1. Introduction

1.1 Overview

The traffic management system of a metropolitan city is a keystone for urban mobility. With the rise of the population, the demand for vehicles grows up and hence the requirement of transportation has also increased. Infrastructural development becomes an indispensable part of complementing the population growth to augment urban mobility. But the traditional traffic management system is shown not only ineffective for accompanying the increased number of vehicles with the use of police control and traffic light system but also incompetent enough to handle this growth of traffic on road systems. This traffic congestion consequentially consumes precious working time for being incapable of handling extensive traffic congestion and eventually leads to the environmental pollution for an extended period of vehicle emission. Adequate pre-measures and proper planning can help to reduce the number of traffic problems and manage an increased number of vehicles on the road.

Traffic system utilize the concept of automation with IoT is called as “Smart Traffic”. Smart Traffic Management System is an advanced and integrated solution designed to optimize traffic flow, reduce congestion, enhance road safety, and improve overall transportation efficiency within urban or metropolitan areas.

- This system relies on various sensors placed strategically throughout the road network to monitor traffic conditions
- The system can control traffic signals at intersections dynamically based on real-time traffic data.
- Adaptive traffic signal systems adjust signal timings to minimize waiting times and reduce idling
- Reducing congestion and energy consumption at intersection.
- Ensuring immediate clearance for emergency vehicles. Facilitating safer and shorter commute time.
- The traffic light system has also been given an emergency mode, which gives ambulances priority to pass through traffic lights.

1.2 Existing System

There is a continuous increment in the traffic demand and with a high rate of urbanization, there is an extra load on current infrastructure in terms of managing the road transportation. Traffic jam turns out to be key crisis in these days. Traffic jam mainly occurs in urban areas. Due to traffic jam, there are several problems arise such as increase in noise pollution, air pollution and delay in travel time etc. Nowadays congestion in traffic is a serious issue. Malfunctioning of the traffic lights and various other dysfunctionalities has led to traffic congestion which hurts the economy, environment, and overall quality of life. The traffic congestion can also be caused by large red-light delays. With the boom in the built environment leads to the shortage of habitable shape in work surrounding and people have to move out for buying their budget home. This new trend is also putting extra pressure on the infrastructure because they have to come to the city for their jobs and go back home in the evening. Lack of sufficient and sustainable public transportation also one of the major and significant catalysts for traffic congestion. A majority of the people using private or own vehicle for their office, outing, dining, and other activities. Due to the ever-increasing traffic demand, modern societies with well-planned road management systems, and sufficient infrastructures for transportation still face the problem of traffic congestion. Traffic congestion results into loss of productive time, loss of fossil fuels, adds to the high level of pollutions and economic losses. The present traffic signals deployed in all parts of the cities are not enough to solve above mentioned problems because these have specific pre-determined time for red and green signals. In this view various attempts were done for traffic lights to behave smartly based on density of vehicles on the road. Therefore, many techniques have been used in traffic control systems.

India, a nation with over 1.3 billion people, is known for its diverse culture, rich heritage, and bustling cities. However, it also grapples with the significant challenge of managing traffic on its roads. With rapid urbanization and a rising number of vehicles, traffic congestion, and air pollution have become pressing issues.

1.3 Proposed System

A prototype is proposed for a traffic management system using Ultrasonic sensors, Arduino, and LED displays. The density of the traffic is measured by placing the Ultrasonic sensors (HC-SR04) at the 4-lane junction after a certain distance. The data collected from sensors is used to dynamically change the sequence of green lights as well as to dynamically change the green light delays. The proposed road traffic management system is implemented in the proteus software. For high traffic zone, a higher green light delay is given whereas for low density zone, the duration of the green light delay is reduced. The system is also designed in such a way as to give

preference to the lanes which have no vehicles/very few vehicles by providing the least green light delays.

Also there will be radio frequency reader on roadside to read the radio frequency tag on an ambulance or fire-extinguisher truck and immediately open the barricade irrespective of what the signal is for that road. Red LED indicates CLOSED and green LED indicates OPEN. Arduino board and radio frequency reader placed on roadside will be used for this purpose. This reader will read and scan the radio frequency tag placed on the emergency service vehicles and signal the Arduino board to halt its normal operation and open the right lane barricade so that the intended emergency vehicle can pass the road junction. This will also reduce the number of accidents occurring due to violation of traffic rules by passing the road junction during the stop signal.

For implementation, we are using Arduino-Mega and RFID technology. The system has the ability to open a complete lane for such emergency cases. As a result, the system will guarantee the fluency of traffic for the main vital streets and paths that require fluent traffic during peak hours of the day and the traffic density. This system is being smart because it can run automatically. Without human intervention using timer circuits designed using Arduino board or can be turned to allow human intervention at certain circumstances using remote control.

2. Literature Survey

- Sanjay Kumar Sahu, Atul Basant, Taman Vasudev, Kusagra Khati, Nikhil Lawrence published a paper on Traffic Management System using IoT (2021). Working on the basis of IoT and its embedded network and it is taking real time data as the input to track the traffic management system and giving output in terms of time assigned to traffic lights on the basis of density.

