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Design and Implementation of Smart Traffic Control System for Ambulance Using IoT

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Abstract: ***Traffic congestion is a significant problem in modern cities, which often leads to a delay in emergency vehicles such as ambulances. Delays in emergency vehicles can cause serious issues because every minute is crucial in emergency medical situations. This paper aims to propose a smart traffic control system that facilitates the movement of ambulances using IoT and RF communication. The proposed smart traffic control system will identify the presence of an ambulance approaching a traffic intersection. The traffic light will then turn green to allow the ambulance to pass without any further delay. The proposed smart traffic control system utilizes microcontrollers such as Arduino or ESP8266, along with RF transmitter and receiver, to facilitate communication between the ambulance unit and traffic light unit. The proposed smart traffic control system utilizes IoT-based monitoring and RF communication to respond to emergency situations. This proposed smart traffic control system not only reduces the response time of ambulances but also improves coordination between emergency services and traffic management systems.***

Keywords: Smart Traffic System, IoT, RF Communication, Ambulance Priority, Emergency Traffic Control

I. INTRODUCTION

Traffic congestion has become one of the most serious problems in modern cities. With the increasing number of vehicles on the roads, managing traffic efficiently has become very difficult for traffic authorities. During peak hours, roads often become heavily crowded, which causes long delays for vehicles. While this situation is inconvenient for regular commuters, it becomes extremely critical when emergency vehicles such as ambulances are involved. Ambulances play a vital role in saving human lives by transporting patients quickly to hospitals.

However, due to traffic congestion, ambulances often get stuck at traffic signals and crowded intersections. Even a small delay in reaching the hospital can result in serious consequences and, in some cases, may lead to the loss of human life. Therefore, it is very important to develop a system that can help ambulances move through traffic quickly and safely.To address this issue, modern technologies such as the Internet of Things (IoT) can be used to create intelligent traffic systems that support emergency vehicles [1][3][5]. IoT allows different devices to communicate with each other through the internet or wireless networks, making it possible to monitor and control traffic signals in real time. With the help of such technologies, traffic signals can automatically detect the presence of an approaching ambulance and provide it with priority.

In a smart traffic management system, communication technologies such as RF modules, RFID systems, or wireless transmitters can be used to identify emergency vehicles and send signals to nearby traffic lights [2][10]. Once the system detects an ambulance, the traffic signal can automatically turn green for that particular lane, allowing the ambulance to pass quickly without waiting. This process helps in creating a clear path for emergency vehicles and reducing the delay caused by normal traffic.Several researchers have worked on intelligent transportation systems that provide priority to emergency vehicles using embedded systems and wireless communication technologies [4][9]. These systems are designed to improve traffic efficiency and ensure that emergency services can respond faster. Some advanced systems also use technologies such as GPS tracking, machine learning, and cloud-based traffic monitoring to analyze traffic conditions and control signals more effectively [6][7][8].The main objective of this project is to design and develop a smart traffic signal system that gives priority to ambulances at traffic intersections. By implementing this system, the response time of ambulances can be significantly reduced, which may help in saving more lives during medical emergencies. The system also aims to improve the coordination between traffic authorities and emergency medical services.In addition, such smart traffic management systems can contribute to the development of smart cities, where modern technologies are used to improve urban infrastructure and the overall quality of life for citizens. By integrating IoT-based traffic solutions, cities can become safer, more efficient, and better prepared to handle emergency situations.

II. LITERATURE REVIEW

Traffic congestion has become a serious problem in many cities, especially when emergency vehicles like ambulances need to reach hospitals quickly. Because of heavy traffic, ambulances often get delayed at traffic signals, which can be dangerous for patients. To solve this problem, many researchers have developed different smart traffic management systems using technologies such as IoT, RFID, GPS, wireless communication, and machine learning.

Prathik et al. [1] introduced a smart traffic management system using the Internet of Things (IoT). In their system, traffic signals are connected through IoT devices that help monitor traffic conditions. The system automatically adjusts traffic signals based on the traffic situation, which helps reduce congestion and improves the movement of emergency vehicles.

