical examples; therefore we are recommending a fully practical implementation of the system.
- I recommend UR especially in ACEIoT department to focus more on programming in order to increase the knowledge of students.
- I recommend, who want to use this device to use GPRS for sending data from Raspberry to web server and to put batteries or an uninterruptible power supply (UPS) on the system, so the system can work even when there is no electricity.
- According to the future projections which have been made showing that more traffic congestions are to be expected if no appropriate measures are taken, I recommend to our government to use this system in helping to solve traffic congestion.

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Appendix

ARDUINO CODE

```
#include <ESP8266WiFi.h>
#include "ESPAsyncWebServer.h"

#include <ESP8266WiFi.h>
#include <ESP8266HTTPClient.h>
#include <WiFiClient.h>
#include <Wire.h>
#include <Adafruit_GFX.h>
#include <Adafruit_SSD1306.h>

#include <ESP8266WiFiMulti.h>
ESP8266WiFiMulti WiFiMulti;

const char* ssid = "Anti";
const char* password = "123456789";
AsyncWebServer server(80);

unsigned long previousMillis = 0;
const long interval = 5000;
String temp2="122";

String load ="34";
int a;
int b;
int c;
long duration, distance,duration2, distance2,duration3, distance3;
#define TRIGGERPIN D4
#define ECHOPIN  D5
#define TRIGGERPIN3 D3
```

PAYTHON CODE

In [ ]:
```
import pandas as pd
import numpy as np
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LinearRegression
from sklearn.metrics import r2_score,mean_squared_error
from sklearn.tree import DecisionTreeRegressor
from sklearn.neighbors import KNeighborsRegressor
from sklearn.preprocessing import PolynomialFeatures
import datetime
import matplotlib.pyplot as plt
%matplotlib inline
from sklearn.ensemble import RandomForestRegressor
from sklearn.datasets import make_regression
```

In [ ]:
```
df_road=pd.read_excel('C:/Users/Admin/Desktop/FINA_MODEL.xls')
df_road.head()
```

In [38]:
```
df_road=df_road.drop(columns=['Situation','ACTION','The sequence of roads'])
```

n [125]:
```
df_road.head()
```

ut[125]:

	ROAD 1	ROAD 2	ROAD 3	1st choice	2nd choice	3rd choice
0	HIGH	HIGH	LOW	1	2	3
1	HIGH	HIGH	MEDIUM	1	2	3
2	HIGH	HIGH	HIGH	1	2	3
3	HIGH	HIGH	LOW	1	2	3
4	HIGH	HIGH	MEDIUM	1	3	2

USER MANUAL

- Placement of the sensors to the corresponding place
- Link all the sensors with NodeMCU
- Deploying traffic light and network
- Verify that raspberry pi receive the data
- Verify that the data from raspberry pi is reached to dashboard