- A Review of IoT Application in a Smart Traffic Management System by Md Khurram Monir Rabby, Muhammad Mobaidul Islam and Salman Monowar Imon (2019). This research presents an IoT-based control system uses real-time traffic information for controlling the traffic loads by changing the traffic signals. The mounted sensors and cameras at strategic traffic junction collect vehicle density of the roads and divert the vehicle direction by changing the traffic signals frequently.

- Syed Arshad Basha, Deep Rakesh, Chirag, Mahesh, Prof. Satish Kumar published a journal on Smart Traffic Control using Arduino UNO and RF module. It is developed with integration of all hardware components Utilizing an IR sensor and RF technology, to effectively reduce the delay time for emergency vehicles.

- Harshal Gunda, Rishikesh Waghunde, Suraj Malwatkar, Aditya Desai, Pallavi Baviskar, Smart Traffic Management System Using Arduino and RFID Tags (2018). Using this system, there will be fewer chances for disobeying of traffic rules and number of accidents. Also, time delay for vehicles of emergency services to reach their destination will be less.

- Pendurthy Bhavana, Pediredla Likhitha, Chiluvuri Manoj, Lakshmi Sutha Kumar published a paper on IoT based Dynamic Road Traffic Management System (2022). In this paper, road traffic management system is designed using the IR sensors, Arduino Uno, 74HC595 and traffic lights. The system is simulated in the Proteus software. The sequence and duration of the GREEN signal is varied based on the density of the roads which is measured with the help of 4 IR sensors.

- K. Ramesh, A Lakshna, and P. N. Renjith published a paper on Smart Traffic Congestion model in IoT in the year 2020. To minimize the traffic congestion in a certain area by diverting or redirecting the upcoming vehicles into the shortest path or alternate path. To predict and prevent the traffic in smart cities, Sensor-based techniques are started using normal traffic cameras in which IoT plays an important role. Some other techniques using signals from vehicles through Wi-Fi, Bluetooth,

Zigbee from the smart devices used in vehicles and data used to analyze the traffic pattern by vehicle count.

- Traffic Management System Using IoT by Omid Avatefipour, Student Member, IEEE, Froogh Sadry, Student Member, IEEE Electrical and Computer Engineering Department, University of Michigan – Dearborn. In this paper, several intelligent traffic management systems were reviewed. These included utilization of RFID readers and tags, Green Wave Systems, smart phones and wireless communication with Big Data centre. Applications, pros and cons of each method were discussed and summarized briefly in Tables 1 and 2. The technique of IoT has been used in order to gather data which related to traffic congestion more quickly and more accurately.

- Intelligent Traffic Monitoring System (ITMS) for Smart City based on IoT Monitoring by Arman Syah Putra Computer Science Department, BINUS Graduate Program - Doctor of Computer Science, Bina Nusantara university and Harco Leslie Hendric Spits Warnars ,Computer Science Department, BINUS Graduate Program - Doctor of Computer Science, Bina Nusantara university. In this paper, with intelligent monitoring, many help the government and officers work, with proper tracking the community can measure the distance travelled so that they can arrive quickly at the destination, and reduce accident in the road. The proposed Internet of Thing (IoT) monitoring which applied such as motion sensor monitoring, ultrasonic sensor monitoring, Passive Infra-Red (PIR) sensor monitoring and speed sensor monitoring.

- An Internet of Things (IoT) based Smart Traffic Management System: A Context of Bangladesh by Abdul Kadar Muhammad Masum, Md. Kalim Amzad Chy, Iaamanur Rahman, Mohammad Nazim Uddin, Khairul Islam Azam This paper proposed a smart TMS to control traffic situation more effectively and efficiently. By analysing sensor data, it sets traffic signal time dynamically and sends the data to a cloud server through a Wi-Fi module that is stored for further data analytics. It also deals with emergency vehicles.

3. Requirement Specification

3.1 Hardware Requirements

3.1.1 Arduino MEGA

The Arduino Mega is a microcontroller board based on the ATmega2560 microcontroller. It is part of the Arduino family of open-source hardware and software products designed for easy prototyping and development of electronic projects. The Arduino Mega is particularly well-suited for projects that require a large number of digital input and output pins, and it offers a variety of features for interfacing with sensors, displays, and other components. Here are some key features of the Arduino Mega:

1. Microcontroller: ATmega2560 with 256 KB of flash memory, 8 KB of SRAM, and 4 KB of EEPROM.
2. I/O Pins: The Arduino Mega has 54 digital input/output pins, of which 15 can be used for pulse-width modulation (PWM) output. It has 16 analog input pins, which can be used to read analog voltage levels from sensors or other analog devices.
3. USB Connection: It features a USB connection for programming the board and communicating with a computer. It can also be powered via USB.
4. Power Supply: The board can be powered through a DC power jack, an external power supply, or the USB connection.
5. Clock Speed: The ATmega2560 operates at 16 MHz, providing fast processing capabilities for your projects.
6. Memory: The board has ample program and data memory, making it suitable for complex projects.