Sharma and Gupta [2] proposed a traffic control system based on RFID technology. In this system, RFID tags are installed in ambulances, and RFID readers are placed at traffic signals. When the ambulance comes near a signal, the RFID reader detects the tag and sends a signal to the traffic controller. As a result, the traffic light turns green so that the ambulance can pass without stopping.

Mishra et al. [3] developed an IoT-based smart traffic signal control system that collects real-time traffic information and manages signal timing accordingly. Similarly, Verma and Singh [9] designed a real-time traffic control system using IoT and embedded systems to improve traffic flow and reduce delays at intersections.

Khan and Rehman [4] proposed an intelligent transportation system that gives priority to emergency vehicles at traffic signals. Their system focuses on improving emergency response by allowing ambulances to move faster through busy roads.

Sinha and Wei [5] studied different IoT-based smart traffic monitoring systems and explained how these technologies can help manage traffic more efficiently in modern cities. Their research shows that IoT can play an important role in developing smart traffic systems.

Kumar et al. [6] developed a GPS-based ambulance tracking system using IoT. In this system, the location of the ambulance is continuously tracked and shared with a central traffic control system. This helps traffic authorities manage signals and provide a clear path for the ambulance.

Smith and Brown [7] studied the use of machine learning techniques for traffic management. Their research focused on analyzing traffic data and predicting traffic congestion so that traffic signals can be controlled more effectively.

Gupta and Kumar [8] proposed a cloud-based traffic monitoring and control system for smart cities. In this system, traffic data is stored and analyzed in the cloud, allowing traffic authorities to monitor traffic conditions and manage signals more efficiently.

Rajesh and Kumar [10] developed a smart ambulance system that uses wireless communication to send signals from the ambulance to nearby traffic lights. When the ambulance approaches the signal, the traffic light automatically turns green to allow the ambulance to pass quickly. Although these systems provide useful solutions for giving priority to ambulances, many of them require complex technologies such as GPS networks, cloud systems, or advanced algorithms. Therefore, this research focuses on developing a simple and cost-effective smart traffic signal system using ESP8266 and wireless communication, which can help ambulances pass through traffic signals faster and reduce delays during emergencies.

III. SYSTEM ARCHITECTURE AND METHODOLOGY

This project is designed to create an automatic **"green corridor"** for ambulances using RF communication (433 MHz) and IoT technology. The main aim of this system is to help ambulances move quickly through traffic signals during emergencies and reduce delays caused by heavy traffic. Similar smart traffic management systems using IoT have been proposed by many researchers to improve emergency vehicle movement in cities [1][3][5]. The system mainly consists of two parts: the Ambulance Unit and the Traffic Signal Unit. These two units communicate wirelessly with each other. When the ambulance approaches a traffic signal, it sends a signal to the traffic signal unit. After receiving this signal, the traffic light automatically turns green for the ambulance lane so that the ambulance can pass without stopping. Wireless communication has also been used in earlier systems to provide priority to emergency vehicles at traffic intersections [10].

A. Ambulance Unit

The ambulance unit is installed inside the ambulance. It is powered by a 12V battery, which is converted into 5V using a 7805 voltage regulator so that the electronic components can operate safely. This unit uses a microcontroller such as ESP8266 connected to an emergency push button. When the driver or medical staff presses the emergency button, the microcontroller sends a signal through a 433 MHz RF transmitter. This signal is transmitted wirelessly to the traffic signal unit when the ambulance is about 50–100 meters away from the intersection.

To make the system more reliable and accurate, technologies such as GPS or IoT-based monitoring can also be integrated in the future. These technologies help track the ambulance location and reduce the chances of false signals. Similar GPS-based ambulance tracking systems have been proposed by researchers to monitor emergency vehicle locations in real time [6]. The ambulance unit is designed to be compact so that it can easily be installed inside the ambulance without disturbing other medical equipment.

B. Traffic Signal Unit

The traffic signal unit is installed at the traffic intersection. It is powered by a 230V AC power supply, which is converted into 5V DC for the microcontroller and other electronic components.

