IOT-Based Traffic Control System Using 5G Technology

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Abstract: In this paper, a PIC microcontroller that processes the collected data from the sensor and the real-time traffic condition data are stored in the IOT. The collected data are transmitted wirelessly and relay the processed information from the transmitter side to the receiver side, creating a seamless flow of data across the traffic network. On the receiver side, a complementary set of components, including a LORA receiver, PIC microcontroller, LCD, and an integrated IOT platform, forms a centralized hub for data analysis and decision-making. In the LCD display, the real-time traffic condition is displayed on the receiver side. An AI algorithm interprets the transmitted data, analyzes the traffic pattern, and intelligently adjusts traffic signals in real-time. If the traffic is high, it changes the signal dynamically and reduces the traffic, thereby minimizing the congestion and improving the overall flow of vehicles. Which enables proactive adjustments to traffic signals, significantly enhancing road efficiency and safety.
Keywords:-IoT, LORA, PIC Microcontroller, Traffic control, 5G Technology.

I. INTRODUCTION

This paper proposes an intelligence that is used to reduce traffic by monitoring the real-time condition of the traffic using density sensors. Traffic jams are a big problem in the major cities. It's frustrating for people to go around. By using the IoT and 5G technology can help us to manage traffic in smarter ways. Some gadgets like cameras and sensors are used to understand the real-time conditions on the road. It tells us about the traffic condition. It's like keeping track of traffic. The sensors and cameras collect a vast amount of information, including vehicle speeds and environmental conditions, which are processed and analyzed to make informed decisions. They monitor the traffic and regulate traffic flow dynamically. By deploying these sensors at key intersections on roadways authorities gain real-time traffic patterns and congestion points and it is used to reduce potential hazards. These data are collected by the sensors are stored in the IoT.

IoT works by embedding sensors, chips, and other smart technology objects that we use every day. These gadgets are used to sense and collect data. Then, these data are sent over the internet to the central system where it is analyzed and used to make a decision-making process. IoT enabled the traffic management system to enhance safety by providing the early detection and mitigation of potential hazards. By integrating the sensors that gather the real-time traffic condition. It mitigates the risk of secondary accidents and improves overall road safety. Further integration of IoT and 5G technology opens smart transportation solutions. The 5G technology has it's unprecedented speed, low latency, and high capacity. 5G networks which enables the communication between devices and centralized control systems. The high-speed connectivity improves traffic management to respond swiftly to changing conditions, optimizing traffic signals, and rerouting vehicles in real-time. The main advantage of IoT based traffic control system is the ability to adapt dynamically to traffic demands. Traditional traffic signals operate on fixed time intervals, often leading to inefficiency during peak hours. Sensors are continuously monitoring the traffic conditions and this information is stored in the IoT to make a comparison with the old data. Adjusting the signal timings can reduce the waiting time minimizing congestion and minimizing travel time. This adaptive approach not only improves the overall flow of traffic but also reduces fuel consumption and greenhouse gas emissions associated with idling vehicles.

Another advantage of IoT-based traffic control systems is their flexibility and scalability. Whether they are used in suburban neighborhoods or bustling metropolises, these systems can be tailored to meet the changes of any environment and their unique needs. IoT and 5G technology can be expanded and upgraded to accommodate increasing traffic volumes. It also improves traffic flow and safety, IoT based traffic control system contributes to the overall sustainability of urban environments. Optimizing traffic patterns and reducing congestion can lower the fuel consumption, air pollution, and carbon emissions associated with vehicular traffic. Using IoT and 5G technology heralds a new era in traffic management to optimize mobility and enhance safety. Further innovation of this technology makes the possibilities for creating safer, more efficient, and more livable cities.

II. LITERATURE SURVEY

The author says that the combination of smart objects with the Internet can pave the way for the transformative era of the Internet of Everything (IoE), which helps smart homes, cities industries, and healthcare to create a web of interconnected devices generating vast amounts of valuable data [1]. Real-time monitoring can be used to eliminate manual checks and enable remote access for enhanced efficiency and sustainability [2]. The IoT platform enables diverse devices to communicate empowering cities, interoperability, data drive smart city development and promote sustainable urban growth [3]. The AutoMat project uses crowd sensing sensor to improve traffic measuring and enhance automotive production towards connectivity driven efficiency and innovation in the industry [4].