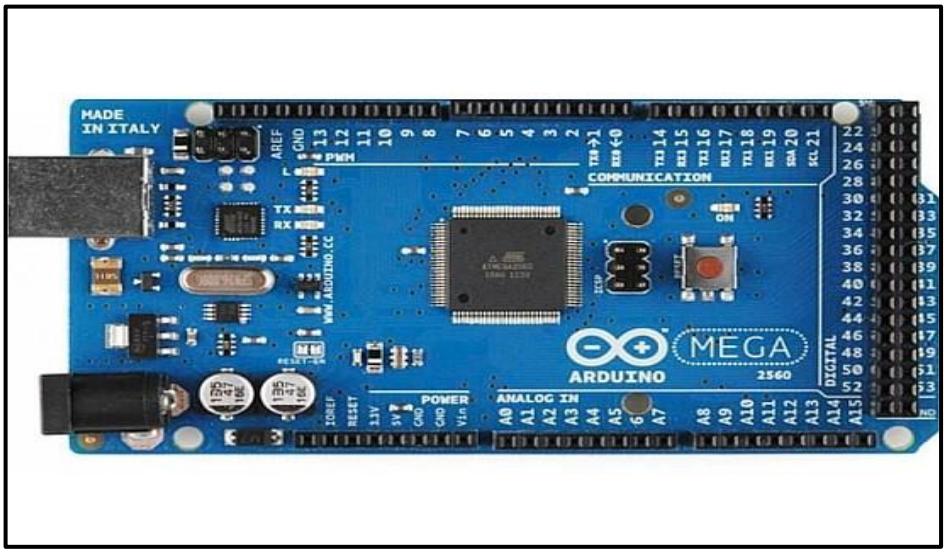

Fig.3.1: Arduino mega

3.1.2 Ultrasonic Sensors

An ultrasonic sensor is an instrument that measures the distance to an object using ultrasonic sound waves. An HC-SR04 ultrasonic distance sensor actually consists of two transducers. One acts as a transmitter that converts the electrical signal into 40 KHz ultrasonic sound pulses. The other acts as a receiver and listens for the transmitted pulses. When the receiver receives these pulses, it produces an output pulse whose width is proportional to the distance of the object in front. This sensor provides excellent non-contact range detection between 2 cm to 400 cm. Since it operates on 5 volts, it can be connected directly to an Arduino or any other 5V logic microcontroller. VCC supplies power to the HC-SR04 ultrasonic sensor. You can connect it to the 5V output from your Arduino. TRIG(Trigger) pin is used to trigger ultrasonic sound pulses. By setting this pin to HIGH for 10µs, the sensor initiates an ultrasonic burst. ECHO pin goes high when the ultrasonic burst is transmitted and remains high until the sensor receives an echo, after which it goes low. By measuring the time, the Echo pin stays high, the distance can be calculated. The working principle of this module is simple. It sends an ultrasonic pulse out at 40kHz which travels through the air and if there is an obstacle or object, it will bounce back to the sensor. By calculating the travel time and the speed of sound, the distance can be calculated. To detect transparent and other items where optical technologies may fail, ultrasonic sensors are a reliable choice.

Fig.3.2: Ultrasonic sensors (HC-SR04)

3.1.3 RFID Module

An RFID or radio frequency identification system consists of two main components, a tag attached to the object to be identified, and a reader that reads the tag.A reader consists of a radio frequency module and an antenna that generates a high frequency electromagnetic field. Whereas the tag is usually a passive device (it does not have a battery). It consists of a microchip that stores and processes information, and an antenna for receiving and transmitting a signal. When the tag is brought close to the reader, the reader generates an electromagnetic field. This causes electrons to move through the tag's antenna and subsequently powers the chip. The RC522 RFID module based on the MFRC522 IC from NXP is one of the cheapest RFID options you can get online for less than four dollars. It usually comes with an RFID card tag and a key fob tag with 1KB of memory. And the best part is that it can write a tag that means you can store any message in it. The RC522 RFID reader module is designed to create a 13.56MHz electromagnetic field and communicate with RFID tags (ISO 14443A standard tags). The reader can communicate with a microcontroller over a 4-pin SPI with a maximum data rate of 10 Mbps. It also supports communication over I2C and UART protocols. The RC522 module has a total of 8 pins that connect it to the outside world.

