Smart Traffic Light System using IOT

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## Abstract:

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A Internet of Things-based smart traffic light system technology is a great example of how cities can increase traffic monitoring and reduce congestion in real time. This system uses IoT sensors like cameras, infrared detectors, and vehicle counters at intersections to measure traffic density. The information gathered by these sensors is transmitted wirelessly to middle control system, which processes the information and adjusts the traffic lights as needed. By adjusting the lights based on real-time traffic conditions, the system helps reduce the time drivers spend waiting at red lights. This, in turn, decreases the amount of time vehicles idle, which lowers fuel use. It also helps reduce air pollution in urban areas. Additionally, the system could be adapted to give priority to emergency vehicles, similar to how regular traffic lights respond in emergencies. The IoT sensors would just need to be programmed to recognize and clear the way for emergency vehicles, just like traditional traffic lights do.

Keywords: Congestion management involves using data collection to monitor traffic in real time, which helps in optimizing traffic flow. This system also prioritizes emergency vehicles to ensure they can move through busy areas quickly. By keeping track of traffic conditions as they happen, operators can make timely decisions to improve overall traffic efficiency.

# I.INTRODUCTION:

As the world's population moves from rural to In cities, traffic management has become a serious concern.The number of vehicles in urban areas has grown quickly, putting a lot of pressure on city roads. Traditional traffic signals, which either rely on manual control or fixed time cycles, are not good enough for

handling these changing traffic conditions. These systems can't adjust to real-time changes, leading to problems like traffic jams, Long journey times, more fuel consumption, and increased emissions.

One big problem with current systems is that they are not flexible. Fixed-time signals keep running even when there are no cars, making people wait longer and causing delays for drivers. Manual control helps during busy or emergency times, but it takes a lot of work and is not always accurate. Even systems that use simple sensors to detect cars can't track how many cars there are, how fast they're moving, or which lanes should get priority. Also, there's no special treatment for Emergency vehicles, such as ambulances, fire engines, and police vehicles, which can cause delays that may cost lives or damage resources.

To address these issues, using a Smart Traffic Light System with the IoT has shown to a smart and effective solution. IoT connects sensors, cameras, controllers, and servers in the cloud, allowing them to share information and make better decisions. In our proposed smart traffic system, real-time traffic density is measured using infrared sensors, cameras, and either image processing or detection methods (or both).

Based on this data, traffic lights are adjusted in

traffic and shorter ones to lanes with less, making the flow of traffic more efficient.

# LITERATURE REVIEW:

Numerous researchers have studied smart traffic management using IoT technologies.[1] Gaikwad, V., Holkar, A., Hande, T., Lokhande, P., and Badade, V. (2023) looked into Intelligent Traffic Controller System with IoTin their paper titled "Data Science and

Intelligent Computing Techniques." They used Raspberry Pi and OpenCV for surveillance and automatic traffic signal regulation, noting improvements in traffic flow. They considered real- time vehicle detection and congestion limits, but their system wasn't reliable when vehicle colors were similar to the road surface.

[2]Arun Kumar (2022) also introduced a Smart Traffic Light Control System in the IJFANS journal – International Journal of Food and Nutritional Science. Their system used PIC microcontrollers with IR sensors and XBee technology, including an emergencyoverride. Traffic signals were adjusted based on traffic density, with longer green lights during high traffic and priority given to emergency vehicles. However, the system had limitations, such as only working at a single junction, requiring manual override, and not considering pedestrians.

In another study, [3]S.C. Rai, S.P. Nayak, B. Acharya, and V.C. Gerogiannis proposed an Intelligent Traffic Signaling System Based on IoT in the journal Electronics (MDPI). They used inductive loops and IR sensors to detect vehicles and determine prioritization. Their system improved traffic flow and reduced waiting times, but the high cost of the technology and the complexity of maintaining large-scale sensor networks were major drawbacks.

Other researchers have also explored innovative IoT- based solutions. For example, [4]Faisal Al Kalbani, Nada Al Bulushi, and Syed Imran (2023) presented an ICT-Based Smart Traffic Light Controller at the 4th Middle East College Conference. Their system used Arduino UNO with IR sensors and RFID to prioritize emergency vehicles. While it allowed for adaptive traffic control and reliable emergency responses, there were issues with scaling their vehicle detection system and hardware reliability.

