SMART TRAFFIC MANAGEMENT SYSTEM USING INTERNET OF THINGS (IoT)

Final Year Project report submitted

Abbreviations

IoT	**I**nternet of **T**hings
IR	**I**nfra **R**ed
LED	**L**ight **E**mitting **D**iode
WiFi	**W**ireless **F**idelity
WSN	**W**ireless **S**ensor **N**etwork
NFC	**N**ear **F**ield **C**ommunication
ITS	**I**ntelligent **T**ransportation **S**ystem

Chapter 1

INTRODUCTION

1.1 Hypothesis

A smart traffic management system utilizing sensor data, communication and automated algorithms is to be developed to keep traffic flowing more smoothly. The aim is to optimally control the duration of green or red light for a specific traffic light at an intersection. The traffic signals should not flash the same stretch of green or red all the time, but should depend on the number of cars present. When traffic is heavy in one direction, the green lights should stay on longer; less traffic should mean the red lights should be on for longer time interval. This solution is expected to eliminate inefficiencies at intersections and minimize the cost of commuting and pollution.

1.2 Motivation

In 2014, 54% of the total global population was urban residents. The prediction was a growth of nearly 2% each year until 2020 leading to more pressure on the transportation system of cities. Additionally, the high cost of accommodation in business districts lead to urban employees living far away from their place of work/education and therefore having to commute back and forth between their place of residence and their place of work. More vehicles moving need to be accommodated over a fixed number of roads and transportation infrastructure. Often, when dealing with increased traffic, the reaction is just widen the lanes or increase the road levels. However, cities should be making their streets run smarter instead of just making them bigger or building more roads. This leads to the proposed system which will use a micro controller and sensors for tracking the number of vehicles leading to time based monitoring of the system.(Babu, 2016)(Zantout, 2017)

Chapter 2

LITERATURE REVIEW

2.1 About IoT

The Internet of Things (IoT), also sometimes referred to as the Internet of Everything (IoE), consists of all the web-enabled devices that collect, send and act on data they acquire from their surrounding environments using embedded sensors,processors and communication hardware. These devices, often called "connected" or "smart" devices, can sometimes talk to other related devices, a process called machine-to-machine(M2M) communication, and act on the information they get from one another. Humans can interact with the gadgets to set them up, give them instructions or access the data, but the devices do most of the work on their own without human intervention. Their existence has been made possible by all the tiny mobile components that are available these days, as well as the always-online nature of our home and business networks. Connected devices also generate massive amounts of Internet traffic, including loads of data that can be used to make the devices useful, but can also be mined for other purposes. All this new data, and the Internet-accessible nature of the devices, raises both privacy and security concerns. But this technology allows for a level of real-time information that we have never had before. We can monitor our homes and families remotely to keep them safe. Businesses can improve processes to increase productivity and reduce material waste and unforeseen downtime. Sensors in city infrastructure can help reduce road congestion and warn us when infrastructure is in danger of crumbling. Gadgets out in the open can monitor for changing environmental conditions and warn us of impending disasters.

2.2 Advantages and Disadvantages of IoT

2.2.1 Advantages

Communication: IoT encourages the communication between devices, also famously known as Machine-to-Machine (M2M) communication. Because of this, the physical devices are able to stay connected and hence the total transparency is available with lesser inefficiencies and greater quality.

Automation and Control: Due to physical objects getting connected and controlled digitally and centrally with wireless infrastructure, there is a large amount of automation and control in the workings. Without human intervention, the machines are able to communicate with each other leading to faster and timely output.

Information: It is obvious that having more information helps making better decisions. Whether it is mundane decisions as needing to know what to buy at the grocery store or if your company has enough widgets and supplies, knowledge is power and more knowledge is better.

Monitor: The second most obvious advantage of IoT is monitoring. Knowing the exact quantity of supplies or the air quality in your home, can further provide more information that could not have previously been collected easily. For instance, knowing that you are low on milk or printer ink could save you another trip to the store in the near future. Furthermore, monitoring the expiration of products can and will improve safety.

Time: As hinted in the previous examples, the amount of time saved because of IoT could be quite large. And in today's modern life, we all could use more time.

Money: The biggest advantage of IoT is saving money. If the price of the tagging and monitoring equipment is less than the amount of money saved, then the Internet of Things will be very widely adopted. IoT fundamentally proves to be very helpful to people in their daily routines by making the appliances communicate to each other in an effective manner thereby saving and conserving energy and cost. Allowing the data to be communicated and shared between devices and then translating it into our required way, it makes our systems efficient.

Efficient and Saves Time: The machine-to-machine interaction provides better efficiency, hence; accurate results can be obtained fast. This results in saving valuable time. Instead of repeating the same tasks every day, it enables people to do other creative jobs.

Better Quality of Life: All the applications of this technology culminate in increased comfort, convenience, and better management, thereby improving the quality of life.

2.2.2 Disadvantages

Compatibility: Currently, there is no international standard of compatibility for the tagging and monitoring equipment. I believe this disadvantage is the most easy to overcome. The manufacturing companies of these equipment just need to agree to a standard, such as Bluetooth, USB, etc. This is nothing new or innovative needed.

Complexity: As with all complex systems, there are more opportunities of failure. With the Internet of Things, failures could sky rocket. For instance, let's say that both you and your spouse each get a message saying that your milk has expired, and both of you stop at a store on your way home, and you both purchase milk. As a result, you and your spouse have purchased twice the amount that you both need. Or maybe a bug in the software ends up automatically ordering a new ink cartridge for your printer each and every hour for a few days, or at least after each power failure, when you only need a single replacement.

Privacy/Security: With all of this IoT data being transmitted, the risk of losing privacy increases. For instance, how well encrypted will the data be kept and transmitted with? Do you want your neighbors or employers to know what medications that you are taking or your financial situation? Safety: As all the household appliances, industrial machinery, public sector services like water supply and transport, and many other devices all are connected to the Internet, a lot of information is available on it. This information is prone to attack by hackers. It would be very disastrous if private and confidential information is accessed by unauthorized intruders.

