iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 **Issue:** III **Month of publication:** March 2025

DOI: https://doi.org/10.22214/ijraset.2025.67909

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue III Mar 2025- Available at www.ijraset.com

Smart Bus Arrival System

Saijyothi Subhash Bedar[1], Fariha Bashir Khan[2], Tilak Murugan Kannadiar[3], Tushar Zombade[4]
Department of Electronics and Telecommunication Engineering Anantrao Pawar College of Engineering and Research Pune, Maharashtra

Abstract: ***An effective vehicle tracking system is designed and developed for monitoring the movement of any vehicle equipped from any place at any time. The designed system utilized a Smartphone and web application in conjunction with a microcontroller. This will be simple to create and cost-effective compared to others. The designed in-vehicle unit operates based on Global Positioning System (GPS) and Global system for mobile communication / General Packet Radio Service (GSM/GPRS) technology that is one of the most popular methods for vehicle tracking. The GPS tracking module is integrated into a vehicle whose location is to be identified and monitored in real-time. A microcontroller is utilized to manage the GPS and GSM/GPRS modules. The vehicle tracking system utilizes the GPS module to obtain geographic coordinates at a set time interval. The GSM/GPRS module is utilized to send and update the vehicle location to a database. A Smartphone and web application is also implemented for real-time monitoring of the vehicle location. The Google Maps API is utilized to indicate the vehicle on the map in the Smartphone application. Therefore, users will be able to monitor a moving vehicle continuously on demand using the Smartphone application and calculate the estimated distance and time for the vehicle to reach a specified destination. In order to demonstrate the feasibility and effectiveness of the system, this report provides experimental results of the vehicle tracking system and some experience on practical implementations.***
Keywords: GPS (Global Positioning System), Microcontrollers, GPRS (General Packet Radio Service)

I. INTRODUCTION

Buses for long and short-distance travelers are provided; however, there is no detailed information given to most travelers about such buses. Detailed information comprises, but is not limited to, the number of buses available to the
Destination, identification numbers or names of buses, schedule timings, estimated time of arrival, routes that buses will follow, and maps that will help the traveler navigate during the journey. Most importantly, the capability of tracking the bus's current Position is needed. The system outlined above will eliminate these issues discovered. It will be an Android application that is meant to provide users with relevant information about the bus they will board, including checking the current position of the bus, the next stop the bus will take, and the estimated time of arrival, among other functionalities. The SMART bus System will provide customers with various functionalities, such as automated voice announcements of stops through a loudspeaker, automated announcements of exterior routes and destinations through both a loudspeaker and LED displays, and GPS location services, among others. Generally, riders making use of the SMARTBUS are able to track their bus in real-time. This removes inefficiency in standing at a bus stop wondering if a bus is on its way or stuck in traffic, therefore allowing commuters to plan their travel better. The SMARTBUS system will offer detailed departure and arrival schedules for the buses, along with real-time route information stating the current locations of buses using the SMARTBUS technology. Because there is no need to stand at the bus station to wait for the bus unnecessarily.

II. METHODOLOGY

The data flow in the Smart Bus Arrival System starts with every bus reporting its geographical location to a server. Every bus is equipped with a GPS module that reports its location. This location is then processed by an ESP32 microcontroller within the bus and uploaded to a central server that contains a database. The server not only monitors the location of every bus but also keeps important information, including the identity of the bus, its route, and estimated times of arrival at different stops along the route. This central database is the basic building block of the system, offering real-time access and updating to all information. In order to enable efficient transfer of data over long distances using little energy, the system applies sophisticated technology. The technology enables the bus to transmit its distance to the subsequent stops as it arrives at each stop.

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Through the use of different modules, the system can monitor the relative distance of each bus to a stop, hence improving the precision of arrival time predictions. These features avoid latency in information transmission, thus rendering updates timely even over long distances, which is particularly beneficial for real-time public transport applications.

