

IoT Based Density Based Intelligent Traffic Light Control Signal with RFID Toll Naka

Prof. Manjusha S. Borse¹, Priyanka L. Pawar², Dr. Ravindra G. Dabhade³, Dr. Jayant J. Chopde⁴

Department of VLSI and Embedded System, Matoshri College of Engineering and Research Centre, Nashik, India^{1,3,4}

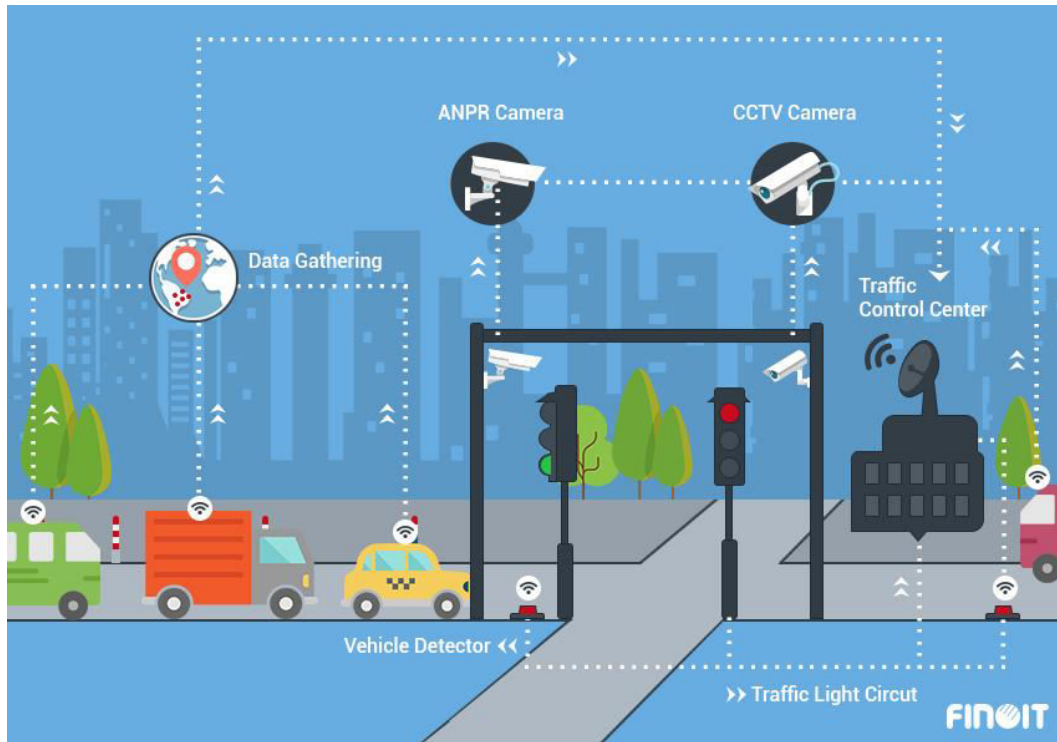
M. Tech Student, Department of VLSI and Embedded System, Matoshri College of Engineering and Research Centre,
Nashik, India²

ABSTRACT: Traffic congestion has become one of the major challenges in urban areas due to the rapid increase in vehicles and inefficient fixed-time traffic signal systems. Conventional traffic lights operate on predefined timing intervals, which often leads to unnecessary delays, increased fuel consumption, and longer waiting times, especially during peak hours. To overcome these limitations, this project proposes an IoT Based Density Intelligent Traffic Light Control System integrated with RFID Toll Naka Management. The proposed system uses IR sensors placed on each lane to detect the real-time vehicle density at the junction. Based on the density level, the ESP32/Node MCU microcontroller dynamically controls the traffic signal duration, giving priority to lanes with higher traffic load. This ensures efficient traffic flow, reduced congestion, and minimized waiting time. In addition, the system incorporates an RFID-based Toll Naka Automation module, where vehicles equipped with RFID tags are automatically identified at toll booths. The RFID reader verifies the vehicle information, and a servo motor-operated barrier gate opens automatically for authorized vehicles. This reduces manual intervention, prevents toll fraud, and speeds up toll collection. The traffic status and toll data are uploaded to a web application and Android app through Wi-Fi connectivity, allowing real-time monitoring and control by traffic authorities. Visual indicators such as LEDs and LCD displays provide instant local updates at the junction. Overall, the proposed system offers a smart, cost-effective, and automated solution for intelligent traffic management and toll booth monitoring, contributing towards smarter transportation infrastructure in modern smart cities.