Lesser Employment of Manpower: The unskilled workers and helpers may end up losing their jobs in the effect of automation of daily activities. This can lead to unemployment issues in the society. This is a problem with the advent of any technology and can be overcome with education. With daily activities getting automated, naturally, there will be fewer requirements of human resources, primarily, workers and less educated staff. This may create Unemployment issue in the society.

2.3 IoT in Traffic Management

Traffic management is one of the biggest infrastructure hurdles faced by developing countries today. Developed countries and smart cities are already using IoT and to their advantage to minimize issues related to traffic. The culture of the car has been cultivated speedily among people in all types of nations. In most cities, it is common for people to prefer riding their own vehicles no matter how good or bad the public transportation is or considering how much time and money is it going to take for them to reach their destination.

Chapter 3

REQUIREMENTS

3.1 Hardware Components

1. Microcontroller (Arduino Mega 2560): The Arduino Mega 2560 is a microcontroller board based on the Atmega 2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Mega 2560 board is compatible with most shields designed for the Uno and the former boards Duemilanove or Diecimila.

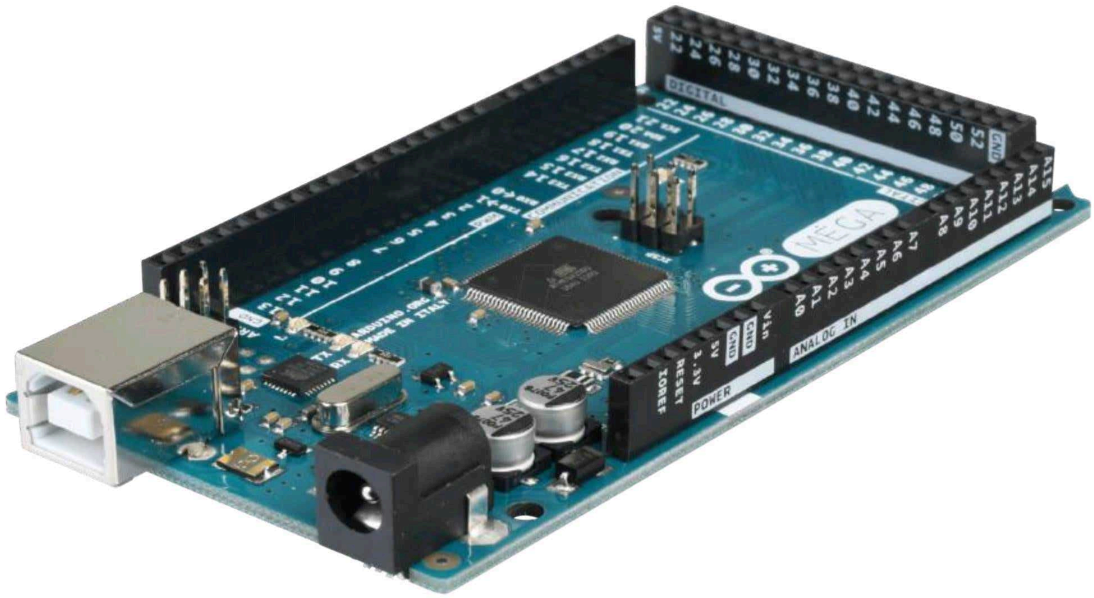

FIGURE 3.1: Arduino Mega 2560.

2. Microcontroller (Arduino Uno): The Arduino UNO is an open-source microcontroller board based on the Microchip ATmega328Pmicrocontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 Digital pins, 6 Analog pins, and programmable with the Arduino IDE (Integrated Development Environment) via a type B USB cable.

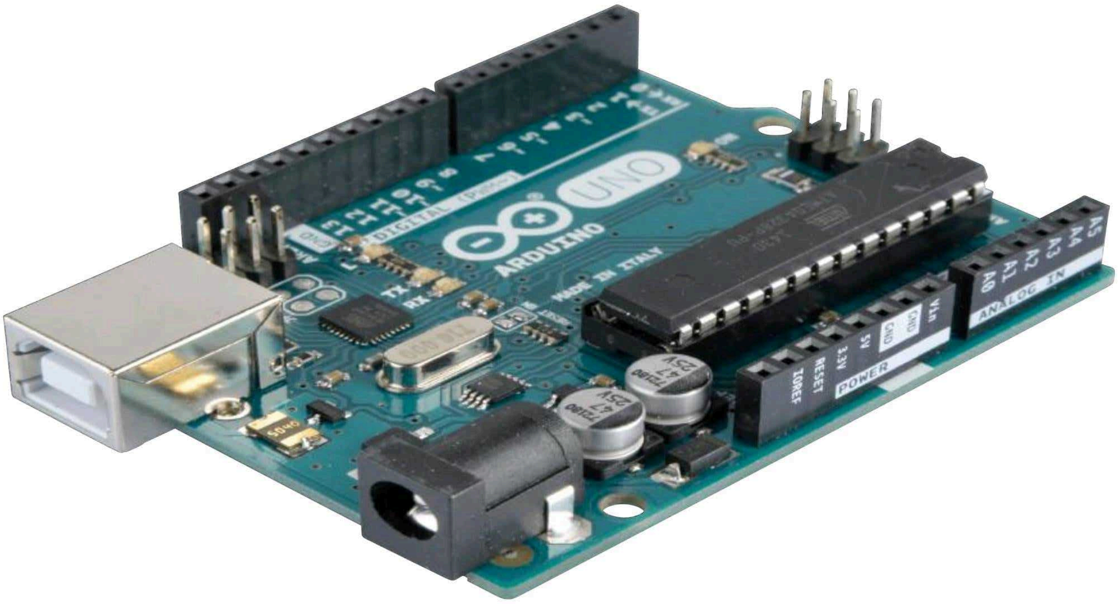

Figure 3.2: Arduino Uno.

3. LEDs: LEDs are used for the purpose of signaling according to the traffic condition.

Figure 3.3: LED for Traffic Lights.