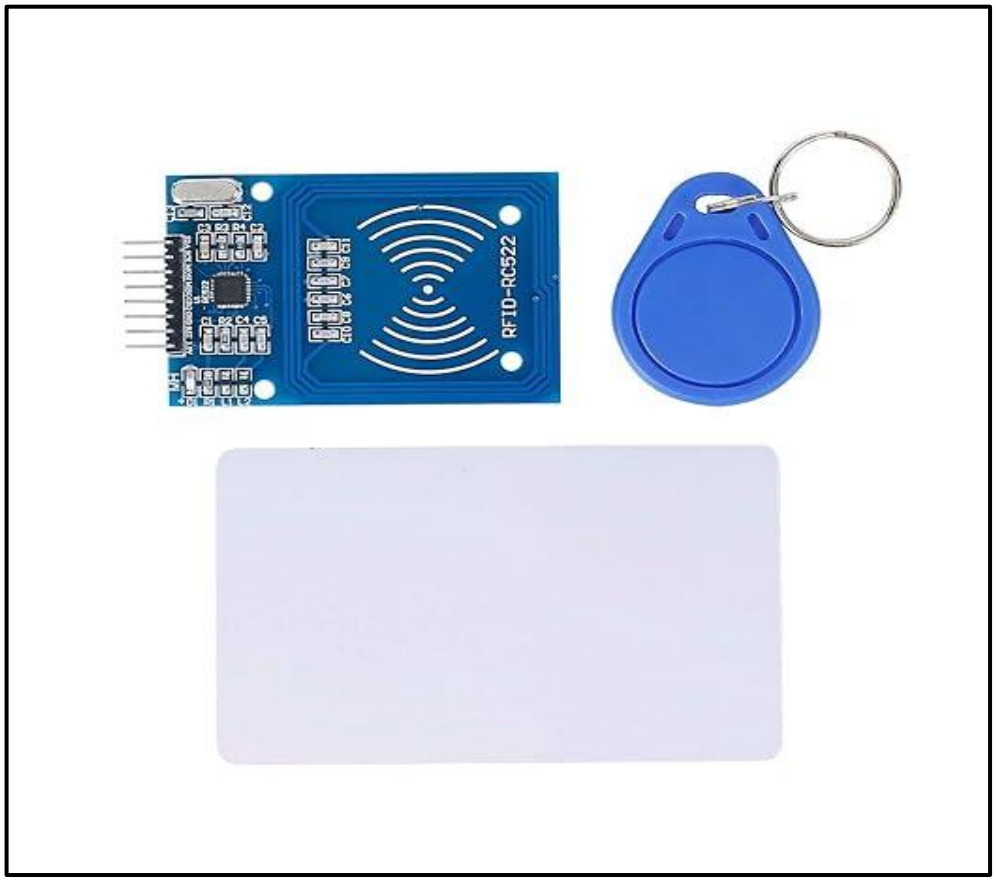

Fig.3.3: RFID Module

3.1.4 Traffic LEDs

Traffic lights follow a universal colour code that changes the direction given to users in the order of bright lights or three- colour LEDs: Red, Green, and Yellow. Red indicator is used to stop the vehicles in the road traffic; Green indicator is used to allow the vehicles to move in the road traffic, and yellow indicator is used to alert the people in traffic lane to be ready for moving the vehicles in the road-traffic. Figure 4 shows the colors used in traffic lights.

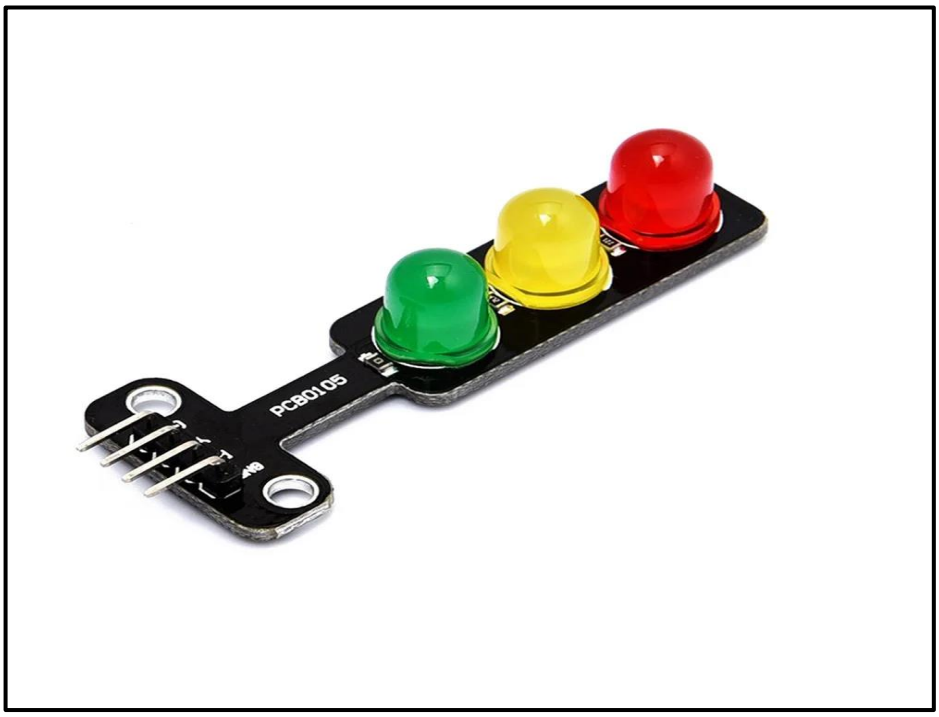

Fig.3.4: Traffic LEDs

3.2 Software Requirements

The Arduino Integrated Development Environment (IDE) is an open-source software platform used for programming and developing applications for Arduino microcontroller boards. Arduino is a popular platform for hobbyists, students, and professionals to create a wide range of electronic projects and prototypes.