A dot matrix LED display at each bus stop is controlled by an ESP32 microcontroller, making it possible to offer real-time information to the passengers. The central server, after processing information from each bus, sends the information to the respective bus stop display through LED technology. It is not just the nearest upcoming bus but also important information like the route number and destination. When buses are approaching the stop, the LED display automatically updates, and the passengers are provided with accurate, real-time information about the upcoming bus.

The real-time flow of information allows travelers to plan their trips more effectively, thus reducing delays and making bus travel more convenient. The integration of GPS and ESP32 modules in the Smart Bus Arrival System creates a smooth and reliable real-time communication system, significantly improving the reliability and efficiency of public transportation services.

1) GPS Module

The GPS module is the basic component that is responsible for the identification of the instantaneous position of buses. The GPS modules utilize the signals coming from satellites in order to compute the geographical positions, i.e., latitude and longitude, of the bus. The GPS module picks up signals from several satellites revolving around the Earth. The signals are embedded with time stamps and the satellites' positions. By comparing the time difference when the signal has been sent and received, the module computes the distance of each satellite. The module works based on the method of trilateration for finding the actual coordinates of the bus in latitude and longitude terms. The data is then transmitted to the microcontroller (ESP32) to process and also for communication purposes. In this project, GPS data plays an essential role in tracking the bus current position and predicting the time of arrival at different bus stops.

2) ESP32 Microcontroller:

ESP32 is a powerful and flexible microcontroller that can process multiple communication protocols such as Wi-Fi, Bluetooth, and lora. It supports a dual-core processor, Wi-Fi and Bluetooth modules integrated into the hardware, and a large GPIO pin count for sensor and display connections. ESP32 is responsible for reading data from the GPS module, processing data, and transmitting data via the Network.

The ESP32 receives real-time location information in real time through the GPS module and stores it to be transmitted later through the module. 4. Dot Matrix LED Display Dot Matrix LED display is used as a bus stop device to provide live information about the arrival of buses to commuters. The display is made up of a matrix of leds arranged in rows and columns, which allows the system to display characters, numeric data, and simple graphic images. 8x320 or 16x64 Dot Matrix LED modules are widely used displays for this particular purpose, which provide adequate space to display bus numbers, estimated arrival time, and so on.

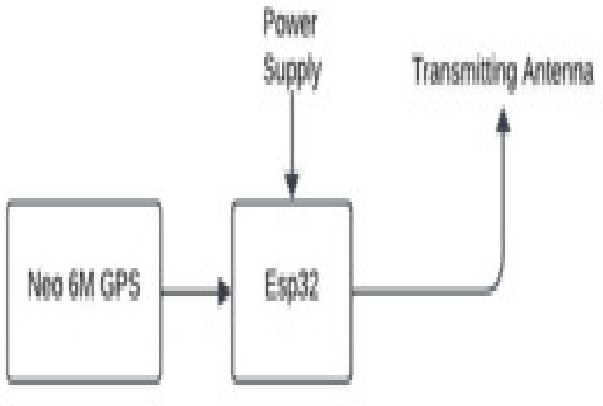

Fig. 1 Transmission Antenna

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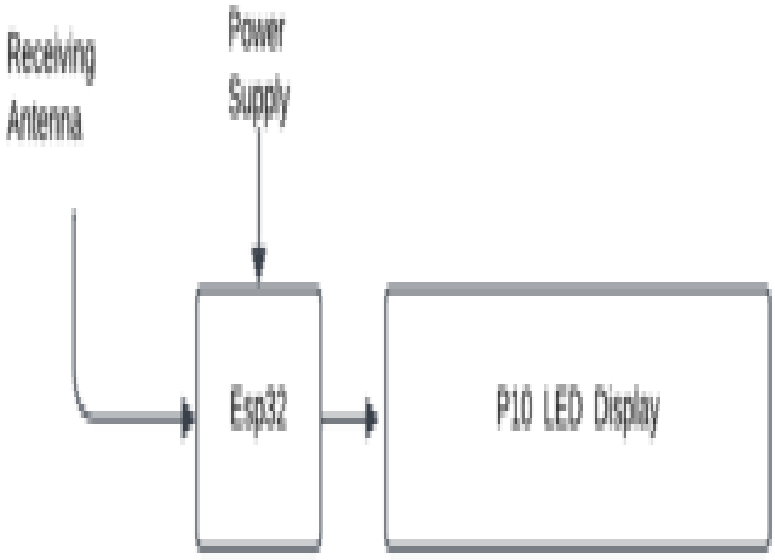