4. IR Sensor: IR Sensor is used to count the vehicles on the road.

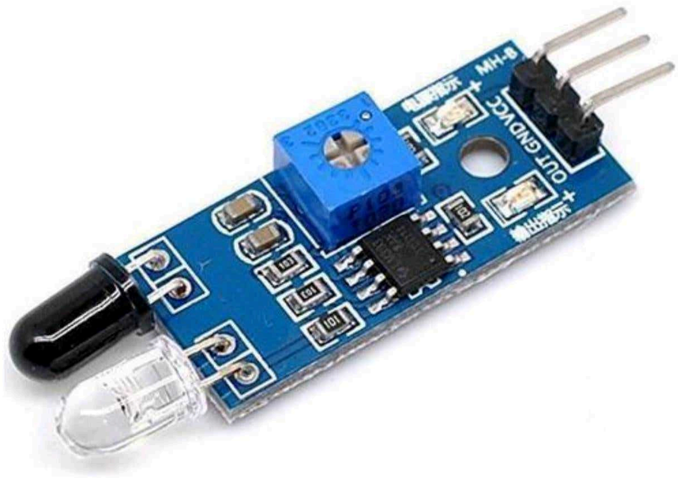

FIGURE 3.4: IR Sensors.

5. Jumper Wires: It is used to connect the components to each other.

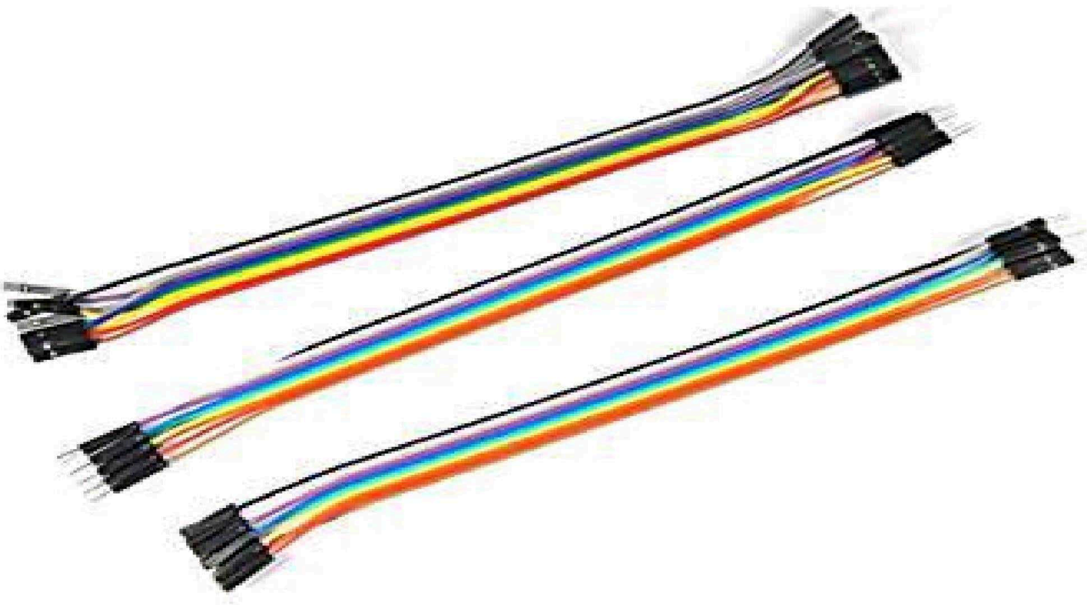

FIGURE 3.5: Jumper Wires.

3.2 Software Requirement

1. Arduino IDE: The Arduino integrated development environment (IDE) is a cross-platform application (for Windows, MacOS, Linux) that is written in the programming language Java. It is used to write and upload programs to Arduino board.
The source code for the IDE is released under the GNU General Public License, version 2. The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures.

2. Proteus Design Suite: The Proteus Design Suite is a proprietary software tool suite used primarily for electronic design automation. The software is used mainly by electronic design engineers and technicians to create schematics and electronic prints for manufacturing printed circuit boards.

Chapter 4

PRINCIPLE

4.1 Existing System

The exiting traffic system is generally controlled by the traffic police. The main drawback of this system controlled by the traffic police is that the system is not smart enough to deal with the traffic congestion. The traffic police official can either block a road for more amount of time or let the vehicles on another road pass by i.e. the decision making may not be smart enough and it entirely depends on the official's decision. Moreover, even if traffic lights are used the time interval for which the vehicles will be showed green or red signal is fixed. Therefore, it may not be able to solve the problem of traffic congestion. In India, it has been seen that even after the presence of traffic lights, traffic police officials are on duty, which means that in this system more manpower is required and it is not economical in nature.(Viswanathan and Santhanam, 2013)

4.1.1 Disadvantages of Existing System

i) Traffic congestion
ii) No means to detect traffic congestion
iii) Number of accidents are more
iv) It cannot be remotely controlled

v) It requires more manpower
vi) It is less economical

4.2 Proposed System

The first and primary element of this system is the wireless sensor nodes consisting of sensors. The sensors interact with the physical environment means vehicles presence or absence while the local server sends the sensors data to the central microcontroller. This system involves the 4*2 array of sensor nodes in each way. This signifies 4 levels of Traffic and 2 lanes in each way. The sensors are ultrasonic sensors which transmits status based on presence of vehicle near it. The sensor nodes transmit at specified time intervals to the central microcontroller placed at every intersection. The Microcontroller receives the signal and computes which road and which lane has to be chosen based on the density of Traffic. The computed data from Microcontroller is then transmitted to the local server through Wi-Fi connectivity. The controller makes use of the collected data to perform the Intelligent Traffic routing. In this system, the primary aim is to gather the information of moving vehicles based on WSN to provide them a clear path till their destinations and traffic signals should switch automatically to give a clear way for these vehicles.(Dave, 2018)

4.2.1 Advantages of Proposed System

i) Minimizes number of accidents.
ii) Reduces fuel cost and saves time.
iii) Low budget.
iv) Easy implementation and maintenance.
v) Remotely controllable.
vi) Minimizes hassle and cost of commuting.