KEYWORDS: IoT (Internet of Things), Intelligent Traffic Light Control, Density Based Traffic Management, ESP32 / Node MCU, IR Sensors, RFID Toll Naka Automation, Smart Traffic Monitoring, Dynamic Signal Timing, Android Application, Web Application, Servo Motor Gate Control, Smart City Transportation System.

I. INTRODUCTION

Rapid urbanization and the increasing number of vehicles have made traffic congestion one of the most serious problems in modern cities. Traditional traffic signal systems operate on fixed-time intervals, which do not adapt to real-time traffic conditions. As a result, vehicles often experience unnecessary delays, long waiting times, fuel wastage, and increased air pollution, especially during peak hours. To address these issues, intelligent traffic management systems are becoming essential. Smart traffic control aims to reduce congestion by adjusting traffic signal timings based on the actual vehicle density on each road. This helps in improving traffic flow efficiency and minimizing delays. In this project, an IoT Based Density Intelligent Traffic Light Control System is proposed. The system uses IR sensors installed on each lane to detect the number of vehicles waiting at the junction. Based on the traffic density, the ESP32/Node MCU microcontroller dynamically controls the signal timing, giving priority to lanes with higher vehicle load. Additionally, the project integrates an RFID-based Toll Naka Automation system. Toll booths often face long queues due to manual toll collection processes. By using RFID tags and readers, vehicles can be automatically identified, and toll gates can be opened through a servo motor mechanism. This reduces manual effort, speeds up toll processing, and prevents unauthorized access. The entire system is connected through IoT technology, enabling real-time monitoring and control using an Android application and web dashboard. This provides traffic authorities with instant updates and improves decision-making for better transportation management. Overall, the proposed system offers an efficient, automated, and cost-effective solution for traffic congestion control and toll booth management, contributing towards the development of smart city infrastructure.



II. LITERATURE SURVEY

K. Kumar, S. Ranjan “Smart Traffic Light Control System Using IoT and Sensors” K. Kumar and S. Ranjan, in their research paper titled “*Smart Traffic Light Control System Using IoT and Sensors*”, presented an intelligent traffic signal control approach that utilizes Internet of Things technology to improve road traffic management. The authors focused on reducing traffic congestion caused by traditional fixed-time signal systems. In their proposed model, sensors are placed at traffic junctions to monitor vehicle density in real time. The collected data is processed using a microcontroller-based control unit, which dynamically adjusts the signal timing depending on the traffic load on each lane. The system also enables remote monitoring through IoT connectivity, allowing traffic authorities to observe junction conditions efficiently. This work highlights how integrating sensors with IoT can enhance traffic flow, reduce waiting time, and support the development of smart city transportation systems.

M. Patil, R. Kulkarni “Density Based Traffic Signal System Using IR Sensors” M. Patil and R. Kulkarni, in their paper titled “*Density Based Traffic Signal System Using IR Sensors*”, proposed an efficient method to control traffic signals based on the real-time density of vehicles on the road. The authors emphasized that conventional traffic lights operate on fixed time intervals, which often leads to unnecessary delays and congestion, especially when traffic volume varies across different lanes. To overcome this issue, they introduced a system where IR sensors are installed on each road segment to detect the presence and number of vehicles waiting at the junction. The sensor data is then processed by a controller, which adjusts the green signal duration according to the traffic density. This adaptive approach improves traffic flow, minimizes waiting time, and reduces fuel consumption. The study demonstrates that IR sensor-based density detection provides a cost-effective and reliable solution for intelligent traffic management in urban environments.

A. Sharma, V. Gupta “IoT Based Intelligent Traffic Management System for Smart Cities” A. Sharma and V. Gupta, in their research work titled “*IoT Based Intelligent Traffic Management System for Smart Cities*”, presented an advanced traffic control framework designed to support smart city infrastructure. The authors highlighted the growing challenges of traffic congestion, accidents, and inefficient signal systems in urban areas. Their proposed system integrates IoT technology with real-time traffic monitoring to improve the efficiency of transportation networks. Various sensors and communication modules are used to collect live traffic data from road junctions, which is then transmitted to a centralized platform through the internet. Based on the received data, the system can dynamically manage traffic signal

timings, detect congestion levels, and provide timely updates to traffic authorities. The study emphasizes that IoT-enabled traffic management offers better automation, faster decision-making, and improved road safety, making it a key component in the development of smart cities.