[5]Gunashree H.S., Harshitha D.V., Siddesh Prasad B.C., Karthik Kumar J., and Dimple R. proposed an IoT-based Smart Traffic Signal Monitoring System Using Vehicle Density in their paper (IRJMETS). Their system used line-of-sight RF communication but had limited practical use beyond the scope of their study. [6]Dr. Sowmya K.S., Soumya Ranjan Sahoo, Urmila M, and Harshith J. Raj discussed a Smart Traffic Management System Using IoT in the

International Journal of Creative Research Thoughts. Their model used YOLOv3 for vehicle detection, IR sensors for density control, and an NFC system for emergency vehicle prioritization. Combining AI and IoT, their system could help reduce emergency vehicle wait times if integrated across a city. However, the initial setup and ongoing maintenance costs and complexity are major considerations.

1. Shailesh Shivajirao Bhise (2025) published an IoT Application in a Smart Traffic Management System in the Journal for Research in Applied Sciences and Biotechnology. The paper reviewed IoT applications in traffic management, focusing on real-time data, AI, and sensor cooperation. It noted that IoT systems improve traffic efficiency with real-time monitoring, adaptive control, and predictive management. However, challenges like large-scale deployment, cybersecurity risks, and interoperability issues still exist.
2. Megha Balmiki, Sahali Dutta, Ankita Majumder, Osmeeta Chauhan, and others (2022) proposed a Smart Traffic Lighting System in JETIR – Journal of Emerging Technologies and Innovative Research. They used IR and ultrasonic sensors with an AT89C51 microcontroller to manage traffic signals in real time and track emergency vehicles. The system improved waiting times and traffic flow, but high implementation costs, complex maintenance, and limited efficiency in emergency services were noted.
3. Rahul Biju, Sakshi Jain, Nehal Hemdev, Teesha P Jain, Preeth T Jain, Dr. Anita Walia, and Dr. Supriya Rai (2023) developed a Smart Traffic Management System Using IoT published in IRE Journals.
4. Pratik Prakash, Aadarsh Singh, Aayush Parasrampuria, and Gargi Sharma (2021) created an IoT-based smart traffic management system described in the International Journal of Electrical, Electronics and Computers. They used IR sensors and Arduino Nano, with simulations on Proteus and a web-based live monitor. Their system reduced waiting times and monitored traffic and emergency vehicles in real time. However, they faced issues with limited range and adjustment requirements for real-world applications.

[11]G. Goutham, T. Maheshwar Reddy, N. Varun Reddy V. Karthik, and K. Sai Sudheer (2020) designed

an IoT-based Intelligent Traffic Management System in the International Research Journal of Engineering and Technology (IRJET0).

They used Arduino UNO and IR sensors to detect vehicle density and simulate traffic control. Their system allowed for quicker clearance of emergency vehicles and safe traffic guidance. However, sensor range limitations, hardware costs, and scalability issues in large-scale real-world environments were noted.

# EXISTING SYSTEM:

Most of the traffic control and management systems in use today rely on fixed-time or manual control methods, which do not have the ability to sense traffic conditions in real time. Fixed-time signals operate on set time intervals, which means they cannot adjust to changing traffic density or the presence of emergency vehicles. This can result in unnecessary delays. Semi- automated systems, even when they include road sensing technology, are not able to adapt quickly to sudden events like accidents or a sudden increase in traffic volume. Systems that are commonly considered include: fixed-time traffic signals, manually controlled signals, and semi-triggered automated systems. Fixed- time signals use a preset timeline to determine how long each lane gets a green light, for example, 30 seconds per lane. The timing is fixed and does not take into account the actual presence of vehicles or emergency vehicles. If vehicles are already on the road during the pre-scheduled green light, this can cause problems and lead to inefficient traffic flow. Manual control requires traffic police or operators to manage traffic during busy periods, special events, VIP movements, or emergencies. This approach is often time-consuming and not always effective. Semi- triggered automated systems use devices like inductive loops or pressure switches to detect vehicle presence. These systems can only identify if a vehicle is in a specific location or among several lanes, giving a general idea of traffic volume. However, they are not equipped to adjust dynamically for changing traffic conditions or to prioritize emergency vehicle paths for safety.