4.3 Method

In this proposed system, the traffic lights are LEDs and the car counting sensor is an ultrasonic sensor. Both blocks are connected to a Microcontroller using physical wires. The Microcontroller is the traffic light controller which receives the collected sensor data and manages the traffic lights by switching between green, yellow and red. The Microcontroller computes the number of cars in the street of the intersection it is monitoring based on the distances measured by the ultrasonic sensor and the timing between those measurements. The Microcontroller then sends the number of cars every minute to the local server. This communication is done using the Microcontroller serial port. The local server exchanges the data received with the cloud server in order to better predict the changes in timings of the traffic light. This communication is done using Wi-Fi. More specifically, the cloud server uses an equation that takes the data received (number of cars) as input then determines the time interval of LEDs needed for a smooth traffic flow. This calculated time is then compared to the current actual time of the LEDs (this data is saved in a database on the cloud server). The server then comes up with a decision. If the current actual green time is less than the calculated time, the decision is to increase the green time, else to decrease the green time.(Chandana K K, 2013)

4.3.1 A View of Signals at Different Lanes

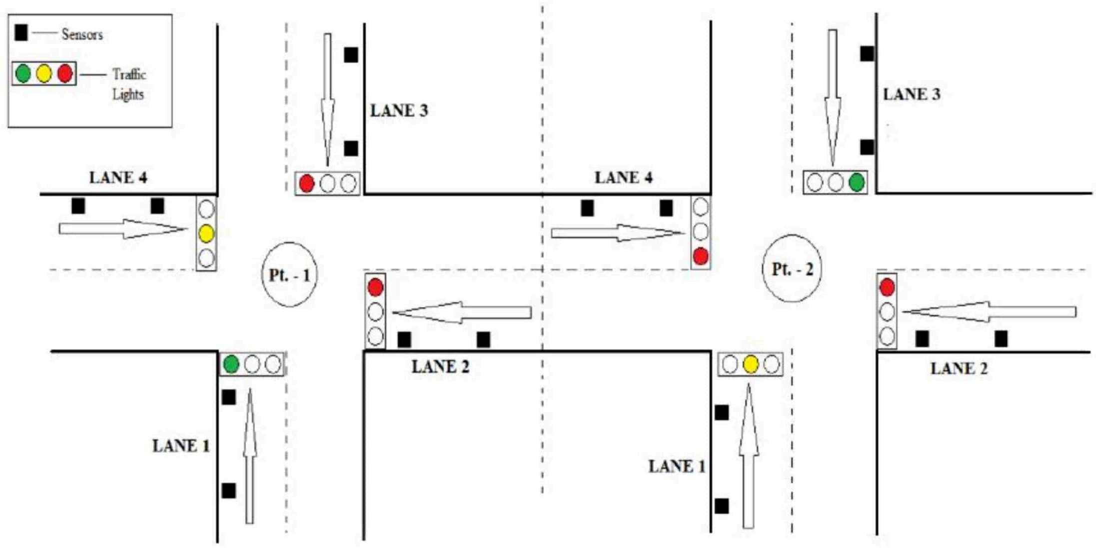

FIGURE 4.1: Control of previous Intersection

In the above figure, in Pt. - 1, LANE 1 is currently open with green signal and LANE 4 is ready with an yellow signal but LANE 2 and LANE 3 are blocked. In LANE 3, vehicle count is already greater than the threshold value, therefore the road coming to LANE 2 of Pt. - 1 is blocked in the Pt. - 2 itself. Thus re-routing them through another lanes. (Assuming that Pt. - 1 is the current intersection and Pt. - 2 is the previous intersection.)

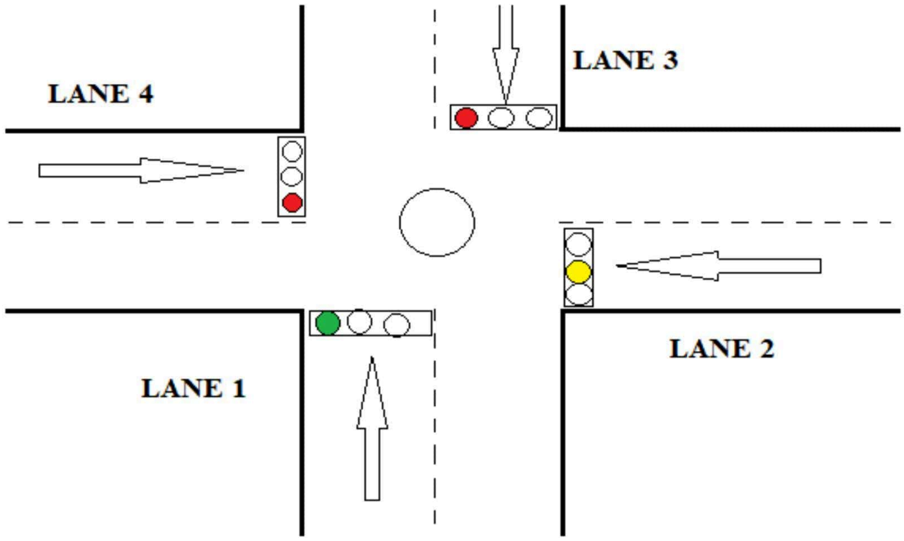

FIGURE 4.2: Signal at Lane 1

In the above figure, Lane 1 is open with green signal and other lanes are closed with red signal.