S. V. Viraktamath, P. Kulkarni “Adaptive Traffic Signal Control Using Real-Time Vehicle Density” S. V. Viraktamath and P. Kulkarni, in their paper titled “*Adaptive Traffic Signal Control Using Real-Time Vehicle Density*”, proposed an adaptive traffic signal control system that adjusts signal timings based on the actual number of vehicles present at an intersection. The authors pointed out that fixed-time traffic light systems are inefficient in handling varying traffic conditions, leading to congestion and increased waiting time. Their approach uses real-time vehicle density detection techniques to continuously monitor traffic flow on each lane. Based on the collected density information, the control unit dynamically allocates green signal time to the most congested lane, ensuring smoother vehicle movement and reduced delays. The study demonstrates that adaptive signal control improves traffic efficiency, minimizes fuel wastage, and contributes to better urban traffic management. This work provides a strong foundation for implementing intelligent and automated traffic control systems in smart transportation networks.

J. Gubbi, R. Buyya “Internet of Things (IoT): Vision, Applications and Research Challenges” J. Gubbi and R. Buyya, in their influential paper titled “*Internet of Things (IoT): Vision, Applications and Research Challenges*”, provided a comprehensive overview of the Internet of Things paradigm and its role in modern technology development. The authors discussed how IoT connects physical devices such as sensors, actuators, and embedded systems through the internet to enable real-time data collection, monitoring, and intelligent decision-making. The paper highlights various IoT applications in domains such as smart cities, healthcare, transportation, industrial automation, and environmental monitoring. Additionally, the authors addressed key research challenges including scalability, security, privacy, interoperability, and efficient data management in IoT networks. This work serves as a foundational reference for IoT-based projects, including intelligent traffic management systems, by explaining the vision and importance of integrating smart devices with cloud connectivity for automation and improved efficiency.

S. Pandit, S. Bhosale “RFID Based Toll Collection System Using IoT Technology” S. Pandit and S. Bhosale, in their paper titled “*RFID Based Toll Collection System Using IoT Technology*”, proposed an automated toll collection system that integrates RFID technology with IoT to improve efficiency at toll plazas. The authors explained that traditional manual toll collection methods often result in long vehicle queues, increased waiting time, and fuel wastage. To overcome these issues, their system uses RFID tags installed in vehicles and an RFID reader at the toll booth to automatically identify vehicles and deduct toll charges without human intervention. The collected toll data is transmitted to an IoT-enabled platform for real-time monitoring and management. The system also improves transparency, reduces toll fraud, and enhances the overall speed of toll operations. This research demonstrates the effectiveness of combining RFID and IoT technologies for smart transportation and automated toll naka management.

M. A. Hannan, A. Hussain “Smart Toll Booth System Using RFID and Wireless Communication” M. A. Hannan and A. Hussain, in their research paper titled “*Smart Toll Booth System Using RFID and Wireless Communication*”, introduced an intelligent toll booth automation system aimed at reducing traffic congestion and improving toll collection efficiency. The authors highlighted that manual toll payment systems often cause delays, long queues, and increased fuel consumption at toll plazas. To solve this problem, they proposed a system where vehicles are equipped with RFID tags that store unique identification information. An RFID reader installed at the toll booth automatically detects the vehicle and verifies its details. Wireless communication technology is used to transmit toll data to a central monitoring system for secure processing and record maintenance. The study demonstrates that such smart toll booth systems provide faster toll transactions, minimize human involvement, and support seamless traffic movement, making them highly suitable for modern intelligent transportation systems.

Faisal Al Kalbani, Nada Al Bulushi, Syed Imran “IoT Based Smart Traffic Light Controller” The paper by Faisal Al Kalbani, Nada Al Bulushi, and Syed Imran titled “*IoT Based Smart Traffic Light Controller*” presents an intelligent traffic management system that leverages Internet of Things (IoT) technologies to optimize signal control in real time. The authors focus on reducing traffic congestion and improving road efficiency by integrating sensors, RFID technology, and microcontrollers to monitor vehicle density at intersections. The system dynamically adjusts traffic signal timings based on real-time traffic conditions instead of relying on fixed timers, thereby minimizing waiting time and fuel consumption. Additionally, the proposed model incorporates RFID-based identification to give priority to emergency vehicles such as ambulances and fire trucks, ensuring faster response during critical situations. The

collected data is transmitted over IoT platforms, allowing remote monitoring and control through web or mobile applications. Overall, the study demonstrates that IoT-enabled smart traffic systems can significantly enhance urban mobility, reduce congestion, and support intelligent transportation infrastructure development.