Fig. 2 Receiving Antenna

Each bus stop has an LED dot matrix display powered by an ESP32 microcontroller that is responsible for showing real-time data to the passengers. Every bus sends data to a central server that is processed. And shown on the corresponding bus stop display using LED indicators, yet also showing other important data such as route number and destination.

The system is likely to assist bus operators in enhancing the safety of passengers. Adequate timetables for individual route services are determined by applying GPS technology. Bus operators will also be able to handle emergencies effectively through access to real-time information. The proposed system tries to make traveling easier by utilizing public transport like day or night buses for the deaf and blind.

Combined, the following embody aspects Automatic announcement of internal stops. (via loudspeakers installed inside buses/high performance vehicles) of Important stops and landmark information

- Local next stop and automatic current stop data on the LCD screen;
- Automatic route of departure and destination announcement. (via outdoor speakers and LCD screen high performance vehicles).
- The technology is anticipated to enable bus operators to enhance passenger safety and schedule dependability for fixed route service.
- It also provides drivers with improved services and related service information while on the move.
- The system is also programmed to automatically announce the next stop on the schedule and simultaneously display the same information real-time on indoor and outdoor LCD displays, thereby giving assistance to the hearing impaired.
- Automatically announces the destination and estimated bus time for waiting passengers at each scheduled bus stop using an Android mobile application, thus saving the passengers time. Since they do not have to wait at the bus stop for the bus.

The intelligent bus arrival system uses Internet of Things (iot) and wireless technologies for communication to show real-time information regarding the arrival of buses. The system consists of two major components: a bus monitoring module and display terminals at bus stops. Every bus is equipped with a NEO-6M GPS module that communicates with an ESP32 microcontroller that continuously logs GPS data latitude, longitude, and time then transmits the data via Wi-Fi to a central server.

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III. FLOWCHART

The Smart Bus Arrival System Utilizes A Number Of Core Technologies, Such As Gps And Microcontroller-Based Processing, To Present Real-Time Bus Arrival Time Data. The Working Principle And The System Model Are Described In Detail Below.

Gps Module: It Is Used To Precisely Locate The Position Of The Bus. It Receives Signals From Satellites To Determine The Present Coordinates Of The Bus, I.E., Its Latitude And Longitude, And Velocity.

Esp32 Microcontroller: This Multifunctional Microcontroller Is Responsible For Overseeing Data Collection, Processing, And Transmission. It Obtains Data From The Gps Module, Processes This Information To Determine The Estimated Time Of Arrival (Eta), And Transmits It Back To The Module.

IV. LITERATURE REVIEW

1) Lora wan-based GPS tracking for smart public transport- Gaurav K [2022]

This paper explores Low-power lorawan and proves that they are effective in providing long-range tracking with minimal energy consumption, ideal for public transport systems. Public Transportation system faces challenges in providing efficient and reliable services, GPS tracking can improve operations but traditionally cellular networks are costly and consume more power.

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The paper demonstrates that lorawan is effective in providing reliable, long-range tracking with minimal energy consumption, making it ideal for public transit systems where power efficiency and wide coverage are essential. According to the study, traditional GPS tracking systems often rely on cellular networks, which can be costly and have high power requirements.

