TRAFFIC MANAGEMENT USING IOT

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 aimis to optimally control the duration of green or red light for a specific traffic lightat an intersection. The traffic signals should not flash the same stretch of green orred all the time, but should depend on the number of cars present. When trafficis heavy in one direction, the green lights should stay on longer; less traffic shouldmean the red lights should be on for longer time interval. This solution is expectedto eliminate inefficiencies at intersections and minimize the cost of commuting andpollution.

1.2 Motivation

In 2014, 54% of the total global population was urban residents. The prediction wasa 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 businessdistricts lead to urban employees living far away from their place of work/educationand therefore having to commute back and forth between their place of residenceand their place of work. More vehicles moving need to be accommodated over afixed number of roads and transportation infrastructure. Often, when dealing withincreased 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 makingthem bigger or building more roads. This leads to the proposed system which willuse a micro controller and sensors for tracking the number of vehicles leading totime based monitoring of the system.(Babu, 2016)(Zantout, 2017)

Innovation

This section first discusses the recent research developments in intelligent traffic management including system models for traffic updates, traffic congestion measures, emergency vehicle handling, and applications of roadside units to deliver messages. Current advances in cost-effective and power-efficient wireless sensor nodes for traffic monitoring follow this. This section also includes specific printed circuit boards based on sensor nodes to detect vehicles, estimate speed, and classify them. The discussion includes the features of these nodes, their pros, and cons.

2.1. Real-time traffic updates

Real-time traffic monitoring systems play a key role in the transition toward smart cities. A considerable amount of literature has been published on intelligent traffic management systems based on the IoT paradigm [25,56,60,61]; Z [38]. Autonomous traffic sensing is at the heart of smart city infrastructures, wherein smart wireless sensors are used to measure traffic flow, predict congestion, and adaptively control traffic routes. Doing so effectively provides an awareness that enables more efficient use of resources and infrastructure.

Identifying and measuring congestion is the very first step in the traffic management process [40]. The flow, occupancy, density is the widely used traffic congestion measures, which are mostly obtained from images or videos captured by vision systems initially [53]. Based on these measures, the traffic warning messages are broadcasted through smartphones, radio, televisions, light signals, dynamic variable message signs, or display units. Among them, the mobile-based web applications received much attention among researchers [18,56].

Most of the recent developments in delivering real-time traffic updates used the congestion estimates to dynamically control the traffic signal [3,27,32,43,59,63]. An IoT based real-time traffic monitoring system is proposed [43] for dynamic handling of traffic signals based on traffic density. The proposed system uses a set of ultrasonic sensors and has two modules: one for vehicle monitoring and other for priority management. The ultrasonic sensors are used to detect vehicles, and the density levels of a given road are sent to an LCD, and the data sent to the server for later usage. In similar research [63], the authors proposed an ultrasonic sensor-based system model specifically for road intersections. In addition to traffic signal lightings, the system alarms on any false vehicle activities such as crossing the red signals. In another research, an IoT based smart traffic management system is proposed [29] to manage real-time traffic through both central and local servers. The data collection layer uses sensors, cameras, and RFIDs. The application layer automatically controls the traffic signal based on traffic density and provides a daily report through a web application. Besides sensors, video monitoring is also used to estimate traffic congestion density [32] and update traffic signals in real-time.

The internet of connected vehicles is another research development in this area [26] to collect real-time traffic data. The connected vehicles support individual vehicle monitoring which enables efficient emergency vehicle management. Integrating roadside units (eg: traffic lights) with the vehicular network to ensure the trustworthiness of traffic events [66]. The emergency vehicle (e.g. Police cars, Fire engines, Ambulances) handling is very critical, the delay of every second matter because of the urgency of the services they are providing. Automatic scheduling of emergency vehicles can be performed by controlling the traffic signals [45,64] to improve the response time [57]. However, these systems are specifically designed for highways.

As this research does not anticipate any smart devices with the drivers, the traffic updates through roadside message units are analyzed in detail. A patented device for displaying traffic conditions [17] is designed to install on the roadside. The graphical message unit displays the upcoming traffic conditions and incidents through messages, signs, or colors. The studies on the impact of dynamic message signs through roadside message units show that it has received acceptance among drivers [23,35,65]. The dynamic message signs can be delivered in permanent mode through roadside message units (installed on bridges, toll plazas, tunnels, etc.) or portable units. The portable units are mainly used to warn about unusual traffic incidents. The roadside units mostly display the messages about over spilled roads, planned activities, environmental updates, traffic flow conditions, etc. The impact analysis of such message units reported that they mainly assist elderly drivers in their decision making [23].

The transportation project for the Beijing Olympics (F [69]. is a great example of providing traffic updates through public message units. The project used changeable message boards, radios, television, internet, and in-vehicle displays to monitor and dispatch traffic updates. However, system development was quite expensive due to advanced programs and devices [5]. After that, several research efforts have been made in this area to provide real-time traffic updates. A system is proposed to display traffic intensity through three different light colors on installed electronic boards at decision points [60]. In this system, the real-time traffic density is calculated from the average vehicle speed determined by vehicle detection systems. The authors apply image processing algorithms to process real-time traffic videos, and the traffic congestion estimation is based on optical flow. Similarly, electronic signboards are used to avoid congestions by setting up different speed limits [21].

The studies discussed above are tested for highways, and real-time updates are delivered through traffic signals or mobile applications. Instead, this research proposes a system model for real-time traffic updates through roadside message units using an IoT platform Nowadays, digital electronic boards are widely used in smart campuses, that can be also reused (if any) to deliver traffic updates during peak hours. Next, discuss the wireless sensors which are mainly used for vehicle detection, classification, speed estimation, etc.