This unit includes a 433 MHz RF receiver connected to a microcontroller (ESP8266). When the receiver detects the signal sent from the ambulance unit, the microcontroller immediately overrides the normal traffic signal sequence and turns the green light ON for the ambulance lane. This allows the ambulance to pass the intersection without delay. Similar intelligent traffic signal control systems for emergency vehicles have been proposed in previous research studies [2][4][9]. The traffic lights are controlled using the microcontroller output pins, where D5 controls the red light, D6 controls the yellow light, and D7 controls the green light. A relay driver circuit is used to safely control the high-voltage traffic lights. With the help of IoT technology, traffic authorities can also monitor the traffic signal system remotely. This makes the system more efficient and suitable for smart city applications. Cloud-based traffic monitoring systems have also been suggested in earlier studies for better traffic management and control [8].

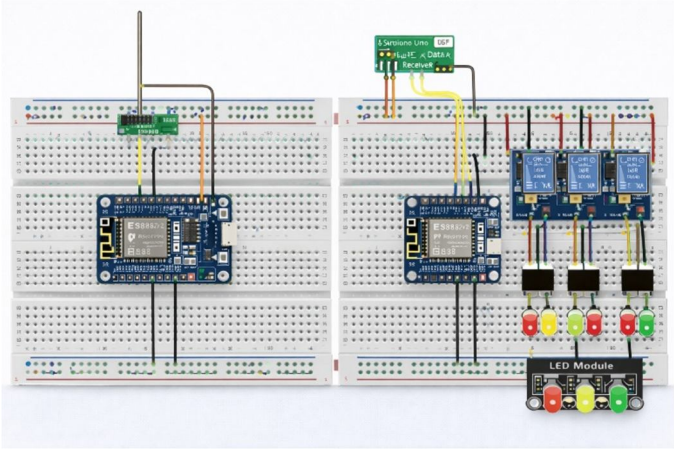

Fig.1 Circuit Diagram of Smart Traffic Control System for Ambulance Using IoT

When the ambulance sends a signal, the traffic signal unit receives it and immediately changes the traffic light to green. This allows the ambulance to pass through the intersection without waiting. After the ambulance crosses the intersection, the system automatically returns to the normal traffic signal cycle so that other vehicles can continue moving normally. This process continues at each intersection along the ambulance route, creating a green corridor that allows the ambulance to reach the hospital quickly during emergencies.

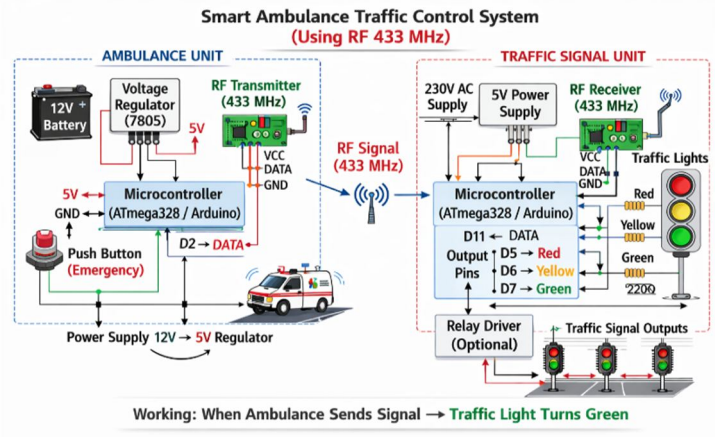

Fig.2 Architecture Diagram of Smart Ambulance Traffic Control System

IV. IMPLEMENTATION

The system is implemented using embedded hardware components and simulation tools.

1) Hardware Components

• Microcontroller: Arduino or ESP8266 used for signal processing and control.
• RF Modules: 433 MHz RF transmitter (ambulance unit) and RF receiver (traffic signal unit).
• LED Traffic Lights: Used to simulate real-world traffic signal behavior.
• Power Supply Unit: Provides stable voltage to all system components.
• Push Buttons or Sensors: Used for manual override or testing purposes.