2) Use of GPS in Public Transportation Systems- Liu et al [2020]

The integration of GPS into public transportation has been widely studied to improve the accuracy of vehicle tracking and scheduling. According to a study on GPS technology has revolutionized the way transit systems monitor vehicle positions and optimize routes. The paper highlights that real-time GPS data allows public transportation systems to reduce delays, increase predictability, and provide accurate information to passengers. Their research focused on enhancing public transportation services in congested urban environments through real-time GPS tracking. They proposed a system where GPS data is continuously relayed to a central monitoring station, enabling dynamic route adjustments based on traffic conditions. The system also provides real-time arrival information to passengers, reducing waiting times at bus stops.

3) Energy Efficient Street Light Controller for Smart Cities- N. Katiyar [2017]

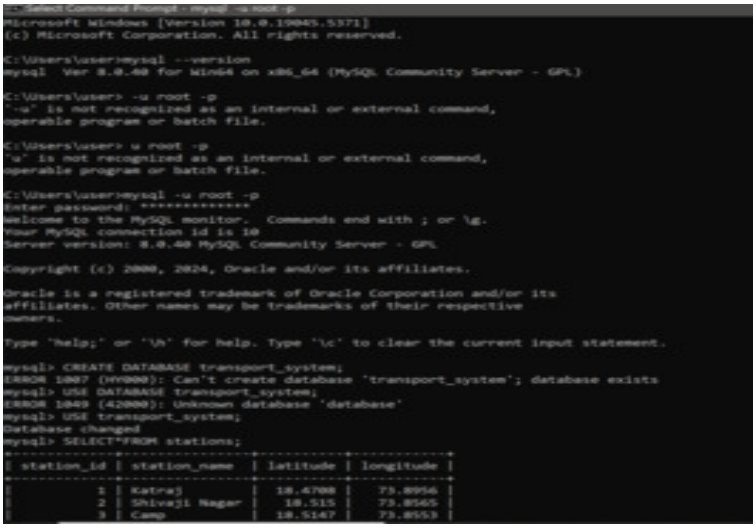
This paper presents an energy-efficient street light controller designed for smart cities. The system optimizes energy consumption and performance through intelligent control and management techniques. Katiyar's street light controller design includes several critical components and operational methodologies: Sensor Integration: Light Sensors: The controller uses light sensors to detect ambient light levels and adjust streetlight brightness accordingly. For instance, during twilight or cloudy days, the system can increase brightness, while on a clear night, it can reduce brightness to conserve energy.

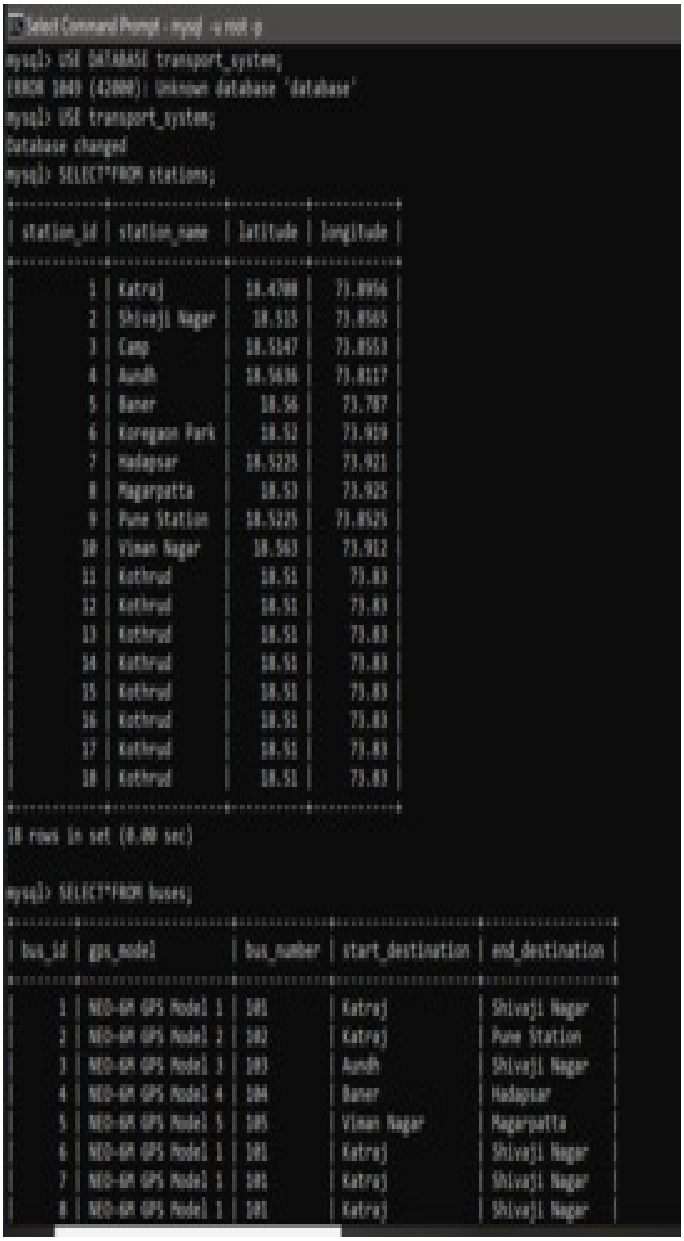
4) Street Light Control Based on Pedestrian and Automobile Detection- R. Sujatha, J. Gitanjali, R. Pradeep Kumar, Automatic Must Ansar, Ali, Ghazanfar, Babiyah, and Jyoti Moy Chatterjee, [2022]