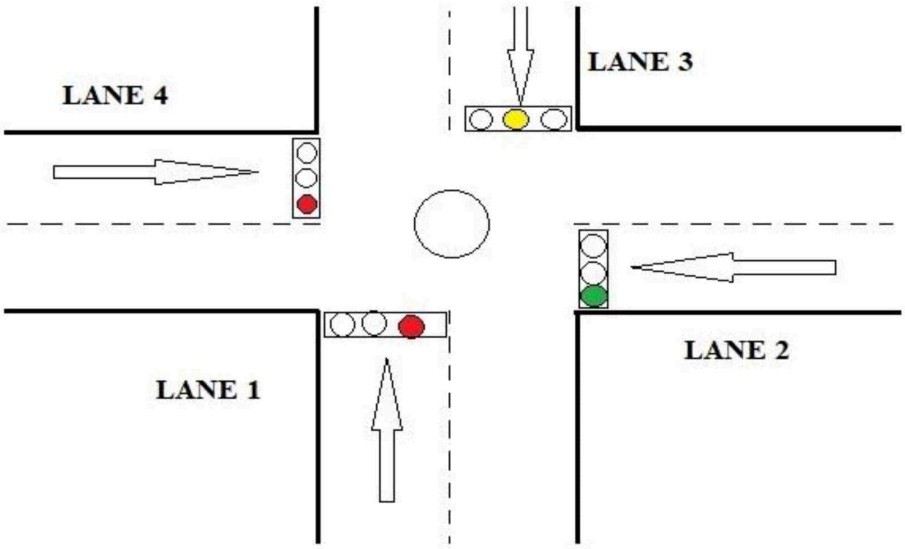

FIGURE 4.3: Signal at Lane 2

In the above figure, Lane 2 is open with green signal and other lanes are closed with red signal.

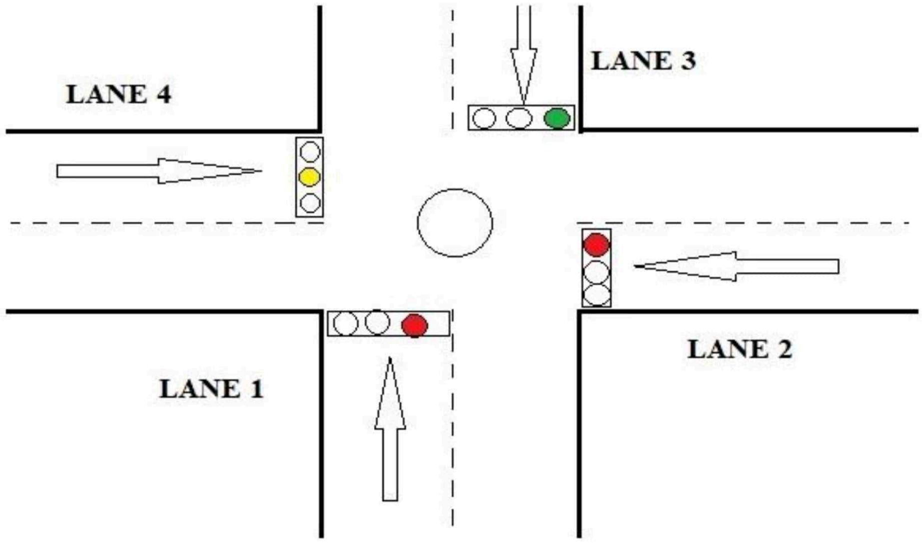

Figure 4.4: Signal at Lane 3

In the above figure, Lane 3 is open with green signal and other lanes are closed with red signal and after that Lane 4 will get the green signal automatically.