2) Software Tools

• Arduino IDE: Used to program and upload code to the microcontrollers.
• Proteus: Used to simulate circuit behavior and signal flow

A. Ambulance Unit

The ambulance unit is installed inside the emergency vehicle. It mainly consists of an emergency push button, a microcontroller (ESP8266 or Arduino), and a 433 MHz RF transmitter. When the ambulance approaches a traffic signal during an emergency, the driver presses the emergency push button. This action sends a signal to the microcontroller, which processes the input and activates the RF transmitter. The transmitter then sends a wireless signal to inform the traffic signal unit that an ambulance is approaching the intersection. Similar wireless communication methods have been used in previous smart ambulance systems to provide priority to emergency vehicles [10].

B. RF Communication

The communication between the ambulance unit and the traffic signal unit is done using a 433 MHz RF communication module. The RF transmitter in the ambulance sends the signal wirelessly to the RF receiver installed at the traffic signal unit. This wireless communication helps the system quickly inform the traffic controller about the approaching ambulance without the need for physical connections. Wireless communication techniques have also been used in earlier research to support emergency vehicle priority at traffic intersections [2][4].

C. Traffic Signal Unit

The traffic signal unit is installed at the road intersection. It includes a 433 MHz RF receiver, a microcontroller, and traffic signal lights. When the RF receiver receives the signal sent from the ambulance unit, it forwards this information to the microcontroller. The microcontroller then processes the signal and temporarily overrides the normal traffic signal sequence. After receiving the emergency signal, the system changes the traffic light in the direction of the ambulance to green, while the traffic signals for other directions remain red. This stops other vehicles and allows the ambulance to pass through the intersection without any delay. Similar traffic signal control mechanisms for emergency vehicles have been proposed in earlier intelligent traffic management systems [1][9]. Once the ambulance crosses the intersection, the traffic signal automatically returns to its normal operating cycle. In this way, the system helps ambulances move faster through traffic signals and reduces delays during emergency situations.

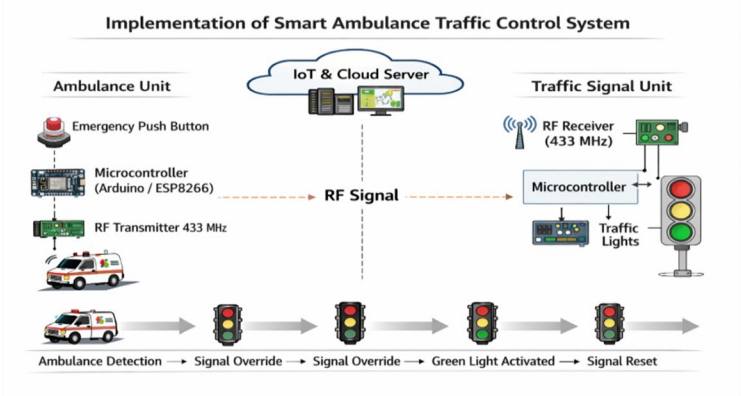

Fig. 3 Implementation Diagram of Smart Traffic Control

V. WORKING PROCESS

The proposed system works by giving priority to ambulances at traffic intersections. When an ambulance approaches a signal, the system helps create a clear path so that the vehicle can move quickly toward the hospital. As shown in the diagram, the ambulance is equipped with a device that sends a wireless RF signal. When the driver activates the system, this transmitter sends the signal to the traffic signal controller located at the nearby intersection. The traffic signal controller receives this RF signal and processes it using a microcontroller. After detecting that the signal is coming from an emergency vehicle, the controller temporarily changes the normal traffic light operation. The system then turns the traffic light green in the direction of the ambulance, while the lights for other directions remain red. This stops other vehicles and allows the ambulance to pass through the intersection without being delayed by traffic . After the ambulance crosses the signal, the traffic lights return to their normal operation. By using RF communication and automatic signal control, the system helps reduce traffic delays for emergency vehicles and allows ambulances to reach the hospital faster. Overall, this system improves emergency response time and can help save lives by ensuring that patients reach medical facilities as quickly as possible.