2.2. Wireless sensors for vehicle data collection

This section presents the review of sensors that are used for vehicle detection and classification. The sensors used in intelligent traffic monitoring systems can be on-road sensors or in-vehicle sensors. The on-road traffic sensors can be again classified into two types: intrusive and non-intrusive. The intrusive sensors are paved on the road and are costly compared to non-intrusive sensors. The intrusive sensors provide accurate information; however, they are questioned for the expenses in terms of installation. maintenance, repair costs [22]. The maintenance of such sensors requires road lane closures and traffic disruptions. The non-intrusive sensors can be fixed on different parts of roads/roadsides. This includes magnetic sensors [16,31], ultrasonic sensors [39], infrared sensors [47], acoustic sensors [9,46], video cameras [12]; B [36]. Each sensor has its advantages and disadvantages. The ultrasonic sensors are prone to environmental factors [6]. The video monitoring systems are comparatively costly than other sensors when considering the purchase, installation, and maintenance costs [55]. However, the sensors are relatively less expensive in purchase costs. A comparison of different intrusive and non-intrusive sensors have been already reported in a few kinds of research [44,48,55]. The infrared sensors are sensitive to bad weather; acoustic sensors do not give accurate results during cold temperatures. The magnetic sensors are unable to detect the vehicles which are not moving [44]; however, there is no climatic influence. The magnetic sensors are widely used for vehicle detection and classification because of its easy installation, portability, and low cost [16,72]. The vehicle speed and length can be estimated by one or more magnetic sensors, which will help to approximate the road space occupancy measure.

Besides different types of sensors, a few research efforts have attempted to develop printed circuit boards (PCBs), which can be directly adapted for vehicle detection/speed estimation/classification such as PRS [62], LCTS [72], iVCCS [8], and CPIUS [47]. Fig. 1 shows the PCBs of PRS, LCTS, and iVCCS sensor nodes. The main objective of all these researches is to design and develop inexpensive and portable sensor nodes. On average, a single sensor node costs an average of $30 and operational for many years [6].

Fig. 1

Fig. 1. (a) LCTS Sensor Node [72], (b) PRS Physical Board [47], and (c) iVCCS Physical Board [8].

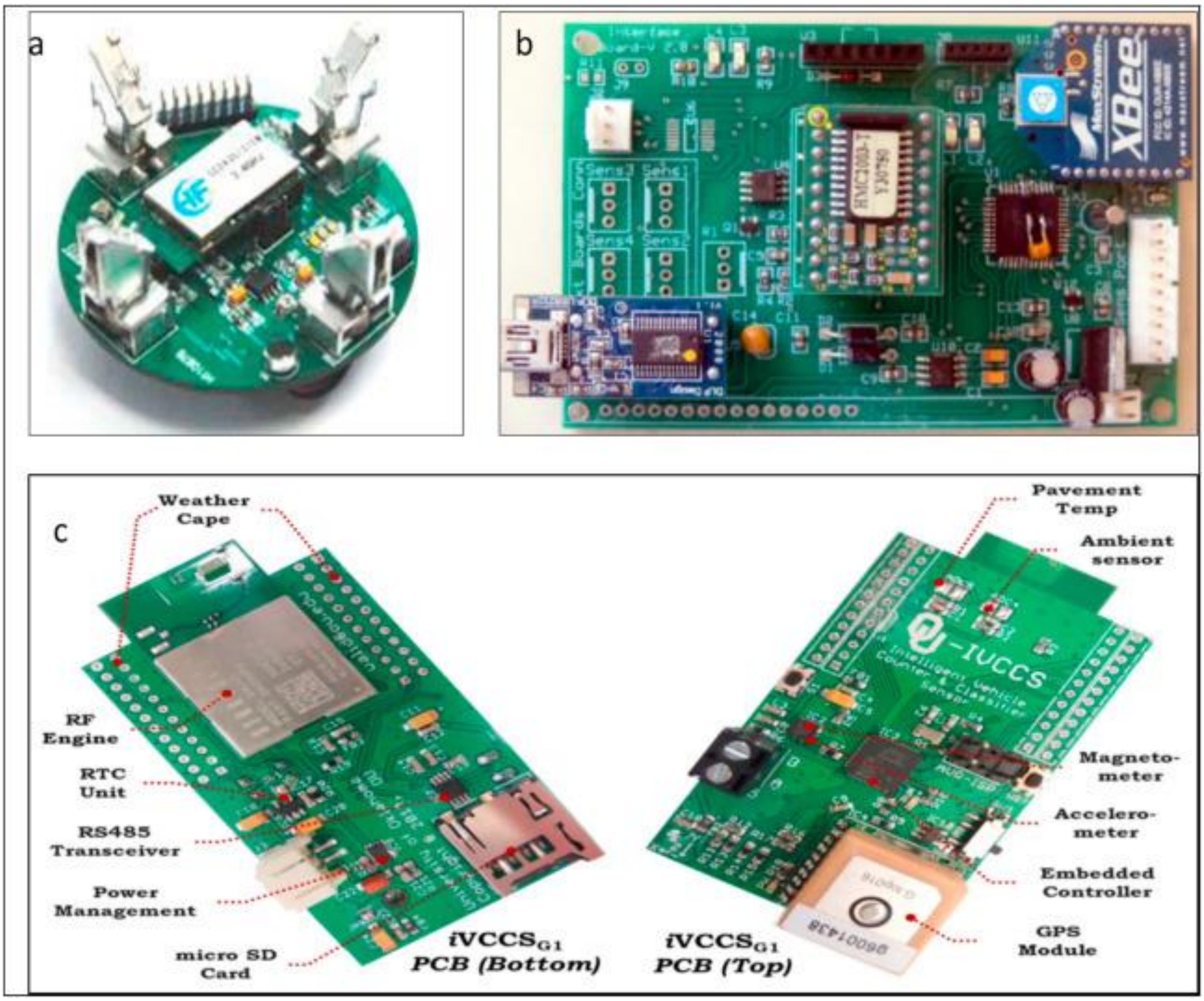
PRS is a portable roadside sensor for vehicle detection, counting, classification, and speed estimation [62]. PRS uses a magnetic sensor for vehicle detection. The single PCB board of PRS contains two magnetic sensors (HMC2003). This sensor uses the XBee module for wireless communication. PRS shows an accuracy of 99% in vehicle detection, and the maximum error rate of speed estimation is 2.5% (in a range of 5–27 m/s). Besides, the system also detects the right intersection. The vehicle length and height are estimated from the magnetic length.