4.4 Diagrams

4.4.1 Flowchart

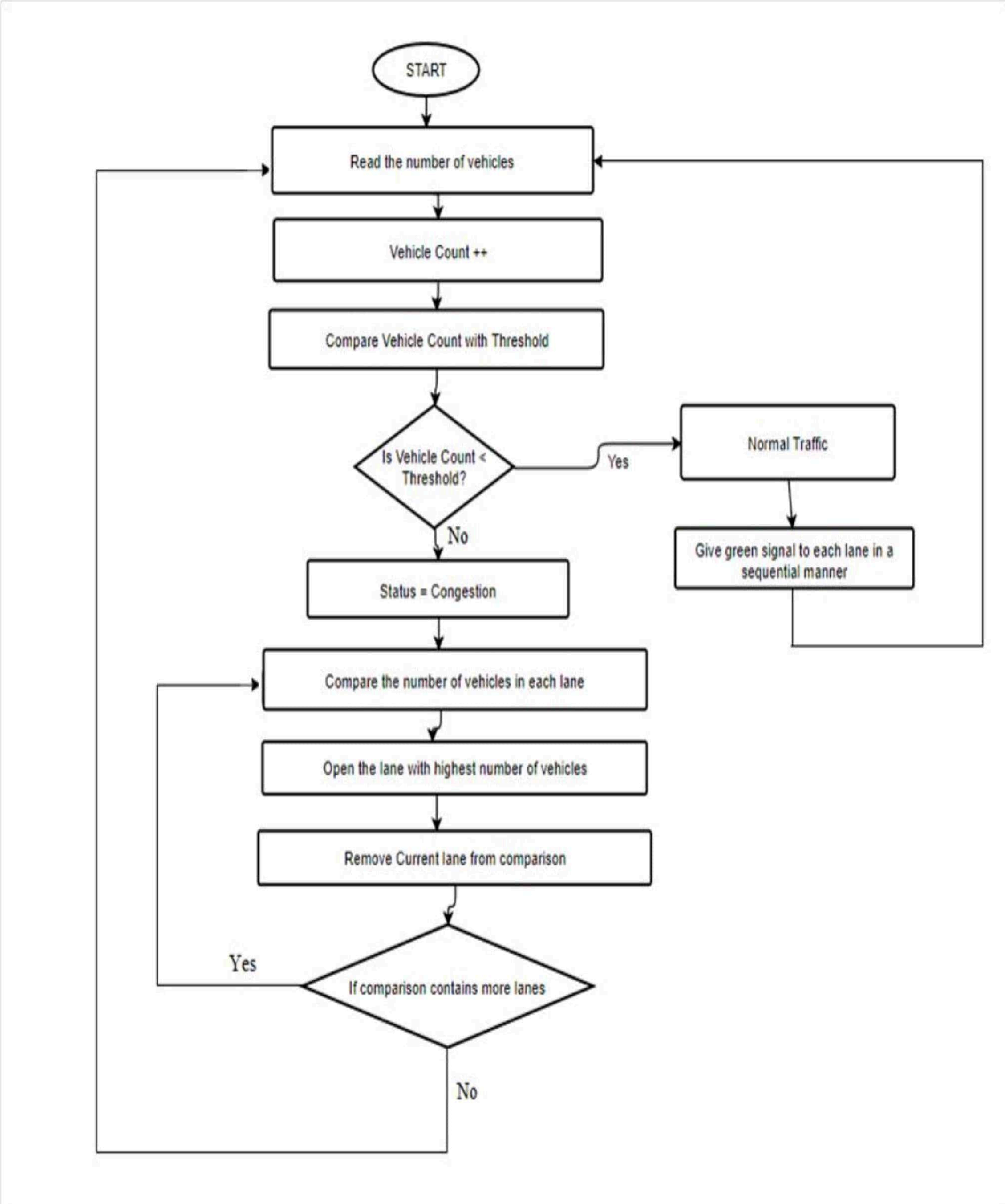

Figure 4.5: Flowchart.

4.4.2 Sequence Diagram

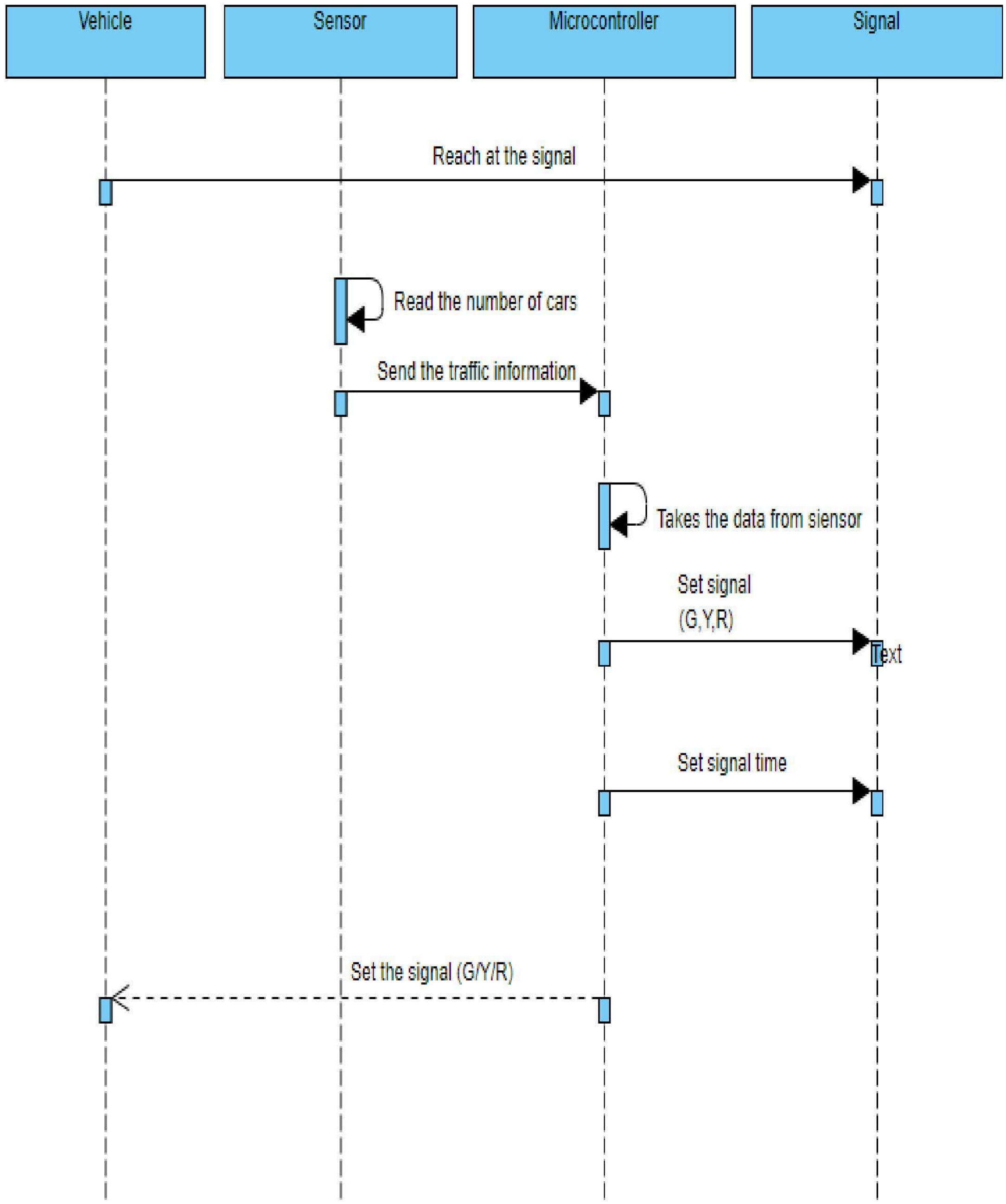

FIGURE 4.6: Sequence Diagram.