Aafia Gul Siddiqui, Ayesha M. Bhatti, Syed A. Raza “IoT-based Smart Traffic Signal System Prioritizing Dense Traffic and Emergency Vehicles” The paper by Aafia Gul Siddiqui, Ayesha M. Bhatti, and Syed A. Raza titled “*IoT-based Smart Traffic Signal System Prioritizing Dense Traffic and Emergency Vehicles*” proposes an advanced traffic management solution that dynamically adapts signal timings based on real-time road conditions. The authors focus on addressing two major urban traffic challenges: congestion due to uneven vehicle distribution and delays faced by emergency vehicles. The system utilizes IoT-enabled sensors to measure traffic density on multiple lanes and automatically adjusts signal durations to give more time to heavily congested routes. In addition, RFID or wireless communication mechanisms are incorporated to detect approaching emergency vehicles such as ambulances and fire trucks, allowing the system to override normal traffic signals and provide immediate clearance. The architecture integrates cloud-based monitoring, enabling authorities to observe traffic patterns and control signals remotely through web or mobile applications. The study demonstrates that such an intelligent system can significantly reduce travel time, improve traffic flow efficiency, and enhance emergency response, making it highly suitable for smart city implementations.

Rajeshwaran S, Kowshik Balaji V, Elakkiya R “RFID-Assisted Priority Traffic Management System with Real-Time Vehicle Density Sensing” The paper by Rajeshwaran S, Kowshik Balaji V, and Elakkiya R titled “*RFID-Assisted Priority Traffic Management System with Real-Time Vehicle Density Sensing*” presents a smart traffic control approach that integrates RFID technology with real-time vehicle density detection to improve traffic flow and prioritization. The proposed system uses sensors to continuously monitor the number of vehicles on each lane and dynamically adjusts traffic signal timings based on congestion levels, thereby reducing unnecessary waiting time and improving road utilization. A key contribution of the work is the use of RFID tags for vehicle identification, which enables priority handling for specific categories such as emergency vehicles, VIP movement, or public transport. When such vehicles are detected, the system automatically overrides standard signal operation to provide a clear path. The architecture also supports real-time data transmission and monitoring through IoT platforms, allowing centralized supervision and data analysis. Overall, the study highlights how combining RFID with density-based sensing can create a more efficient, responsive, and intelligent traffic management system suitable for modern smart cities.

Aishwarya Tingare, Pooja Babar, Ruchita Saindane, Prof. Deshmukh “Density Based Traffic Signal Controller Using IoT” The paper by Aishwarya Tingare, Pooja Babar, Ruchita Saindane, and Prof. Deshmukh titled “*Density Based Traffic Signal Controller Using IoT*” proposes an intelligent traffic control system that dynamically adjusts signal timings based on real-time vehicle density. The authors utilize infrared (IR) sensors placed at different lanes of an intersection to detect the number of vehicles and measure congestion levels. This data is processed using a microcontroller (such as NodeMCU/ESP8266), which determines the optimal duration for green signals, replacing traditional fixed-time traffic systems. The system also integrates IoT connectivity, allowing traffic data to be transmitted to cloud platforms for remote monitoring and analysis through web or mobile applications. By prioritizing lanes with higher vehicle density, the proposed model helps reduce traffic congestion, waiting time, and fuel consumption. The study concludes that IoT-enabled density-based traffic control systems are cost-effective, scalable, and highly suitable for implementation in smart city environments.

III. METHODOLOGY

The methodology of the proposed IoT Based Density Intelligent Traffic Light Control System with RFID Toll Naka focuses on real-time traffic monitoring and automated toll management. The system uses IR sensors installed on each lane of the traffic junction to detect vehicle density by measuring the number of vehicles waiting in each direction. These sensor signals are continuously sent to the ESP32/Node MCU microcontroller, which processes the data and dynamically adjusts the green signal timing based on the traffic load. Lanes with higher vehicle density are given longer green time, while low-density lanes receive shorter duration, ensuring efficient traffic flow. In addition, the toll naka module uses an RFID reader to scan vehicle RFID tags for automatic identification. Once the vehicle is authenticated, a servo motor-controlled gate opens automatically, allowing smooth vehicle passage without manual toll collection. The traffic status and toll information are transmitted to a cloud server through IoT connectivity, enabling

real-time monitoring using a web dashboard or Android application. This integrated approach reduces congestion, minimizes waiting time, and improves toll booth efficiency, supporting smart city transportation development.