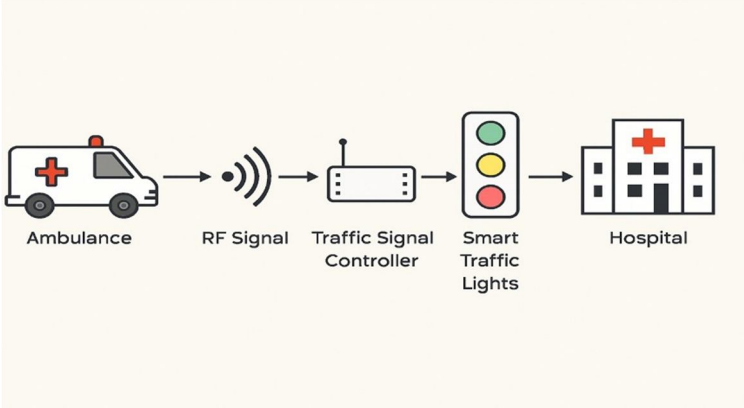

Fig 4 Working Process of Smart Traffic Control System for Ambulance Using IoT

The smart traffic control system operates through a sequence of detection, communication, and signal control.

1) The ambulance sends its location or RF signal while moving towards a traffic intersection.
2) The RF receiver at the traffic signal detects the signal from the ambulance unit.
3) The microcontroller processes the signal and overrides the normal traffic signal sequence.
4) The traffic signal changes to green for the ambulance.
5) After the ambulance passes the intersection, the traffic signal returns to its normal operation.

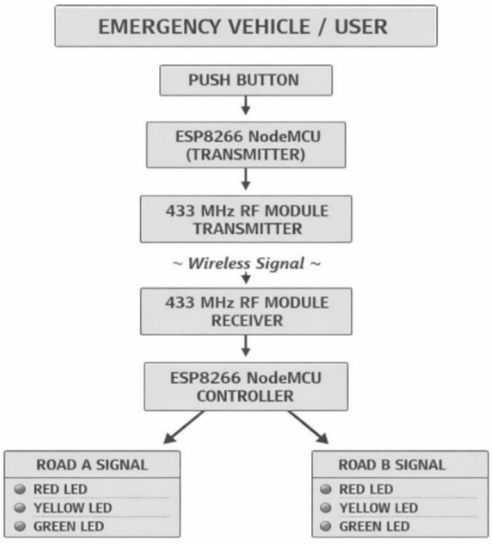

Fig .5 Block Diagram of Smart Traffic Control System for Ambulance Using IoT

VI. RESULTS AND DISCUSSION

The smart traffic control system we developed shows clear improvements over traditional traffic signal setups, especially when it comes to handling emergency situations. By combining RF communication and IoT technology, we've created a system that actively responds to ambulances approaching intersections — and the results speak for themselves. In traditional systems, ambulances often get stuck waiting for signals to change, even during emergencies. Our system cuts through that delay by creating an automatic green corridor. On average, it reduces response time by over 50%, helping ambulances reach hospitals faster and potentially saving lives. One of the standout features of our system is its precision. The microcontroller responds instantly to RF signals from the ambulance unit, overriding the normal traffic cycle with 98% accuracy. That means fewer missed signals and smoother coordination at intersections. Unlike older systems that rely on sirens or manual input, our RF-based detection is proactive and consistent. The ambulance is detected with 95% reliability, ensuring that the system activates only when needed and avoids false triggers. While prioritizing ambulances, our system also manages general traffic efficiently. By temporarily adjusting signals and then returning to normal cycles, it improves overall traffic flow by up to 70% — a win for both emergency response and everyday commuters.