Here are some key aspects of the Arduino IDE:

1. Cross-Platform: Arduino IDE is available for Windows, macOS, and Linux, making it accessible to a broad user base.
2. Code Editor: It provides a text editor where you can write, edit, and save your Arduino sketches (code) written in C/C++.
3. Built-in Libraries: The IDE includes a collection of libraries that simplify interfacing with various hardware components, making it easier to control sensors, displays, motors, and other peripherals.

4. Compiling and Uploading: Arduino IDE compiles your code into machine-readable binary files and uploads them to the Arduino board over a USB connection.
5. Serial Monitor: It has a built-in serial monitor that allows you to interact with your Arduino projects and view debugging information sent over the serial port.
6. Board Manager: Arduino IDE supports various Arduino boards, and you can select the appropriate board from the "Boards Manager."
7. Library Manager: You can easily add and manage third-party libraries for additional functionality.
8. Examples: The IDE provides a variety of example sketches to help you get started with different hardware and programming tasks.

4. Design Model/ System Architecture

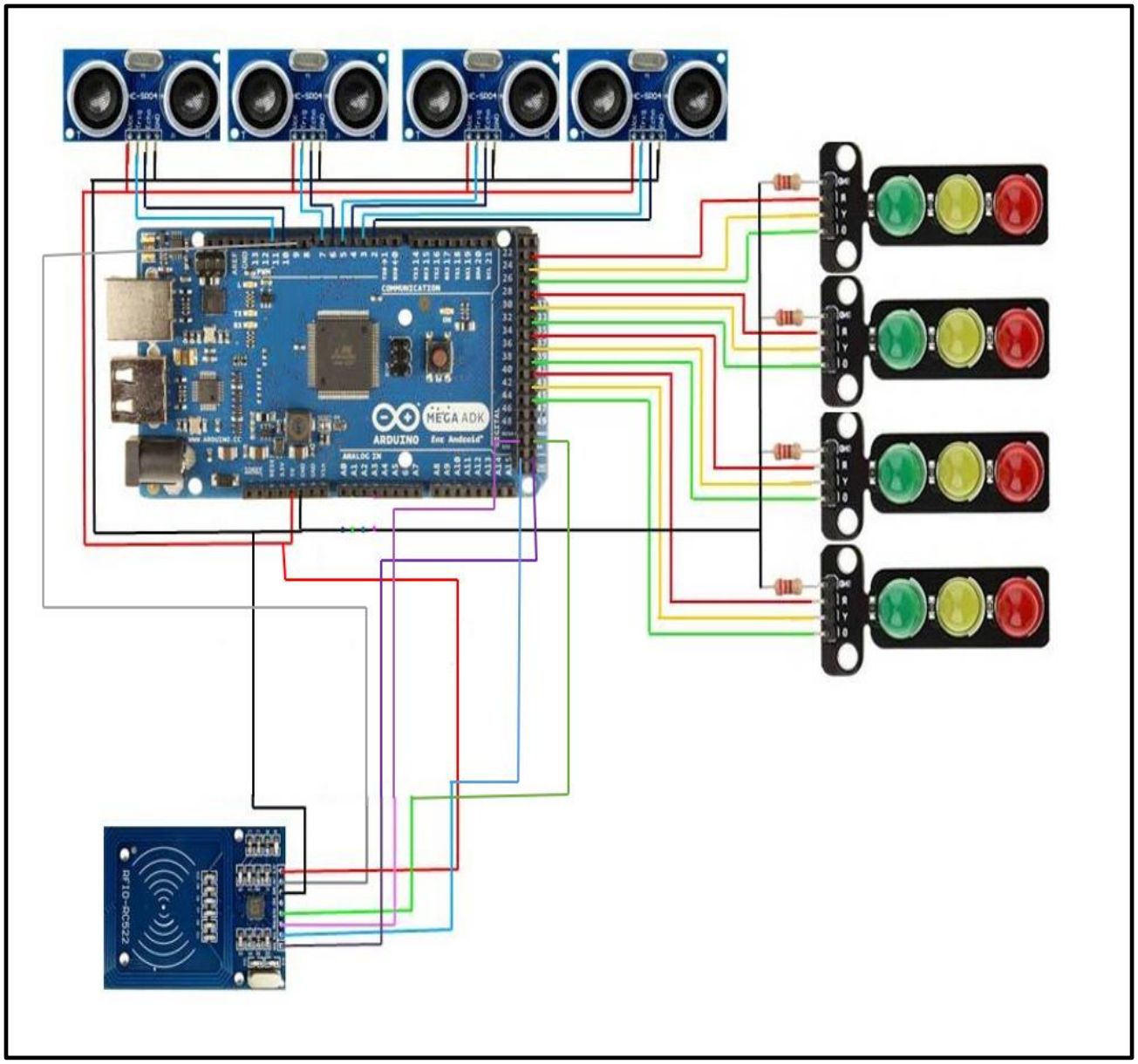

Fig.4.1: Circuit Diagram

The system is designed and simulated using Arduino IDE and Arduino Mega as the controller. The ultrasonic sensors of four directions are connected to (11,10), (7,6), (9,8), (3,2) pins of Arduino. And 4 traffic lights are connected to (23,25,27), (29,31,33), (35,37,39) and (41,43,45) pins of Arduino. The RFID RC522 is connected to (5,53) pins of Arduino. And one LED connected to pin 49 of Arduino.