IoT provides the solution for the researchers, offering insights and an organizing framework to navigate [5]. The blockchain-based IoT data with smart contracts that ensuring secure and transparent data exchange by eliminating intermediaries [6]. To create a collaborative automotive technology and data marketplace for better connectivity, a standardized model (CVIM) is used in cars along with IoT [7]. 5G network improves wireless communication with network slicing, and allows customized services, but there are challenges that remain such as network organization and integration of technology advancement [8].

III. PROPOSED METHOD

The goal of this article is to describe how to build a circuit that allows the user to get real-time traffic condition data and to dynamically change the signal timing to reduce traffic congestion. The circuit is composed of a density sensor, PIC microcontroller, IoT, LORA transmitter, LORA receiver, and LCD. PIC microcontroller is connected to the density sensor and collects the data from it. A density sensor is used to detect the traffic condition whether it is high or low. A power supply is given to the peripheral interface controller. The data collected through the microcontroller are stored in IoT. It is used to make comparisons with the previous year's data, which helps us to make a safe environment. Then these data are transmitted to the receiver side through LORA (Long Range Radio). It is a physical proprietary radio communication technique used to transfer data to a wide range from 10 km to 16 km. This is based on the spread spectrum modulation technique. By transferring the data through LORA users can know about the real-time traffic condition through the receiver.

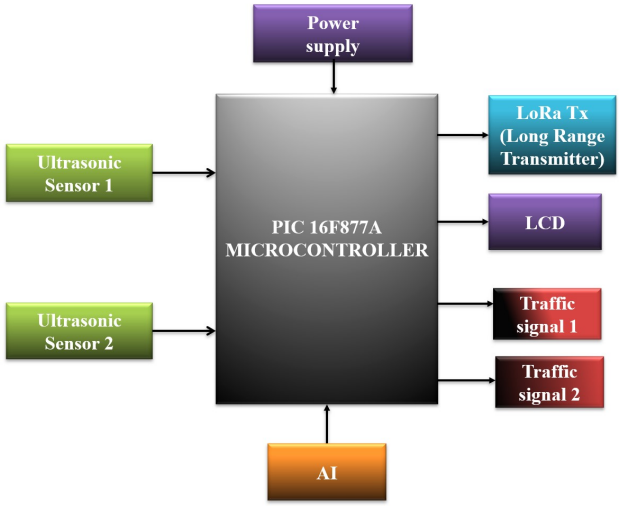

Figure 1. Proposed work transmitter side

If the traffic is high AI algorithm changes the signal timing dynamically and reduces the congestion. This AI technology uses a machine learning algorithm. Supervised learning techniques are used on the basis of the machine learning algorithm. It can solve problems and help for Decision-making process, Supporting vector machines, Naïve Bayes, and Neural networks. By integrating artificial intelligence capabilities with the high-speed connectivity of 5G networks can optimize traffic offloading in urban environments and enhance efficiency. AI algorithm along with 5G technology allows for a decision-making process based on real-time traffic conditions and a more responsive traffic management system. Beyond the traditional method, this method introduces traffic offloading and optimizing data routing and time-sensitive information to enhance the IoT ecosystem's efficiency. The integration of IoT devices facilitates continuous adaptation to evolving traffic patterns and trends. The combined relationship between AI and 5G enables responsiveness and adaptability, leading to reduced congestion

and improved urban mobility. IoT traffic control represents a forward-looking solution, capitalizing on traffic offloading and fostering a more efficient and responsive urban landscape.