LCTS is another low-speed congested traffic sensor node with a magnetic sensor specifically for a single lane road [72]. The sensor node is designed using magnetic sensor HMC5883L. In addition to the magnetic sensor, the node also contains a sound sensor and four infrared sensors. However, the magnetic sensor alone performs vehicle detection and classification. The validation results show a detection accuracy of 99.05% and a classification accuracy of 93.66%.

The iVCCS is an intelligent vehicle counting and classification sensor; the node has different sensors and components such as temperature sensor, accelerometer, magnetic sensor, GPS module, real-time clock unit, memory unit, etc. [8]. The iVCCS is a small battery-powered node with a 6-axis magnetic sensor and accelerometer FXOS8700. It uses a Zigbee wireless communication. The iVCCS nodes are validated in different field trials and exhibit a 99.98% accuracy in vehicle detection, 97% accuracy in vehicle classification, and 97.11% in speed estimation. The consistency of the sensor's output under different conditions is tested and showed high similarity. Besides, the sensor node is portable and can be installed on the road as well as on roadsides.

CPIUS is the combined passive infrared and ultrasonic sensors (CPIUS) for vehicle classification and speed estimation [47]. The measurements from passive infrared sensors and ultrasonic sensors are used for vehicle classification. They produce a high accuracy in vehicle detection (99%), the mean absolute error in speed estimation is approximately 5.87 km/h, and a mean absolute error of 0.73 m in vehicle length estimation. The proposed sensing platform contains one ultrasonic rangefinder and two arrays of six passive infrared sensors (Melexis MLX90614) connected to a microcontroller unit with different components such as an SD card reader, energy monitoring circuit, and flash memory.

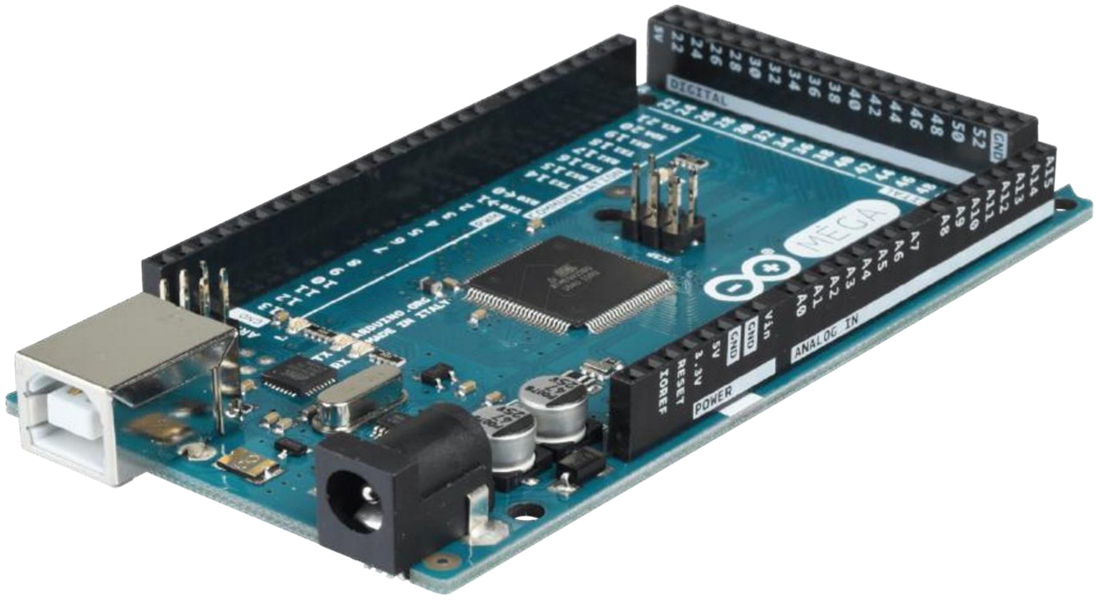
The review reveals that magnetic sensors are appropriate for length-based vehicle classification. This is very relevant in the context of this research as the collector roads are mostly occupied with smaller vehicles and a volume to capacity ratio doesn't fit well.



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

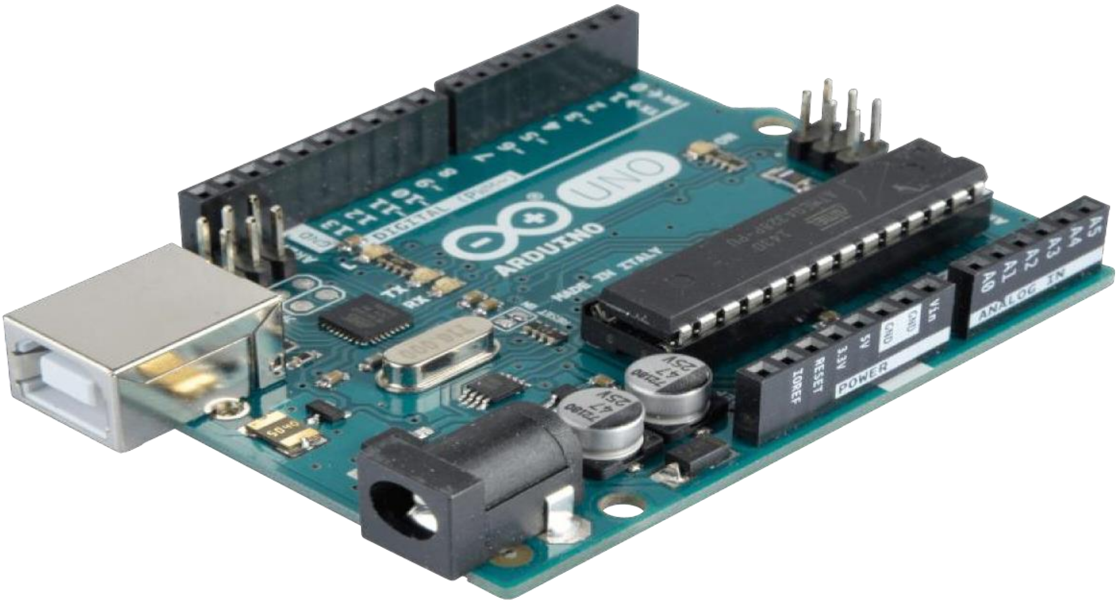
serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Mega 2560 board is compatible with most shields designed for the Uno and the former boards Duemilanove or Diecimila.