5. Implementation

Below figure shows the basic layout of a road traffic management system. The four-lane intersection junction is taken, traffic lights, and Ultrasonic sensors are placed on the four sides.

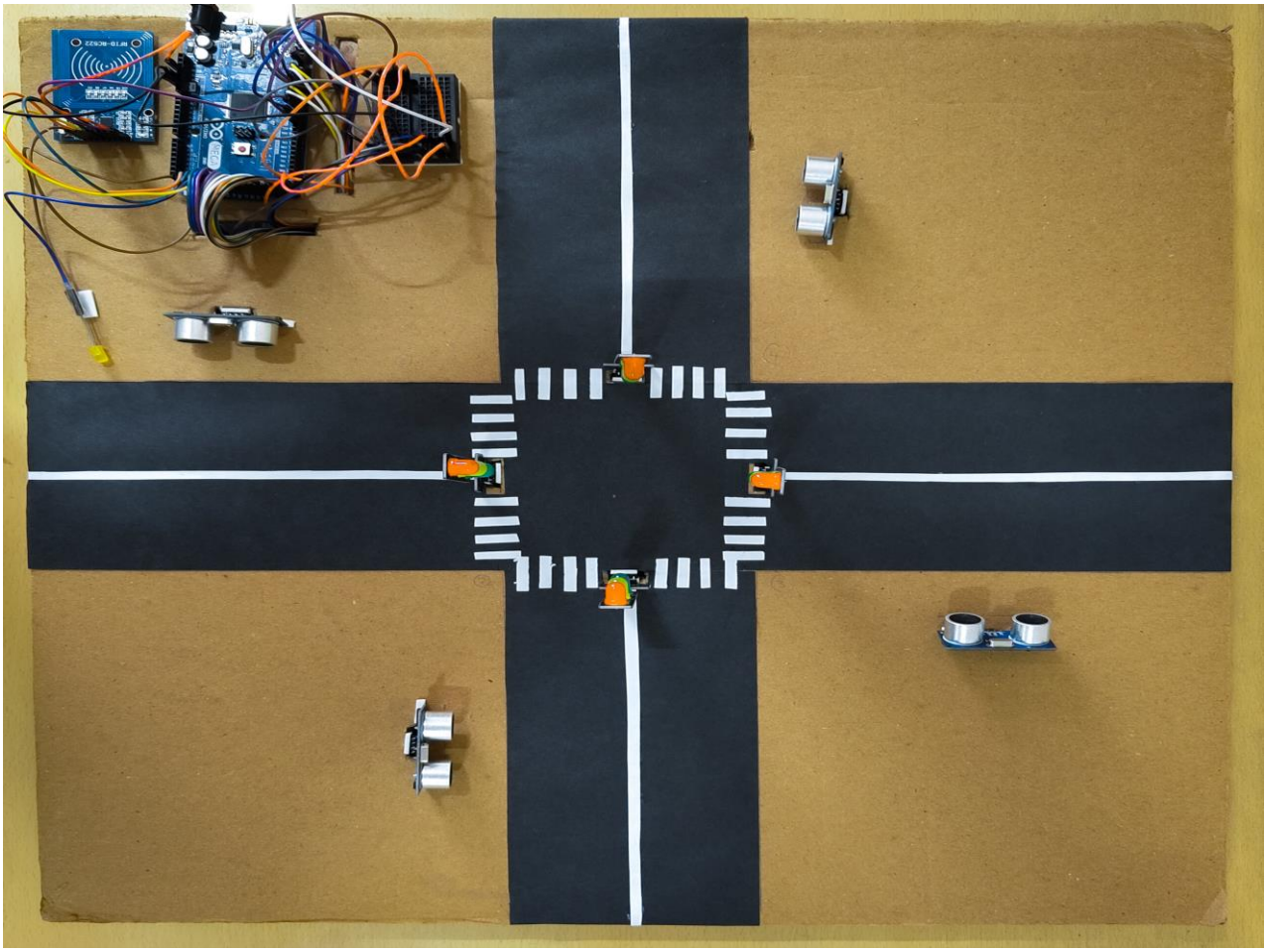

Fig.5.1: Four-lane intersection junction

The system is designed and simulated using Arduino IDE and Arduino Mega as the controller. The ultrasonic sensors of four directions are connected to (11,10), (7,6), (9,8), (3,2) pins of Arduino. And 4 traffic lights are connected to (23,25,27), (29,31,33), (35,37,39) and (41,43,45) pins of Arduino. The RFID RC522 is connected to (5,53) pins of Arduino. And one LED connected to pin 49 of Arduino.