4.4.3 Use Case Diagram

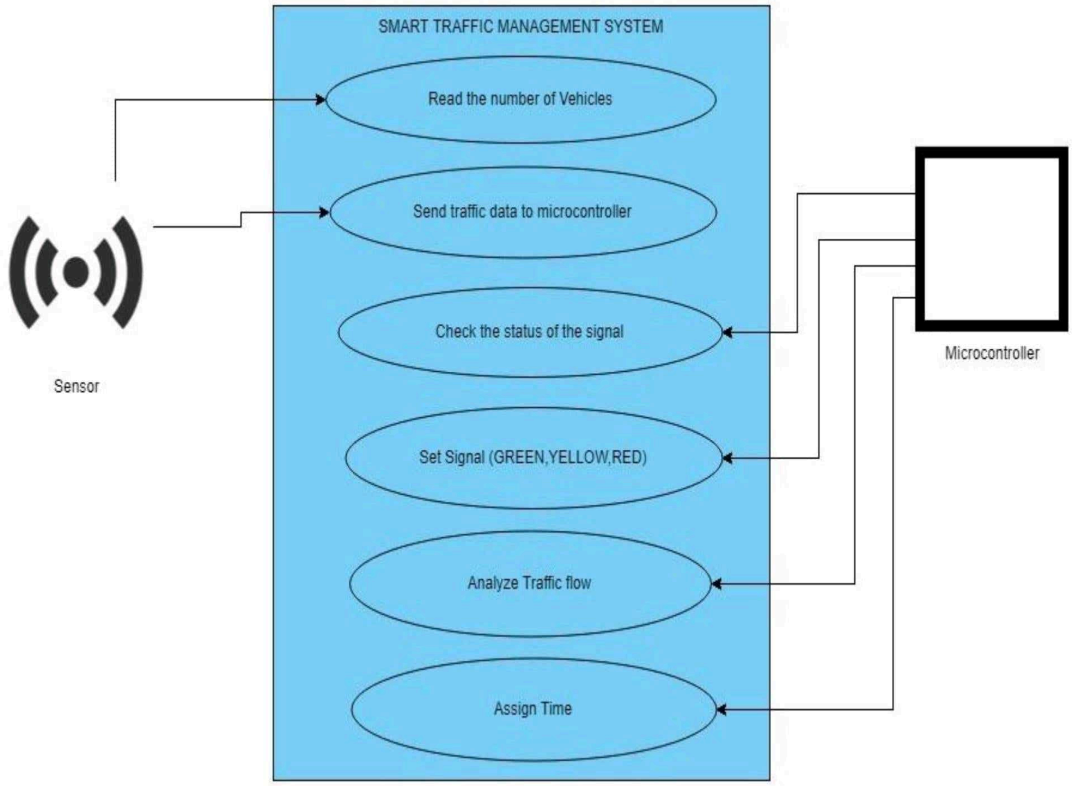

FIGURE 4.7: Use Case Diagram.

4.5 Algorithms

4.5.1 Vehicle Counter Algorithm

Assuming the objects detected by the IR Sensors to be vehicles,
int counter = 0;
int hitObject = false;
int val ;
Step 1: Read value from sensor (val). Sensor gives output 0 if car is detected and 1 if no car is detected.

Step 2: If val == 0 hitObject = false then increment the counter and set hitObject = true.
else if val == 1 hitObject = true
then set hitObject = false.
Step 3: Go to step 1

4.5.2 Traffic Control Algorithm

No. of sensors = 8 and are denoted by S1, S2, S3, S4, S5, S6, S7, S8
No. of cars in Lane 1 (N1) = S1 – S2
No. of cars in Lane 2 (N2) = S3 – S4
No. of cars in Lane 3 (N3) = S5 – S6
No. of cars in Lane 4 (N4) = S7 – S8
Li = (L1, L2, L3, L4), Ni = (N1, N2, N3, N4), Ti = (T1, T2, T3, T4)
Step 1: Start
Step 2: Sensors will read the no. of vehicles on each lane (i.e. L1, L2, L3, L4)
Step 3: if (Vehicle Count < Threshold)
Then status = Normal traffic. Turn on the green signal for all the lanes one after another in a sequential manner (L1-L2-L3-L4). When signal is green for one lane,the others will remain red.
Step 4: else status = congestion.
Step 5: COMPARE (N1, N2 , N3, N4), Select the highest of the four (say Ni),turn on green signal for that lane (say Li) for time (Ti). When time Ti ends, turn on the red signal.
Step 6: COMPARE (N2, N3, N4), Select the highest of the three (say Ni), turn on green signal for that lane (say Li) for time (Ti). When time Ti ends, turn on the red signal.
Step 7: COMPARE (N3, N4), Select the highest of the two (say Ni), turn on green signal for that lane (say Li) for time (Ti). When time Ti ends, turn on the red signal.
Step 8: The last remaining lane automatically gets selected and it is given the green signal for time Ti.
Step 9: Jump to Step 3.

Chapter 5

RESULTS AND ANALYSIS

5.1 Results and Analysis

The proposed system helps in better time based monitoring and thus has certain advantages over the existing system like minimizing number of accidents, reducing fuel cost and is remotely controllable etc.

The proposed system is designed in such a way that it will be able to control the traffic congestion as well as track the number of vehicles. The administrator of the system can access local server in order to maintain the system.