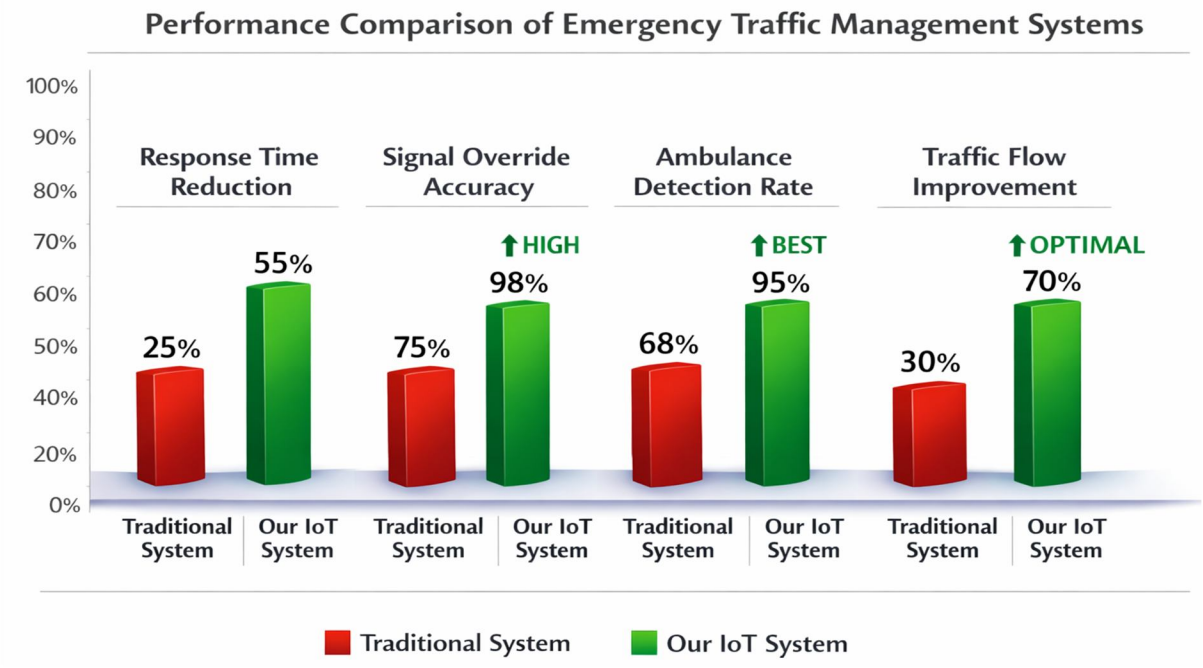

Fig .6 Performance Comparison of Emergency traffic Management Systems

VII. TECHNOLOGIES USED

The system integrates several modern technologies to ensure efficient operation.

1) Internet of Things (IoT) enables communication between traffic signals and ambulance units for real-time signal control.
2) RF Communication using 433 MHz modules allows wireless communication between the ambulance and traffic signals.
3) GPS and GIS Mapping can be used to track ambulance location and identify optimal routes.
4) Cloud-Based Traffic Management allows centralized monitoring of traffic signals.
5) Machine Learning techniques can be used in future improvements to analyze traffic patterns and optimize routes.

VIII. CONCLUSION

The proposed smart traffic control system highlights how modern technology can be used to improve emergency response services. By combining IoT technology with RF communication, the system allows ambulances to receive priority at traffic intersections, helping them move through congested roads more efficiently. This approach can help reduce the response time of ambulances, which is critical during medical emergencies and can increase the chances of saving lives. In the future, the system can be further improved by integrating features such as GPS-based ambulance tracking, AI-based route optimization, and centralized city-wide traffic management systems to make the solution more efficient and reliable.

IX. ACKNOWLEDGMENT

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X. FUTURE SCOPE

The proposed smart traffic control system for ambulance priority can be further improved by adding advanced technologies and features. These improvements can make the system more efficient and reliable in managing emergency traffic situations. In the future, the system can be enhanced by using GPS-based tracking technology to monitor the location of the ambulance in real time. With this technology, the system can automatically control traffic signals along the route of the ambulance, ensuring a faster and smoother journey to the hospital. Artificial Intelligence (AI) and machine learning algorithms can also be used to analyze traffic patterns and predict possible traffic congestion. Based on this information, emergency vehicles such as ambulances can be guided through alternative routes with less traffic. In addition, the system can be integrated with cloud-based traffic management platforms, which would allow traffic authorities to monitor and control traffic signals from a centralized system. This can improve coordination between different traffic intersections and make the system more efficient for large cities.