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.

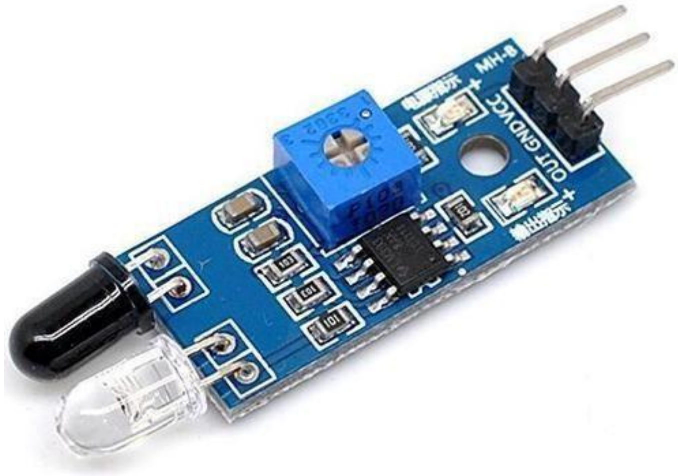


Arduino Uno.

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

LED for Trac Lights.

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



IR Sensors.

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

Jumper Wires.

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.

P R I N C I P L E

Existing System

The exiting trac system is generally controlled by the trac police. The main drawback of this system controlled by the trac police is that the system is not smart enough to deal with the trac congestion. The trac police ocial 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 ocial's decision. Moreover, even if trac lights are used the time interval for which the vehicles will be showed green or red signal is xed. Therefore, it may not be able to solve the problem of trac congestion. In India, it has been seen that even after the presence of trac lights, trac police ocials are on duty, which means that in this system more manpower is required and it is not economical in nature.(Viswanathan and Santhanam, 2013)

Disadvantages of Existing System

i) Trac congestion
ii) No means to detect trac congestioniii) Number of accidents are more iv) It cannot be remotely controlled

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

Proposed System

The rst 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 signies 4 levels of Trac 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 specied 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 Trac. 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 Trac 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 trac signals should switch automatically to give a clear way for these vehicles.(Dave, 2018)

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.

Method

In this proposed system, the trac 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 trac light controller which receives the collected sensor data and manages the trac 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 trac light. This communication is done using Wi-Fi. More specically, 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 trac ow. 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)

A View of Signals at Dierent Lanes

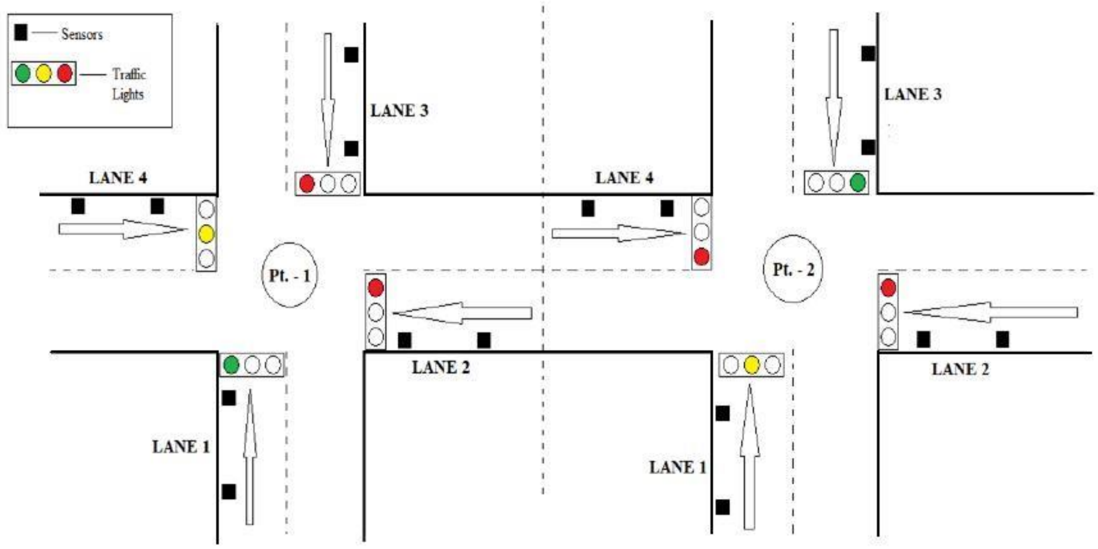
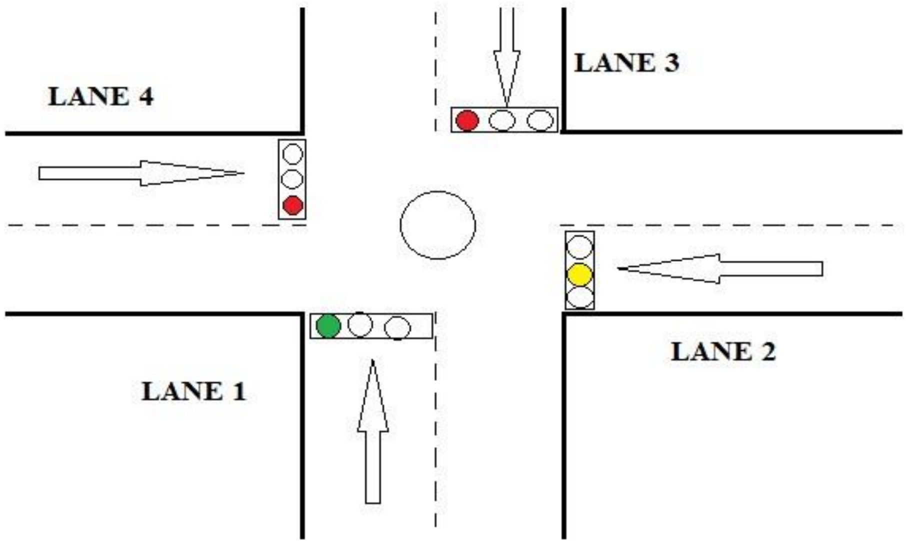