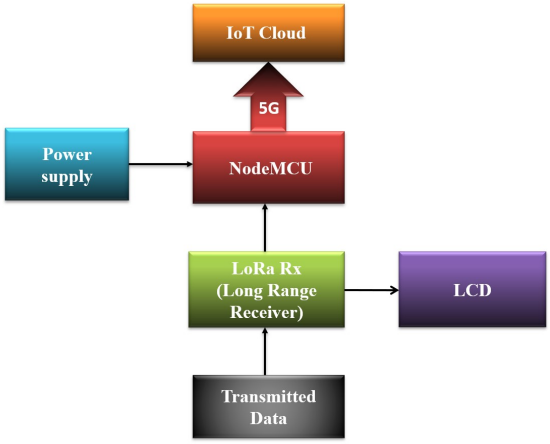

Figure 2. Proposed work receiver side

IV. HARDWARE IMPLEMENTATION

1. PIC Microcontroller:

PIC is a Peripheral Interface Microcontroller. It is often used to control different electronic devices Which acts as the brain of an electronic gadget. A PIC microcontroller is a small chip that contains a processor, memory, and input/output pins. This system uses the "PIC16F877A" microcontroller. It consists of 368 bytes of RAM, and 256 bytes of EEPROM. The RAM consists of multiple banks. The bank consists of special function and general purpose registers. The general purpose registers are used to store temporary data and each register are 8-bit register. It is designed based on the modified Harvard architecture and It as both program memory and data memory. PIC16F877A includes a variety of registers, It can used for different applications such as Automotive Electronics, Educational purposes, Medical devices, and Home automation.

2. LoRa:

LoRa (long range) is a Physical radio communication device that is used to transmit and receive data over a long range from 10 km to 16 km. LoRa uses a spread spectrum modulation technique. It is a wireless technology that offers a long range and data transmission for IoT applications. which can connect sensors, gateways, machines, devices, animals, people, etc. wirelessly to the cloud. This technology operates on different frequency bands based on different regions. LoRa creates a long-range communication link between the gateway connected to the network and the remote sensor.

3. LCD:

LCD stands for "Liquid crystal Display". LCD is made up of two phases of liquid and solid matter. It has two layers of polarized filters and electrons. They are popular because of their several advantages which consume less power, are thin, lightweight, and produce vibrant and sharp images. It consists of liquid crystals, color filters, electrodes, and black light. Mostly it is used in electronic games, digital cameras, camcorders, electronic billboards, etc. This system uses an LCD to display the real-time traffic conditions on the receiver side.

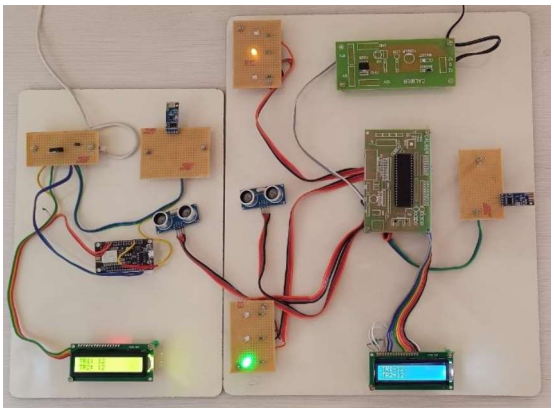

Figure 3. IoT-based traffic control system using 5G technology hardware kit

4. Ultrasonic Sensor:

An ultrasonic sensor is a small device that uses ultrasonic sound waves to measure the distance to an object. It emits sound waves at frequencies beyond the range of human hearing, Which is typically between 20 kHz to several kHz. It consists of two main components transmitter and receiver. The transmitter uses piezoelectric crystals to emit sound and the receiver encounters the sound emitted by the transmitter after it travels to the target and is reflected from it. To calculate the distance between the object and the sensor, an ultrasonic sensor measures the time taken between the sound emitted from the transmitter to contact with the receiver. There are two different types of ultrasonic sensors based on their properties they are range measurement and proximity detection. This system proximity detection detects the object within range and provides an output signal to know the real-time traffic condition.