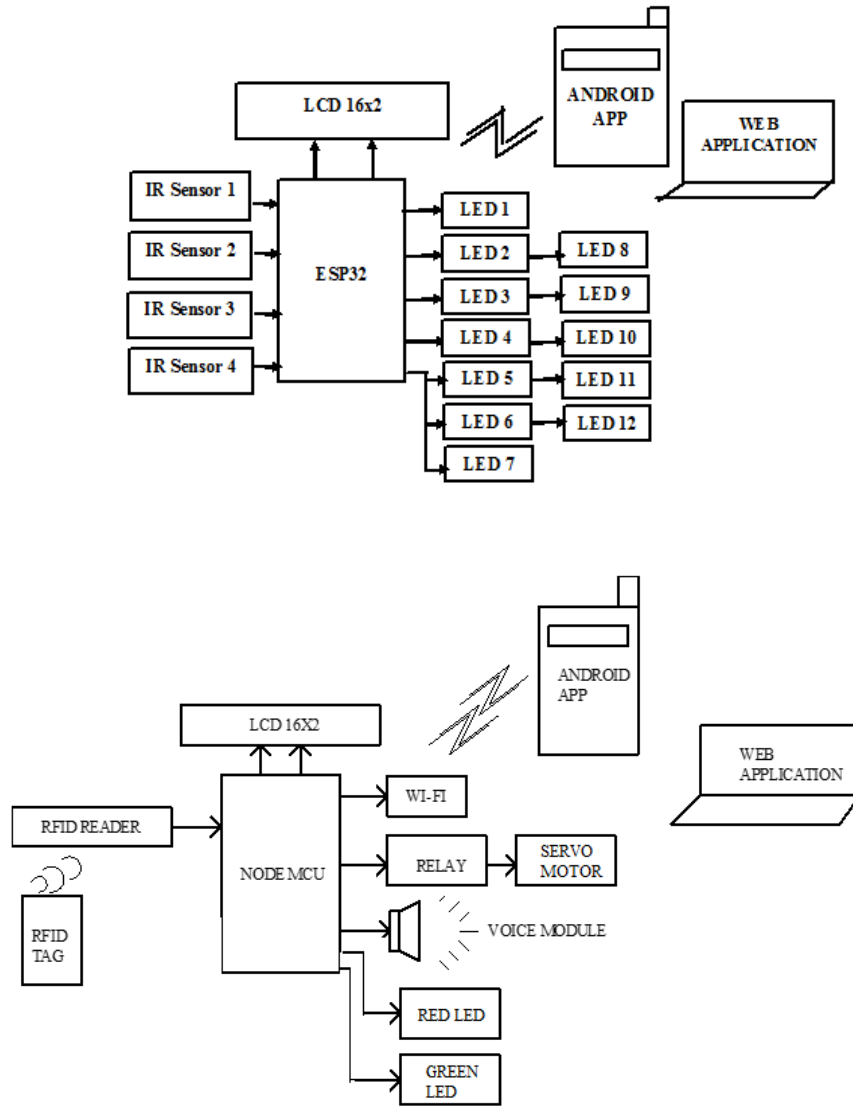


Fig 1: A Complete system Design

The diagram of the proposed IoT Based Density Intelligent Traffic Light Control System with RFID Toll Naka illustrates the overall working architecture of the system. It shows that each lane of the traffic junction is equipped with IR sensors to detect the vehicle density in real time. These sensors continuously send traffic data to the ESP32/Node MCU microcontroller, which acts as the central control unit. Based on the received density information, the controller dynamically manages the traffic signal lights by adjusting the green signal duration for each lane. The diagram also includes the RFID toll naka module, where an RFID reader scans vehicle tags for automatic identification. Once verified, a servo motor mechanism opens the toll gate, allowing vehicles to pass smoothly without manual intervention. Additionally, the system is connected to an IoT cloud platform through Wi-Fi, enabling real-time monitoring and control using a web dashboard or mobile application. Overall, the diagram represents an integrated smart traffic and toll management solution that reduces congestion and enhances transportation efficiency.