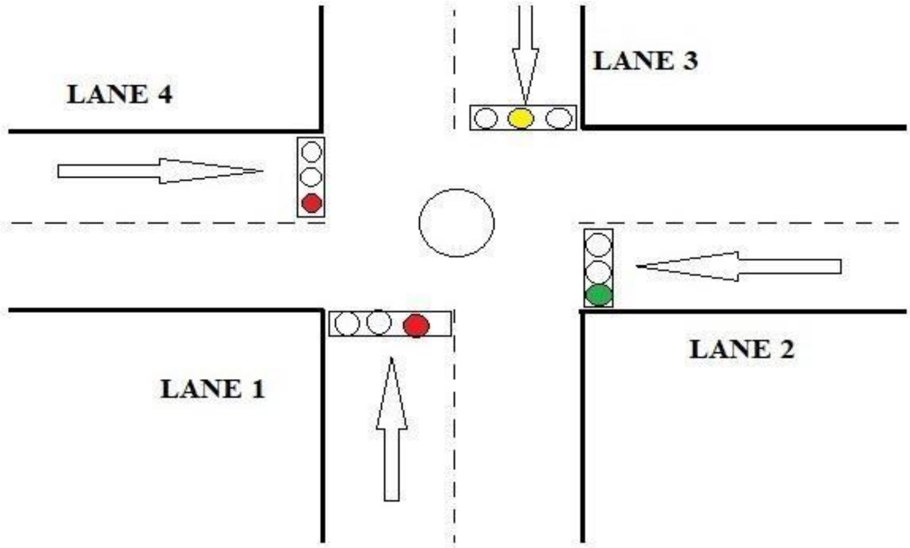
Figure 4.1: Control of previous Intersection

In the above gure, 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.)



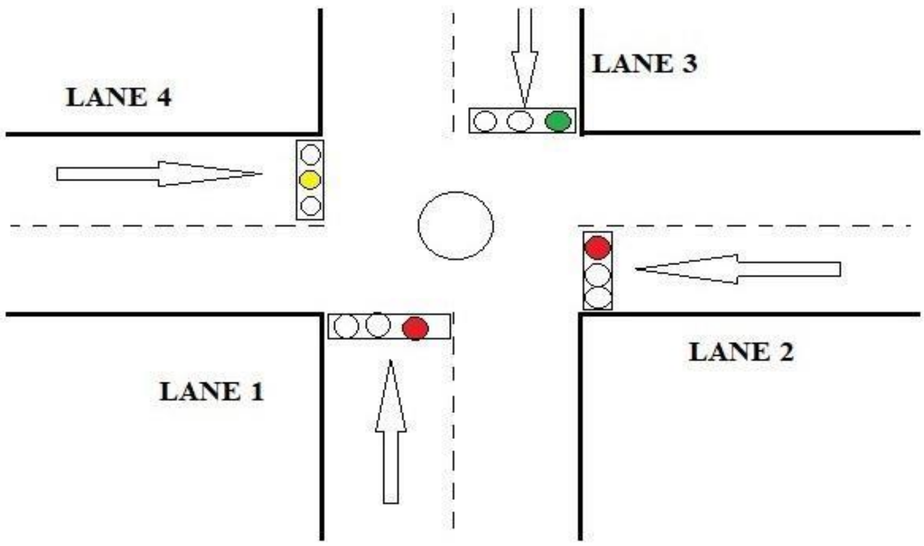
Signal at Lane 1

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



Signal at Lane 2

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



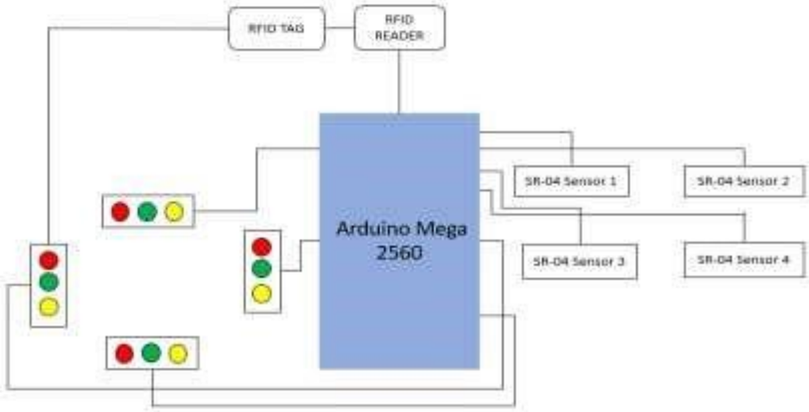
Signal at Lane 3

In the above gure, 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.

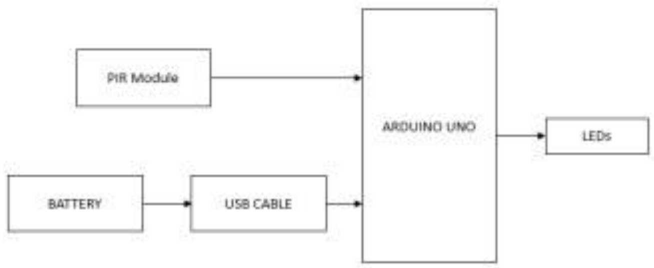
The exertion of our project is carried out utilising following hardware:

1) Arduino Mega 2560 Micro-Controller
2) LED Lights (Red, Yellow & Green)
3) Radio Frequency ID Tag
4) Radio Frequency ID Scanner
5)Patch cards
5) Model ambulances and vehicles
6) LCD Display with Arduino
7) SR-04 ultrasonic sensors
8) Infrared sensors

The Arduino Mega 2560, which serves as the system's. The amygdala interprets data from the SR-04 sensors indefinitely. Figure 2 depicts a comprehensive flowchart of the different procedures required. According on the information collected by the sensors, it will estimate traffic density and govern traffic lights based on the traffic density of each lane, which will then employ traffic stagnation. The system's traffic signals are made from LEDs. Each signal is made up of two red and green LEDs. Crafted a four-lane crosswalk traffic control system. every alley will include four electronic SR-04 camera sensors and eight LEDs that will operate as traffic signals.