# DRABACKS:

The current traffic management systems have several major flaws that make them less efficient and dependable. One problem is that these systems aren't able to adjust to changing traffic conditions in real time. Traffic signals keep running on set

schedules,matter how much or how little traffic is actually moving. This can cause unnecessary delays. For example, if there are no vehicles at an intersection, the light might still stay red, making the wait longer for everyone.Another serious issue is that these systems don't have the ability to detect Emergency vehicles, such as medical vehicles, fire engines, and police vehicles. This can create dangerous delays, especially in urgent situations where quick passage is needed. Sometimes, traffic officers try to fix these problems by manually changing signals, but this process is time-consuming and can lead to mistakes, making the system less effective. When vehicles sit idling for long periods at traffic lights, it wastes both time and fuel, which are big problems. Also, idling engines, especially those running on carbon-based fuel, produce a lot of pollution and emissions. Another big shortcoming is the lack of proper monitoring and data collection. These systems often don't allow for easy access to real-time or historical data, which means traffic authorities can't analyze trends or make improvements. Without this data, it's hard to plan better strategies. Lastly, these systems aren't built to grow or adapt. Making changes usually needs a lot of money and effort, which makes it hard to keep up with the needs of modern cities.

# PROPOSEDSYSTEM: A.SYSTEMARCHITECTURE:

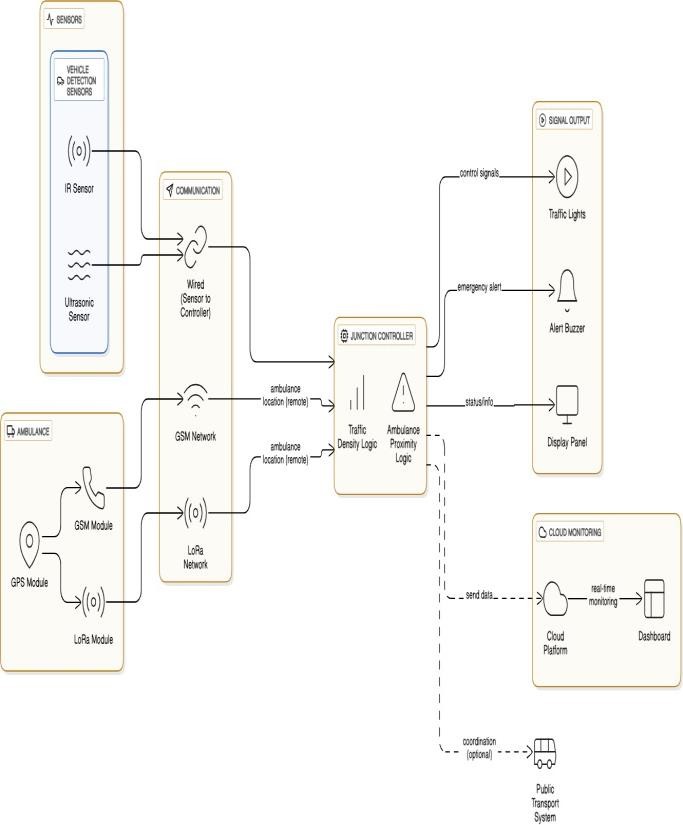


Fig.1. Architecture of IoT-Based Smart Traffic Light System with Emergency Vehicle Priority

The diagram shows the architecture of an IoT-based Smart Traffic Light System designed for real-time traffic management and prioritizing emergency vehicles. Vehicle detection is done using IR and ultrasonic sensors that send data through wires to the junction controller. The ambulance is equipped with GPS and GSM/LoRa modules to share its location over communication networks.

The junction controller uses traffic density logic and ambulance proximity logic to process data from both the sensors and the ambulance. It then decides on the right signal timing based on this information and gives priority to the ambulance.

Once a decision is made for each traffic light, the controller sends the correct signal to the traffic lights, activates one or more buzzers for alerts, and updates the display panels for people on site.

The system also sends information about its status and traffic density data to a cloud platform. This allows traffic authorities to monitor everything in real time and view it on a dashboard when needed. Overall, by keeping track of traffic violations and giving priority to emergency vehicles based on traffic density at intersections, the system makes traffic management more efficient, safe, and reliable in urban areas.

# B.MODULE DESCRIPTION:

The preposed system consist of five modules

1. Traffic Detection Module
2. Emergency Vehicle Detection Module
3. Controller Module y
4. IoT Communication Module
5. Signal Actuation Module

## TrafficDetectionModule:

The traffic detection module is designed to monitor how many cars are on the road. It uses infrared sensors to count all the vehicles present. Additionally, it has a camera that uses OpenCV to analyze a real-time video feed and identify vehicles. The system can also measure the size of each vehicle, giving priority to larger ones. This helps improve the flow of traffic and reduces traffic jams.