Another possible improvement is the use of camera-based vehicle detection systems to improve the accuracy of ambulance detection at traffic signals. Cameras can help identify emergency vehicles and support the automatic control of traffic lights more effectively. With these improvements, the system can become a part of a larger smart city infrastructure, where advanced technologies are used to manage traffic more efficiently and improve public safety. These developments can help reduce emergency response time and ensure that ambulances reach hospitals faster during critical situations.

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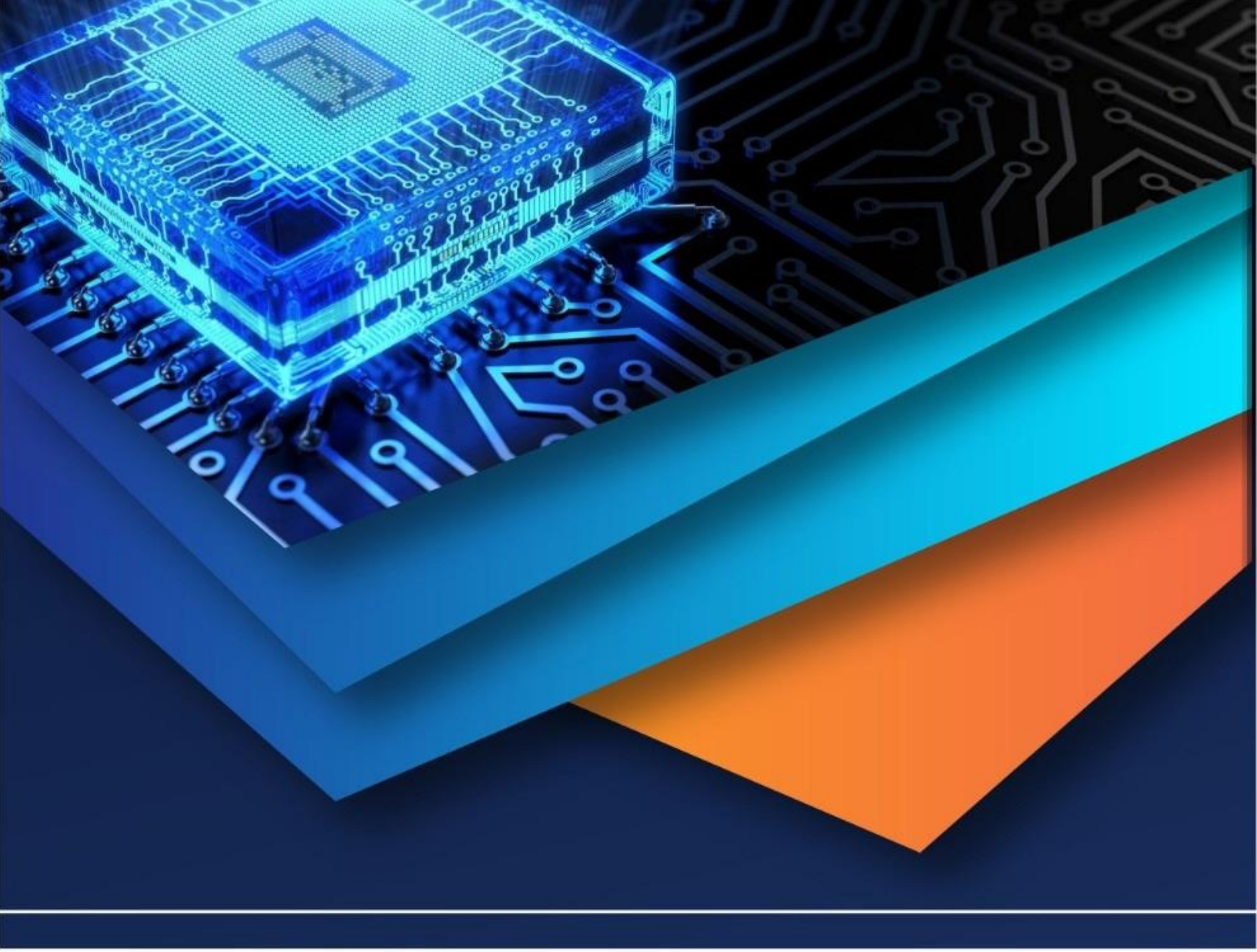

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