5. NodeMCU:

The word "NodeMCU" is a combination of "node" and "microcontroller unit" Which is an both oper source of firmware and prototyping board design. NodeMCU is an open-source board based on the ESP8266 Wi-Fi module, designed to facilitate the Internet of Things projects. It combines the functionality of the Wi-Fi module and the microcontroller, which offers a convenient platform for IoT solutions without the help of other components. Enables the users to easily program and then control the connected devices by the firmware, which is based on the Lua scripting language. The design of NodeMCU is based on the ESP-12 module of ESP8266 with the Wi-Fi SoC. It is widely used for IoT applications, used to build home automation systems, and can serve as a hub.

V. RESULT AND DISCUSSION

From this paper, the implementation of this system improves urban mobility management. By dynamically adjusting traffic signal durations in real-time, the system optimizes traffic flow and manages congestion. Traditional traffic lights typically range from 10 to 60 seconds for green lights, 3 to 6 seconds for yellow lights, and 40 to 180 seconds for red lights. This system adapts signal duration within a range of 10 to 30 seconds based on prevailing traffic conditions. These dynamic adjustments allow more responsiveness ensure smoother traffic flow and minimize delays. While LoRa provides coverage of up to 10 km to 16 km in urban areas, the 5G network offers higher data transfer speeds ranging from 100 Mbps to 1 Gbps it enables the instantaneous transmission of real-time conditions, decision-making, and response to traffic control systems. By leveraging IoT and 5G technology, these systems adapt dynamically to changing traffic conditions, resulting in efficient traffic flow, improved safety measures, and active congestion management.

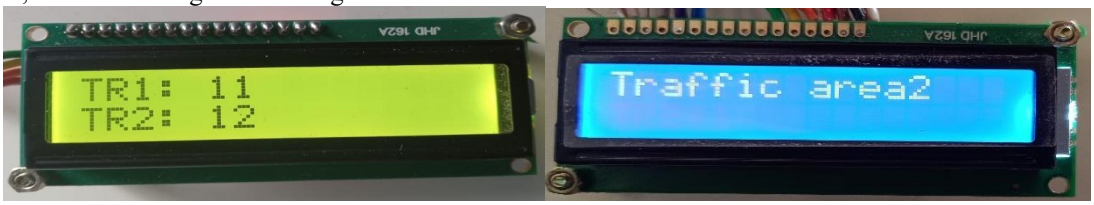

Figure 4. Traffic condition 1(TR1) and Traffic condition 2 (TR2) are sensed

VI. SMART APPLICATION THINGSPEAK

Thingspeak is an IoT analytics platform that allows us to visualize and analyze live data collected by the sensor. Thingspeak is an open-source platform that allows the user to communicate with the internet and is used to store the data privately. Data collected from the devices are stored in the cloud and it makes an advanced data analysis using MATLAB. Its main applications are to analyze, aggregate, and visualize live data from the cloud.

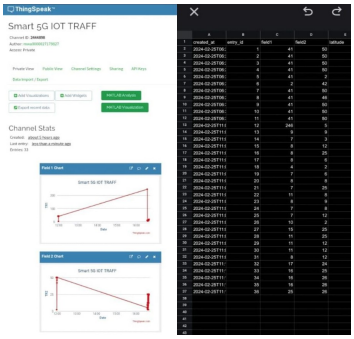

Figure 5. Data analyzed by Thingspeak

VII. CONCLUSION

The concept of integration of IoT technology and 5G networks in traffic control systems presents a promising solution for addressing congestion and enhancing road safety. This system has various components such as sensors and advanced processing capabilities. These elements work together to monitor the traffic conditions in real-time and make decision-making processes to optimize traffic flow. The key features of 5G technology enable the high-speed transmission of data rapidly between vehicles. By integrating sensors and real-time data processing, this system reduces congestion, optimizes traffic flow, and enhances overall safety on the roads. Through leveraging real-time data from IoT and the high speed of 5G traffic flow can be optimized dynamically, reducing travel time and minimizing accidents. In the future the enhancement of IoT and 5G networks has the potential to revolutionize urban transportation, creating a safer environment, and more efficient and sustainable cities for the benefit of all citizens.

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