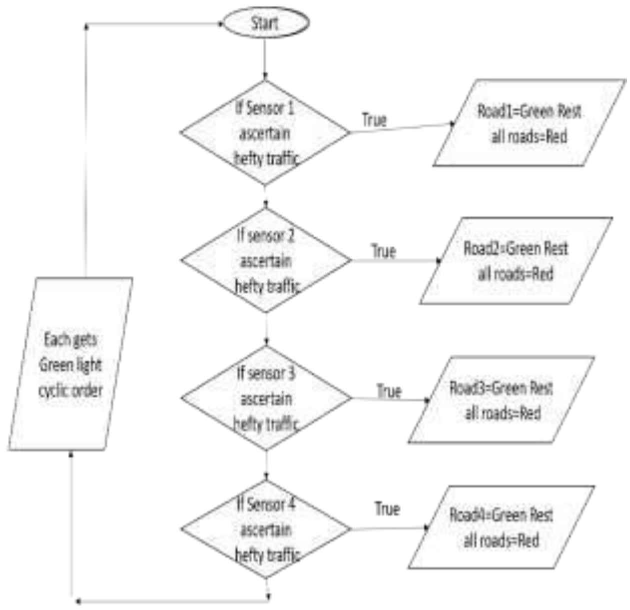


Block Design



. Block diagram 2

Each ambulance is outfitted with just an Radio Frequency ID tag. This usually leads to our first portion, the ambulance segment. It comprises an ambulance with an Radio Frequency ID tag attached to it. The second section discusses traffic lights. It is made up of an Radio Frequency ID reader that scans Radio Frequency ID tags. Following the scanning of the tag, the Radio Frequency ID reader retains the data and transfers it to a server through cloud computing. The initiative, which is powered by the Internet of Things, aims to establish a "Green zone" for compulsion vehicles. The internet of things is transformed into a smart project, which acts as the cornerstone for any Sustainable urban. By combining cloud computing and delving more into the notion of Sustainable commuting, the project may be improved.