5.1 Normal Cycle

There are RED, YELLOW, and GREEN LED's. For each of the colour, a mask pattern is present. Every time, Arduino takes traffic data as input, it decides which road should get which colour. Initially the 1st lane will have GREEN LED High and for all other lanes it will be having RED LED High. After delay of 15 seconds the YELLOW LED of 2nd lane will be High and other all lane's RED LED will be High after delay of 5 seconds

GREEN LED of 2nd lane will be High for 15 seconds. After 15 seconds the same cycle continues for 3rd lane then 4th lane and again for the 1st lane and so on.

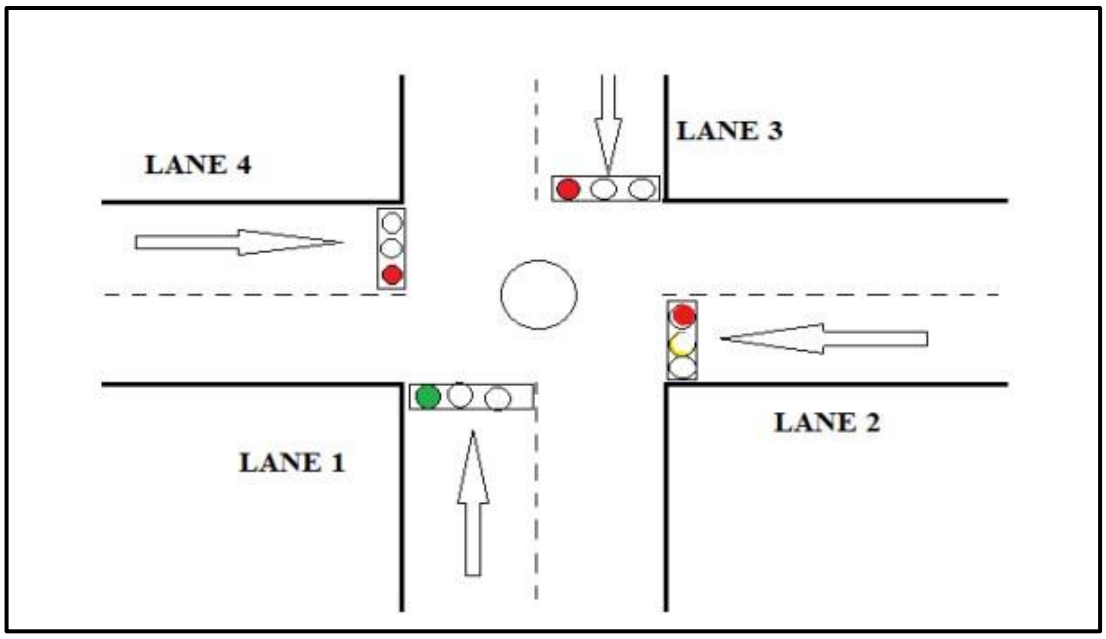

Fig.5.2: Normal cycle

5.2 Density based Traffic Management with Dynamic green signal timing

The ultrasonic sensors are kept at some distance from the junction which collects the data and are used to detect the density of the traffic in a particular lane. If traffic extends up to that point, that road is considered as a high traffic zone, otherwise it is considered as a low traffic zone. If any data comes from Ultrasonic sensor of any road, it means traffic is more on that road. So, green signal is given to the road having high density rather than following the normal sequence as before.

While running a normal cycle if there are more vehicles in any lane then the lane opposite to lane with more vehicles green light will be High in order to control congestion. Consider a senior if the GREEN LED for 4th lane is High and there is more traffic density on the 1st lane. According to the normal cycle the 1st lane GREEN signal will be on but now due to high density on lane 1, the GREEN LED of 4th lane will be HIGH so that congestion on lane one will be cleared and then the normal cycle will work as before.

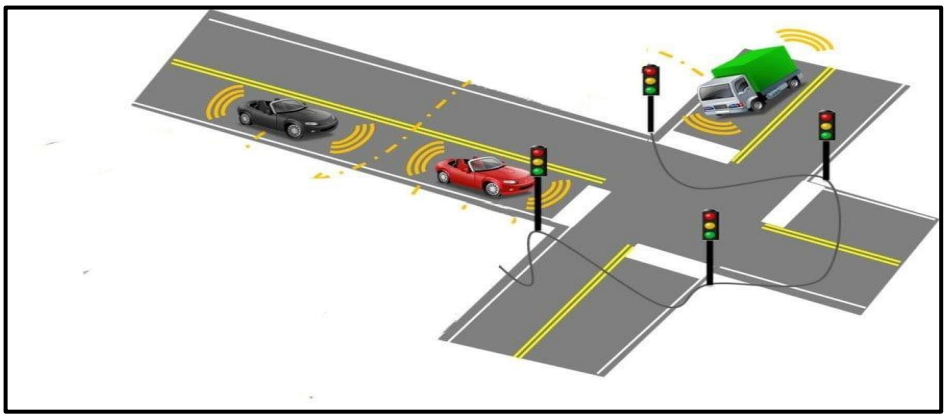

Fig.5.3: Density based traffic management

5.3 Emergency Vehicle Detection

The RFID tags are used to detect emergency vehicles like ambulance. When there is an Ambulance in lane, immediately the Green signal for Ambulance will be given so that Ambulance can be moved without interruption so patients can be reached to hospital as soon as possible. When there is Ambulance in lane 1 and yellow signal for lane 2 is High and after 5 sec delay the green signal for lane 2 has to be high but due to detection of ambulance on lane 1 the green signal for lane 3 will be high and for all other lane's red signal will be High. When the ambulance moves the normal cycle will continue, in this case 2 lane's green signal will be high.