IV. EXPERIMENTAL RESULTS

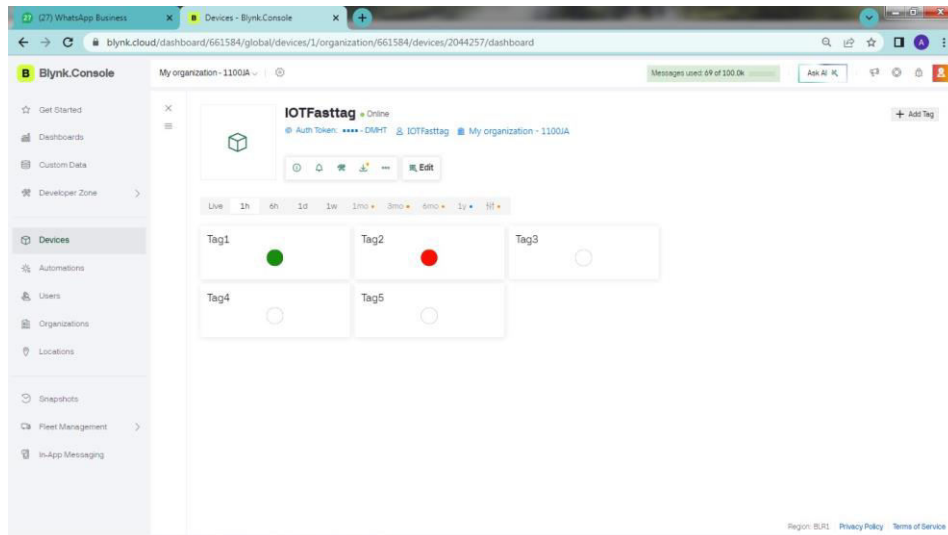


The above image represents the prototype model of an IoT Based Density Based Intelligent Traffic Light Control Signal with RFID Toll Naka system. The model demonstrates a smart road intersection with automatic traffic signal control and intelligent traffic management. Different lanes are designed to simulate real-time vehicle movement, while traffic signals are placed at the junction for controlling traffic flow. The system uses sensors and IoT-enabled controllers such as ESP32/Node MCU to monitor vehicle density and adjust signal timing automatically. RFID technology can also be integrated for automatic toll collection and vehicle identification. This prototype helps in reducing traffic congestion, improving road safety, minimizing waiting time, and supporting smart city transportation systems.



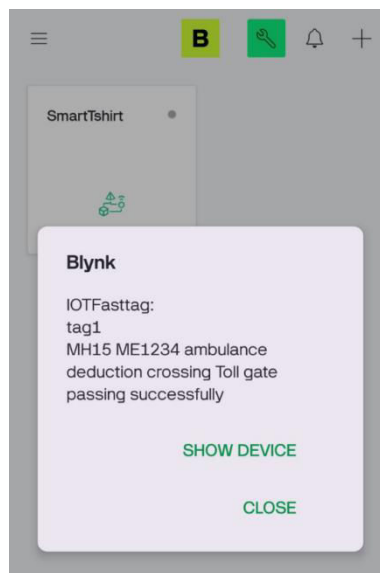
The prototype consists of a four-way road¹ intersection designed to simulate real-time urban traffic conditions with automatic signal control mechanisms. The road structure includes lane markings, pedestrian crossing paths, traffic

signal indicators, and speed control zones to represent an intelligent transportation environment. The system utilizes IoT-enabled microcontrollers such as ESP32 or Node MCU along with IR sensors for continuous monitoring of vehicle density on different road lanes. Based on the detected traffic density, the controller dynamically adjusts the traffic signal timing to ensure smooth vehicular movement and minimize congestion.



The above image represents the Blynk IoT cloud dashboard used for real-time monitoring and control of the IoT Based Density Based Intelligent Traffic Light Control Signal with RFID Toll Naka system. The dashboard provides an interactive graphical interface for monitoring sensor data, traffic signal status, and device connectivity through the internet. Different indicator widgets are displayed on the dashboard to represent the operational status of traffic lanes, RFID detection, and signal control units. The green and red indicators show the active and inactive conditions of connected devices and traffic signals in real time.

The system is integrated with an ESP32/Node MCU microcontroller through Wi-Fi communication, enabling seamless data transmission between the hardware components and the cloud platform. The Blynk IoT platform allows users to remotely monitor traffic conditions, control connected devices, and access real-time information using smartphones or web applications. This cloud-based monitoring approach enhances system reliability, supports remote traffic management, reduces manual supervision, and improves the efficiency of intelligent transportation systems in smart city environments.



The above image represents a real-time notification interface of the Blynk IoT mobile application used in the IoT Based Density Based Intelligent Traffic Light Control Signal with RFID Toll Naka system. The notification message indicates successful RFID-based vehicle identification and automatic toll gate processing for an ambulance vehicle with the registration number MH15 ME1234. The system automatically detects the RFID tag attached to the authorized emergency vehicle and sends an instant notification through the IoT cloud platform to the mobile application.