## EmergencyVehicleDetectionModule:

The emergency vehicle detection module identifies ambulances and fire trucks using detection devices that may include tags, RFID readers, or GPS modules. If an emergency vehicle is recognized, the system interrupts the normal traffic signal cycle to provide a clear path for the vehicle. This allows emergency services to reach their destination without delays by giving them immediate access to the scene or emergency location.

## Controller Module:

The controller module, which could be a Raspberry Pi, ESP32, or similar device, acts like the brain of the system. It gathers data from the sensors and cameras, processes that information, and uses the programmed logic to change how long traffic signals stay on. This

module lets the traffic lights respond to how traffic is behaving instead of following a fixed schedule.

## IoT Communication Module:

This module enables communication between the traffic system and the cloud through Wi-Fi. Traffic data and signal data are transmitted to IoT platforms like ThingSpeak or Firebase, allowing local authorities to monitor the system from a distance. Connecting to the cloud also lets end-users view real-time updates and manually control the system when needed.

## Signal Actuation Module:

The signal actuation module is in charge of managing the traffic lights. It uses LED lights or relays to show the standard red, yellow, and green signals. These signals are controlled via GPIO pins on the controller, based on logic that is calculated using real-time data. The module also allows for longer green light times when there is a higher volume of traffic or when emergency vehicles are present.

C.ALGORITHM:

Algorithm 1: Smart Traffic Light System Using IoT

1. Input: Traffic density statistics (D), Emergency automobile repute (E)
2. Output: Optimized traffic signal timing (T)
3. Initialize gadget modules: Sensors, Controller, IoT verbal exchange, Signal actuation
4. Acquire traffic density from IR sensors and digicam (OpenCV)
5. Process density records to calculate quantity of vehicles in keeping with lane
6. If Emergency vehicle detected (E = TRUE):
   1. Identify nearest lane with emergency vehicle
   2. Override ordinary cycle and set GREEN signal for emergency lane
   3. Maintain RED indicators for different lanes till emergency vehicle passes
7. Else (no emergency vehicle):
   1. Compare density values across all lanes
   2. Assign GREEN signal length proportional to traffic density
   3. Assign shorter GREEN indicators to low-density lanes
8. Update traffic lights through Signal Actuation Module
9. Transmit visitors facts and gadget repute to IoT cloud server
10. Display real-time statistics on monitoring dashboard.

# RESULTS AND DISCUSSIONS: IMPLEMENTATION DETAILS:

The smarter traffic light system mentioned earlier combines both hardware and software to better manage traffic flow. IR sensors and cameras help measure how crowded the roads are, while RFID readers, tags, and GPS modules help identify

emergency vehicles so they can move through more easily. A Raspberry Pi or ESP32 serves as the main control unit, connected to LED traffic lights and a Wi- Fi module to link the system to the cloud. For the software, Python, C++, and the Arduino IDE are used to control the hardware, and OpenCV is used for processing images. Cloud platforms like ThingSpeak, Firebase, or AWS IoT allow real-time monitoring and data storage, while communication protocols similar to MQTT and HTTP ensure reliable data exchange between the controller and the cloud service.

# CONCLUSION AND FUTURE WORK:

This Smart Traffic Light System solves the problems of traditional traffic management by being flexible. Unlike traffic lights that follow a fixed schedule or require manual control, this system changes in real time based on how busy or quiet the roads are. It can clear the way for emergency vehicles like ambulances and fire trucks on the go. Using IoT-enabled sensors such as cameras and cloud connections, it helps cut down waiting times, saves fuel, reduces pollution, and makes traveling easier for everyone.

The system also allows for remote monitoring and keeps track of data, so officials can see how traffic

moves, where the busiest spots are, and plan for the future. Its ability to grow and be customized makes it useful in smart cities, where smart and flexible solutions are key for building sustainable and efficient urban areas.

While the system offers a strong base for managing traffic smartly, there are several improvements that could be added later. For example, using AI and Machine Learning can help predict traffic patterns and adjust signal timings better. Deep learning for image recognition can help identify vehicles like cars, buses, and trucks and direct them properly. Real-time accident detection can send instant alerts to emergency services, making roads safer. Integrating vehicle communication with infrastructure (V2I) would let cars and traffic lights talk to each other. Solar-powered traffic lights could help in rural areas with limited power. The system could also connect with other smart city platforms to share data across different areas like transport, security, and emergency services, supporting a more sustainable city. A mobile app could give commuters real-time updates on traffic, wait times, and alternative routes, making their travel experience better. Ultimately, the system could expand from individual intersections to a full network, supporting smart and sustainable urban mobility on a large scale.

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