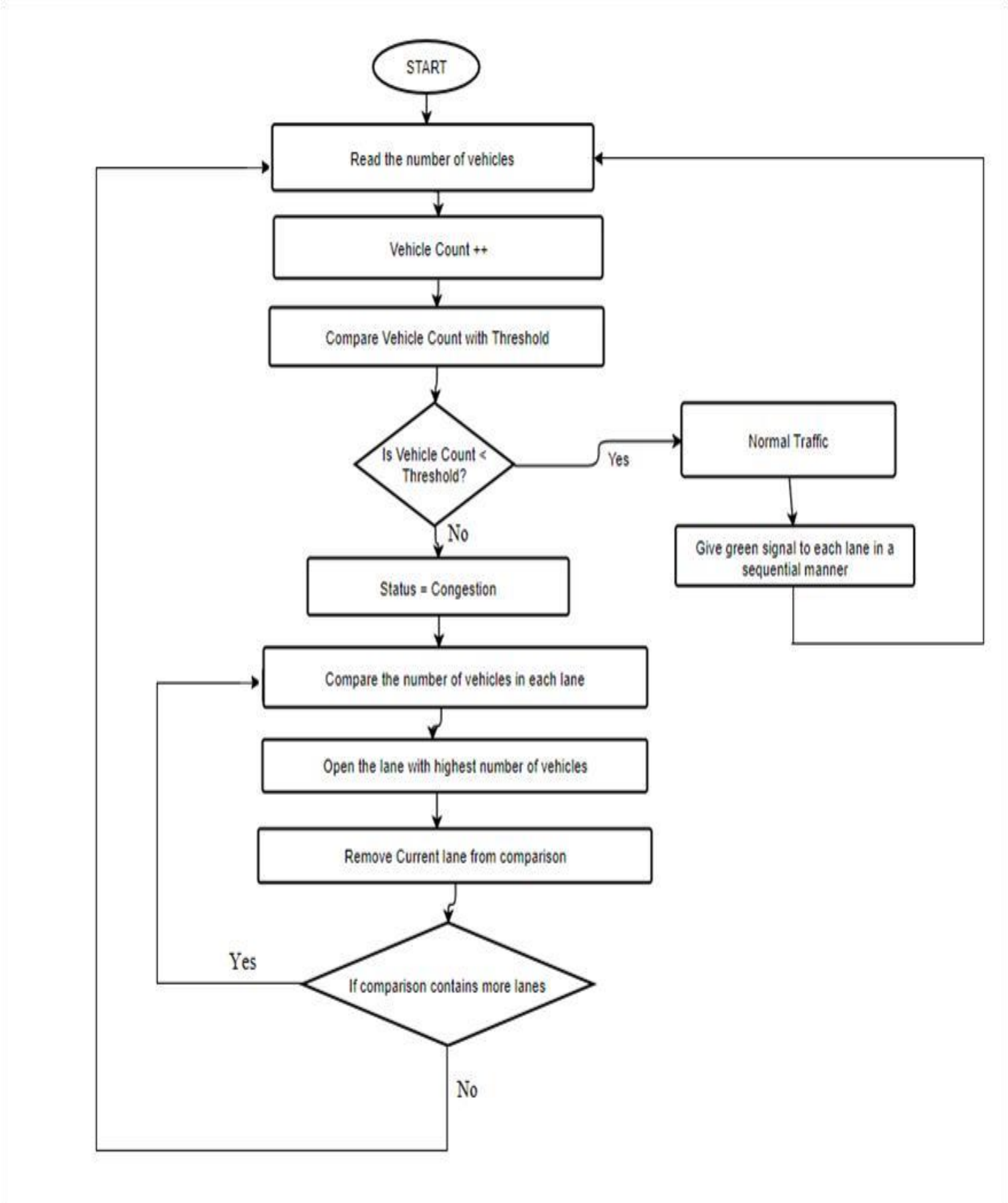


Flow chart to control Traffic density system

This technique may be used to continually update updates on traffic and keep them safe in the cloud. An Android smartphone application might be used to command this [16]. This technology enables traffic lights to be regulated electronically by logging the time and dimensions of the compulsion vehicle and more effectively. A PIR Sensing element is also part of this setup. It's on all four sides of the traffic signals. When a human or animal crosses the road, the PIR sensor detects infrared rays released by all heat-emitting barriers and stops the cars by flashing red until the person or animal passes the road.