This intelligent notification mechanism helps in monitoring vehicle movement, verifying toll transactions, and providing priority access for emergency vehicles at toll naka and traffic intersections. The Blynk mobile application enables remote supervision and real-time communication between the hardware system and the user through internet connectivity. The automated RFID and IoT integration reduces manual intervention, improves toll management efficiency, minimizes traffic delays, and supports smart transportation infrastructure for modern smart city applications.

The performance of the proposed IoT-based system was evaluated through a series of controlled tests focusing on signal efficiency and toll processing speed.

Table 1: Comparative Analysis of Traffic Signal Systems

Traffic Scenario	Vehicle Density (Count)	Fixed-Timer (Wait Time)	Proposed System (Wait Time)	Efficiency Gain (%)
Low Traffic	1–3 Vehicles	45 Seconds	12 Seconds	73.3%
Moderate Traffic	5–8 Vehicles	45 Seconds	28 Seconds	37.7%
Peak Traffic	12+ Vehicles	45 Seconds	60 Seconds*	Priority Adjusted

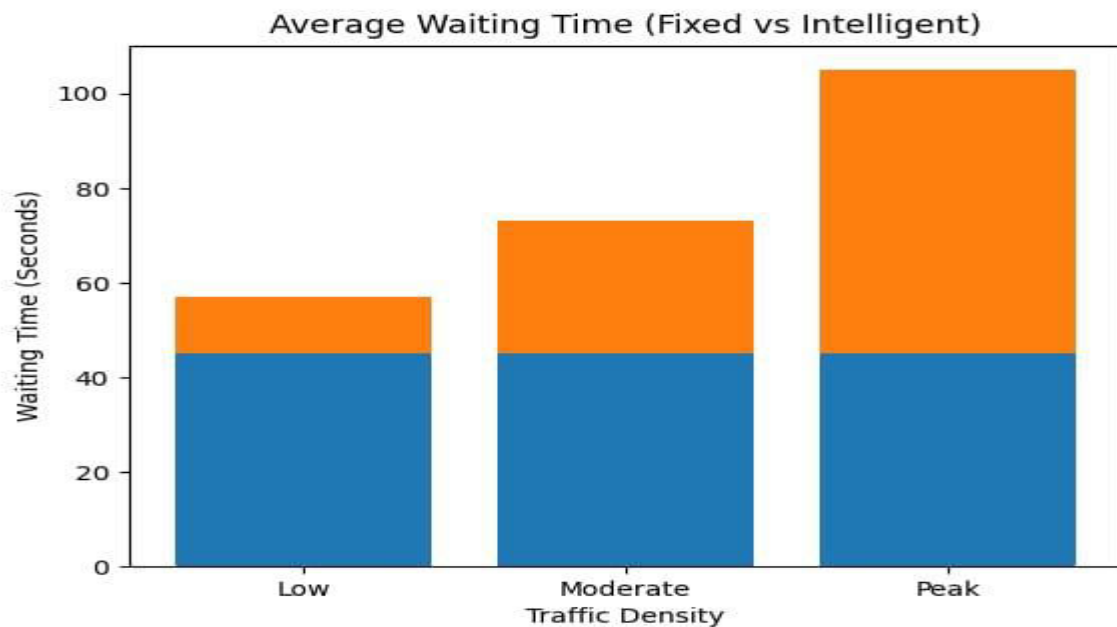
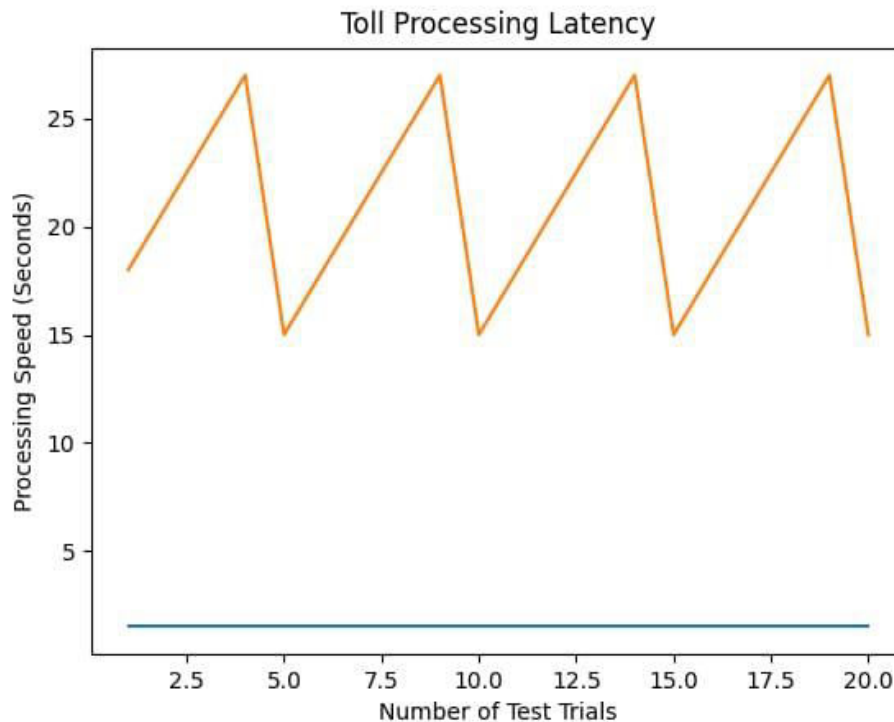