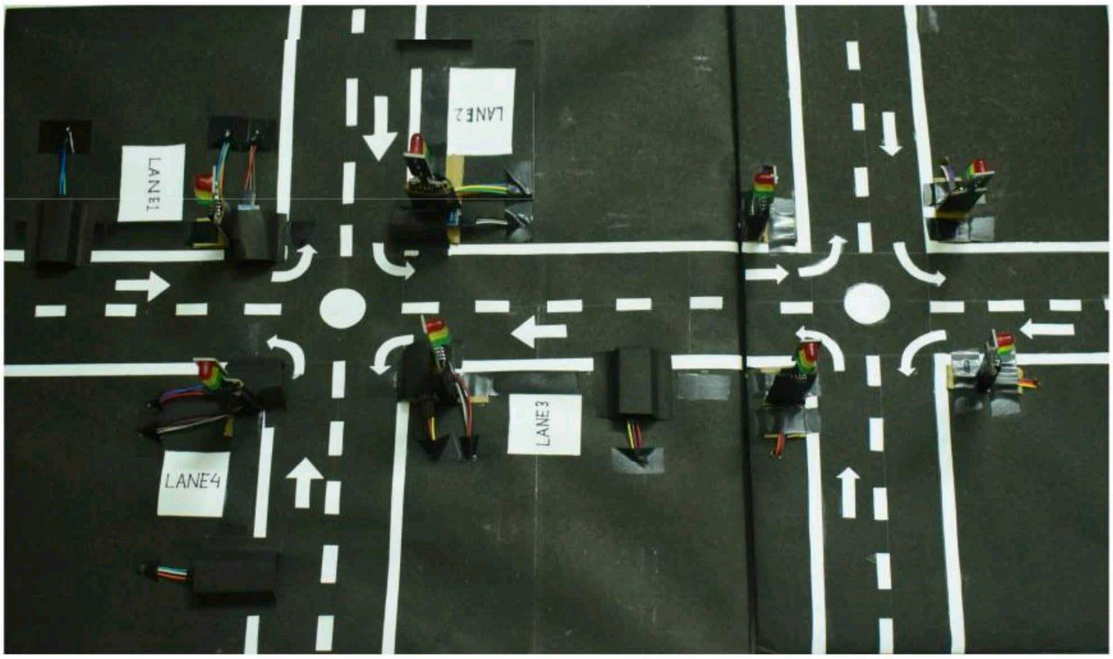

FIGURE 5.1: Model of the Project.

5.2 Challenges

1. Limited Budget: As graduate students our ability to test different technologies for accurate results are very limited.

2. Service to emergency vehicles: No method implemented for providing passage to emergency vehicles such as ambulances.

3. Lack of Time: Due to lack of time only one method using sensors have been implemented.

Chapter 6

MISCELLANEOUS

6.1 Future Scope

For future directions, different priority levels for multiple incidents and scenarios can be considered. The main issue with IoT is that the security of the entire system have to be concentrated on and not a particular IoT layer, device or software. Hence, integrating the entire traffic management system with multiple layer security for various data generated from various sources can be another subject of future scope. Along with that an emergency signal for an emergency vehicle (such as an Ambulance) can also be included in order to serve them better.

6.2 Related Works

In the field of IoT, many systems are proposed in order to control, manage the traffic system effectively. Each of the systems use different types of technologies, components for managing Traffic congestion like IR Sensors, RFID's, Zigbee, Traffic warning systems, Big Data, Bluetooth etc. The following are some the works that are related to our project. In the past ten years, the Internet of Things evolution has been unprecedented. Recently, various driver assistance systems have been actively developed that use both information communication technology and on-board sensors. Invisibility of traffic signal caused by huge vehicles blocking the view, prevent traffic congestion at toll gates and give advanced collision warning to the drivers. A microcontroller with a RF module will be installed and is programmed to connect to each automobile passing by. Later it displays signal status on the traffic signal status display system installed inside the automobile. This system installed in the vehicle is also capable of giving collision warnings to the driver.

IoT links the objects of the real world to the virtual world. It constitutes to a world where physical objects and living beings, as well as virtual data and environments, interact with each other. Urban IoT system that is used to build intelligent transportation system (ITS) has been developed. IoT based intelligent transportation systems are designed to support the Smart City vision, which aims at employing the advanced and powerful communication technologies for the administration of the city and the citizens. ITS uses technologies like near field communication (NFC) and wireless sensor network (WSN).

Automation combined with the increasing market penetration of on-line communication, navigation, and advanced driver assistance systems will ultimately result in intelligent vehicle highway systems (IVHS) that distribute intelligence between roadside infrastructure and vehicles and in particular on the longer term, are one of the most promising solutions to the traffic congestion problem. The simulation and evaluation of a traffic congestion detection system which combines inter-vehicular communications, fixed roadside infrastructure and infrastructure-to-infrastructure connectivity and big data. To simulate and evaluate, a big data cluster was developed based on Cassandra. Big data cluster is coupled with discreet event network simulator with the SUMO (Simulation of Urban Mobility) traffic simulator and the Veins vehicular network framework. The results validate the efficiency of the traffic detection system and its positive impact in detecting, reporting and rerouting traffic when traffic events occur. In order to avoid incidents like jams, accidents and to reduce huge menace concepts like Zigbee, RFID, Bluetooth, GSM-GPS technologies were developed.(Yucheng Huang, 2018)

Conclusion

Smart Traffic Management System has been developed by using multiple features of hardware components in IoT. Traffic optimization is achieved using IoT platform for efficient utilizing allocating varying time to all traffic signal according to available vehicles count in road path. Smart Traffic Management System is implemented to deal efficiently with problem of congestion and perform re-routing at intersections on a road.

This research presents an effective solution for rapid growth of traffic flow particularly in big cities which is increasing day by day and traditional systems have some limitations as they fail to manage current traffic effectively. Keeping in view the state of the art approach for traffic management systems, a smart traffic management system is proposed to control road traffic situations more efficiently and effectively. It changes the signal timing intelligently according to traffic density on the particular roadside and regulates traffic flow by communicating with local server more effectively than ever before. The decentralized approach makes it optimized and effective as the system works even if a local server or centralized server has crashed. The system also provides useful information to higher authorities that can be used in road planning which helps in optimal usage of resources. (Sabeen Javaid, 2018)

Bibliography

Babu, P. R. K. S. M. R. (2016). Real-time smart traffic management system for smart cities by using internet of things and big data. *2016 International Conference on Emerging Technological Trends (ICETT).*

Chandana K K, Dr. S. Meenakshi Sundaram, C. D. M. N. S. N. K. (2013). A smart traffic management system for congestion control and warnings using internet of things (iot). *Saudi Journal of Engineering and Technology*, 2.

Dave, P. N. D. M. . P. S. P. (2018). Smart traffic management system using iot. *International Journal of Computer Engineering and Applications*, 12.

Sabeen Javaid, Ali Sufian, S. P. M. T. (2018). Smart traffic management system using internet of things. *20th International Conference on Advanced Communication Technology (ICACT).*

Viswanathan, V. and Santhanam, V. (2013). Traffic signal control using wireless sensor networks. *2nd International Conference on Advances in Electrical and Electronics Engineering (ICAEE'2013).*

Yucheng Huang, Linbing Wang, Y. H. W. Z. Y. Z. (2018). A prototype iot based wireless sensor network for traffic information monitoring. volume 11.

Zantout, S. (2017). Traffic light controller project final report.