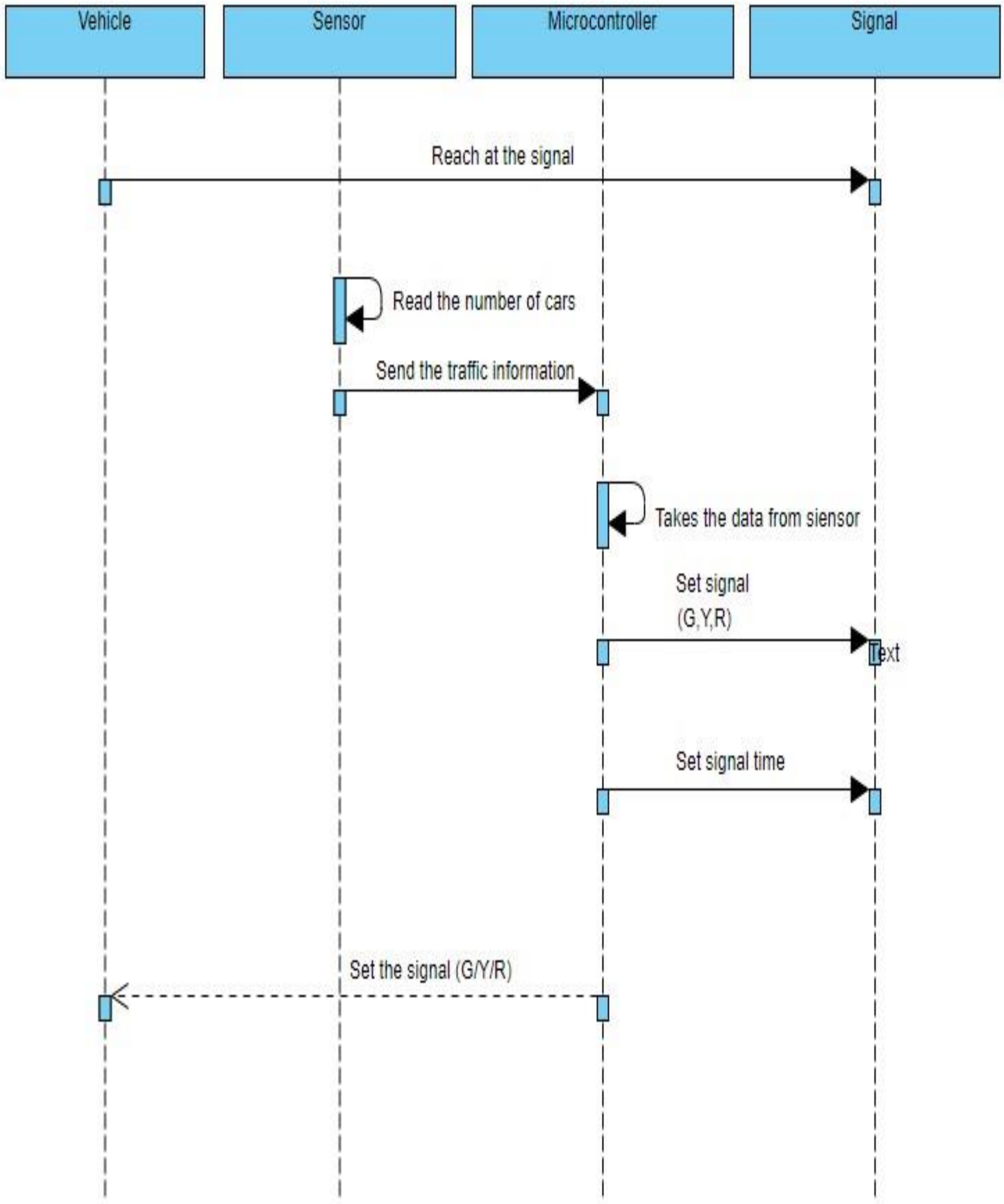
Diagrams

Flowchart



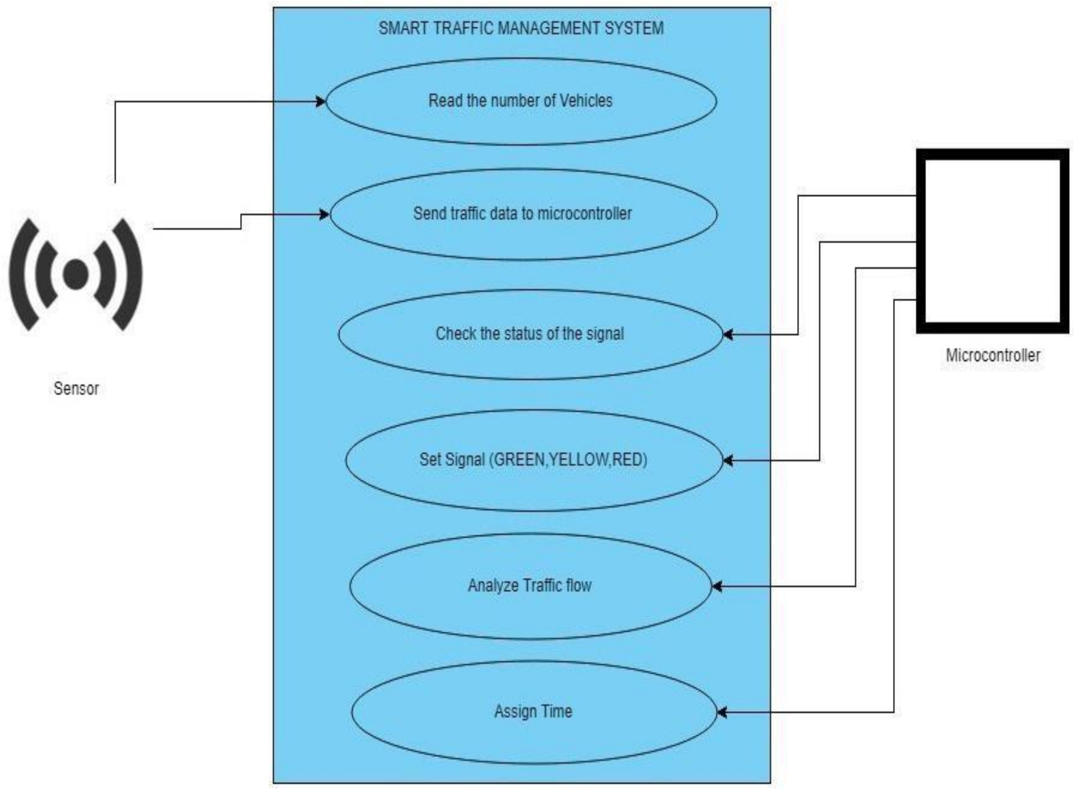
F lowchart.

Sequence Diagram



Sequence Diagram.

Use Case Diagram



Use Case Diagram.

Algorithms

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

Trac 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 < T hreshold)
Then status = Normal trac. 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.

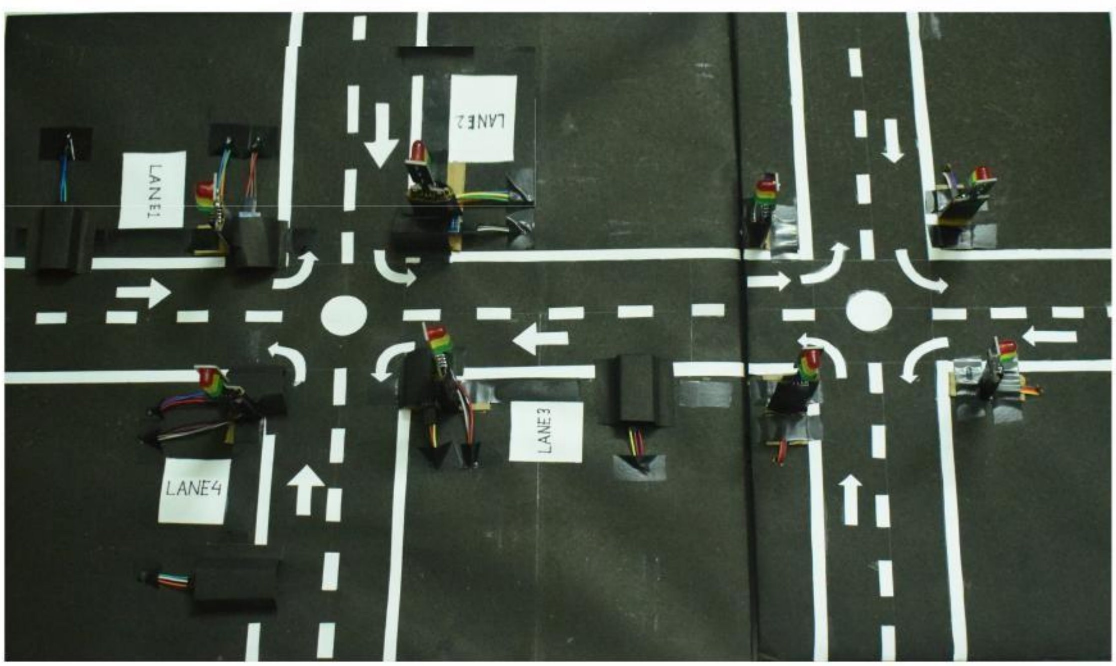
RESULTS AND ANALYSIS

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 trac congestion as well as track the number of vehicles. The administrator of the system can access local server in order to maintain the system.

Chapter 5: Results and Analysis



Model of the Project.

Challenges

---

1. **Limited Budget:** As graduate students our ability to test dierent 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.

M I S C E L L A N E O U S

Future Scope

For future directions, dierent 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 trac 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.

Related Works

In the eld of IoT, many systems are proposed in order to control, manage the trac system eectively. Each of the systems use dierent types of technologies, components for managing Trac congestion like IR Sensors, RFID’s, Zigbee, Trac 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 trac signal caused by huge vehicles blocking the view, prevent Chapter 6: Miscellaneous

trac 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 trac 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 eld 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 trac congestion problem. The simulation and evaluation of a trac congestion detection system which combines inter-vehicular communications, xed 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) trac simulator and the Veins vehicular network framework. The results validate the eciency of the trac detection system and its positive impact in detecting, reporting and rerouting trac when trac 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 Trac Management System has been developed by using multiple features of hardware components in IoT. Trac optimization is achieved using IoT platform for ecient utilizing allocating varying time to all trac signal according to available vehicles count in road path. Smart Trac Management System is implemented to deal eciently with problem of congestion and perform re-routing at intersections on a road.

This research presents an eective solution for rapid growth of trac ow particularly in big cities which is increasing day by day and traditional systems have some limitations as they fail to manage current trac eectively. Keeping in view the state of the art approach for trac management systems, a smart trac management system is proposed to control road trac situations more eciently and eectively. It changes the signal timing intelligently according to trac density on the particular roadside and regulates trac ow by communicating with local server more eectively than ever before. The decentralized approach makes it optimized and eective 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)