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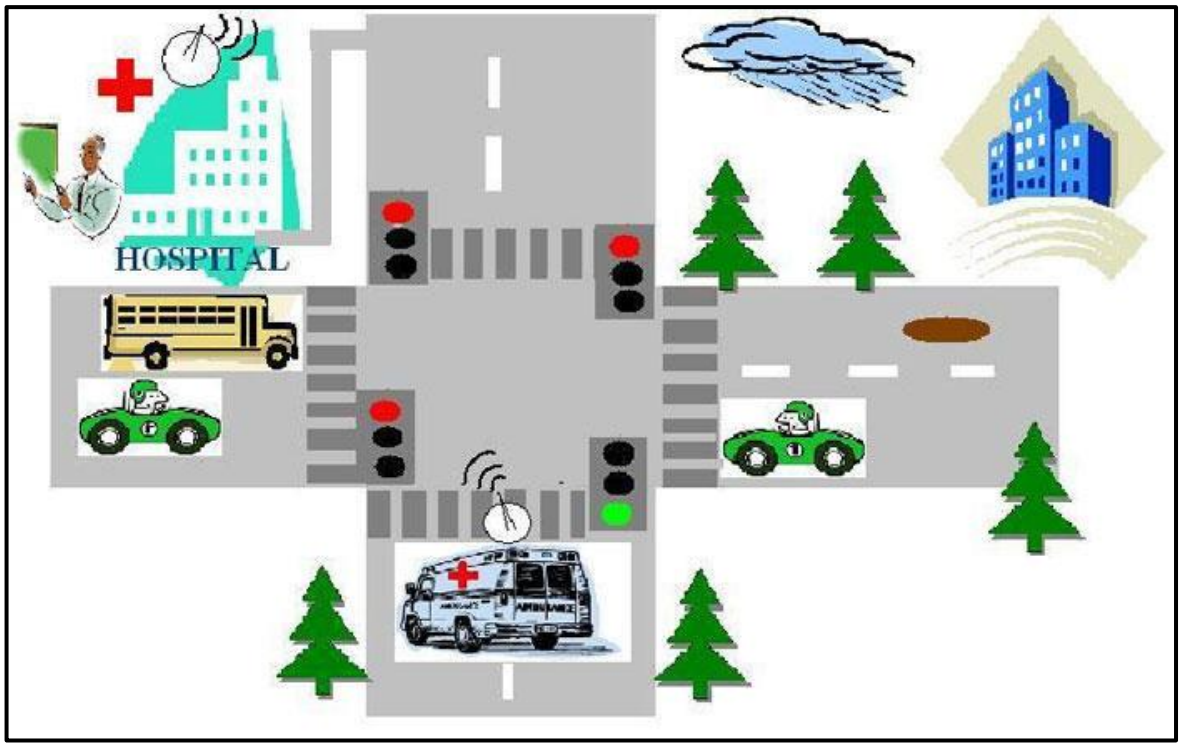

Fig.5.4: Emergency Vehicle Detection

6. Result Discussion

In Normal mode, the system's entire operation depends on an on-chip microcontroller that is programmed to control traffic signals at set, predetermined intervals of time and based on the traffic density. As a result, signals are altered in various ways at various time intervals based on predefined time intervals. Similar to this, each central traffic control system is configured with unique functions and operating principles in response to the level of traffic congestion, Ultrasonic sensors based real-time traffic monitoring system can measure traffic density at roads. The smart traffic management system will give output on the basis of density of the traffic lanes so there will be particular time assigned to the lanes for the passing of vehicles so it will lower down the traffic congestion and also in the case of emergency there will be option for that to continue the traffic in normal way. And whenever it detects emergency vehicle, the traffic light of corresponding lane at intersection turns green and other all lane will become red so that emergency vehicle can move without any interruption.

The 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 system will be designed in such a way that it will able to control the traffic congestion. And it can also be maintained very easily.

7. Conclusion And Scope of Future Enhancement

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.

This project 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. This project also makes sure that emergency vehicle like ambulance will not suffer from any interruption due to traffic signal so that ambulance can reach hospital as soon as possible.

Scope of Future Enhancement:

For this system we can implement the features which help the Ambulance driver to find the nearest hospital in case of emergency. Also, we can provide information about the availability of doctors and send the alert to doctors about the patient so that they can prepare accordingly. By implementing camera module, we can detect the normal cars which are under emergency. And also detect VIP vehicles so that they can move with zero traffic.