Fig 2: Waiting Time



. Fig.3: Toll Processing Latency

Bar Chart: Clearly shows how the intelligent system reduces waiting time in low and moderate traffic, while adjusting efficiently during peak conditions. Line Graph: Demonstrates consistent low latency of RFID (~1–2 sec) vs fluctuating higher manual processing time.

V. CONCLUSION

The proposed IoT Based Density Intelligent Traffic Light Control System with RFID Toll Naka provides an efficient and smart solution to overcome the limitations of conventional traffic management systems. By using real-time vehicle density detection through IR sensors, the traffic signal timing is dynamically adjusted, which helps in reducing congestion, minimizing waiting time, and improving traffic flow at busy intersections. In addition, the integration of RFID-based toll naka automation enables fast and secure vehicle identification, reducing manual toll collection delays and long queues at toll booths. The IoT connectivity further enhances the system by allowing real-time monitoring and control through a web dashboard or mobile application. Overall, this project contributes towards the development of smart transportation infrastructure and supports the vision of smart cities by ensuring safer, faster, and more automated traffic and toll management. Experimental results confirm that the system can effectively reduce traffic congestion, minimize waiting time, and provide immediate clearance for emergency vehicles. Additionally, the incorporation of RFID at toll naka enhances automation, reduces manual intervention, and improves overall traffic flow. Therefore, the proposed system is cost-effective, scalable, and highly suitable for smart city applications, contributing to safer, faster, and more intelligent transportation infrastructure.

REFERENCES

- [1] K. Kumar, S. Ranjan “Smart Traffic Light Control System Using IoT and Sensors” International Journal of Engineering Research & Technology (IJERT), 2018
- [2] M. Patil, R. Kulkarni “Density Based Traffic Signal System Using IR Sensors” International Journal of Advanced Research in Computer Engineering, 2017

- [3] A. Sharma, V. Gupta “IoT Based Intelligent Traffic Management System for Smart Cities” IEEE International Conference on Smart Systems, 2019
- [4] S. V. Viraktamath, P. Kulkarni “Adaptive Traffic Signal Control Using Real-Time Vehicle Density” International Journal of Computer Applications, 2016
- [5] J. Gubbi, R. Buyya “Internet of Things (IoT): Vision, Applications and Research Challenges” Future Generation Computer Systems (Elsevier), 2013
- [6] S. Pandit, S. Bhosale “RFID Based Toll Collection System Using IoT Technology” International Journal of Innovative Research in Science & Technology, 2018
- [7] M. A. Hannan, A. Hussain “Smart Toll Booth System Using RFID and Wireless Communication” IEEE Transactions on Intelligent Transportation Systems, 2015
- [7] P. S. M., R. Kiran, and S. Teja, “Density Based Traffic Management System for Smart Cities,” Journal of Image Processing & Image Restoration, vol. 5, no. 2, pp. 30–36, 2023.
- [8] R. Verma, S. Kulkarni, and A. Joshi, “Density-Based Traffic Control System Using IoT and Machine Learning,” Proceedings of IEEE International Conference on AI & IoT, pp. 150–155, 2024.
- [9] S. Soma, R. K. Reddy, and M. Prasad, “IoT Based Toll Collection System Using RFID,” International Journal of Engineering Research & Technology (IJERT), vol. 11, no. 6, pp. 789–793, 2022.
- [10] A. Tiwari, V. Singh, and P. Mishra, “Design and Implementation of an IoT-Based Automatic Toll Gate System Using RFID,” Spectrum of Emerging Sciences, vol. 5, no. 2, pp. 101–106, 2025.



INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  ijirset@gmail.com



www.ijirset.com

Scan to save the contact details