Ambient Light Sensors: The controller incorporates light sensors to measure ambient light levels. These sensors help the system determine how much artificial lighting is needed, if at all, at different times of day or in various weather conditions. For example, during dawn or dusk, the natural light level may be sufficient, allowing the system to dim the lights or turn them off completely. At night, as ambient light decreases, the system automatically increases brightness to maintain visibility.

Traffic Flow Sensors: The system uses traffic flow **sensors** (e.g., motion detectors or infrared sensors) to detect the presence of vehicles and pedestrians. When high traffic levels are detected, the lights increase in brightness to ensure visibility and safety. Conversely, during low-traffic periods (such as late at night), the system dims the lights to conserve energy. This adaptive response to traffic patterns allows the lights to be at full brightness only when necessary, which reduces unnecessary power consumption.

V. RESULTS





```
mysql> USE DATABASE transport_system;
ERROR 1049 (42000): Unknown database 'database'
mysql> USE transport_system;
Database changed
mysql> SELECT*FROM stations;
+------------+-----------------+----------+-----------+
| station_id | station_name    | latitude | longitude |
+------------+-----------------+----------+-----------+
|          1 | Katraj          |  18.4708 |   73.8956 |
|          2 | Shivaji Nagar   |   18.515 |   73.8565 |
|          3 | Camp            |  18.5047 |   73.8653 |
|          4 | Aundh           |  18.5636 |   73.8117 |
|          5 | Baner           |    18.56 |    73.787 |
|          6 | Koregaon Park   |    18.52 |    73.939 |
|          7 | Hadapsar        |  18.5225 |    73.931 |
|          8 | Magarpatta      |    18.53 |    73.925 |
|          9 | Pune Station    |  18.5225 |   73.8625 |
|         10 | Viman Nagar     |   18.563 |    73.912 |
|         11 | Kothrud         |    18.51 |     73.83 |
|         12 | Kothrud         |    18.51 |     73.83 |
|         13 | Kothrud         |    18.51 |     73.83 |
|         14 | Kothrud         |    18.51 |     73.83 |
|         15 | Kothrud         |    18.51 |     73.83 |
|         16 | Kothrud         |    18.51 |     73.83 |
|         17 | Kothrud         |    18.51 |     73.83 |
|         18 | Kothrud         |    18.51 |     73.83 |
+------------+-----------------+----------+-----------+
18 rows in set (0.00 sec)

mysql> SELECT*FROM buses;
+--------+-----------------+------------+-------------------+-----------------+
| bus_id | gps_model       | bus_number | start_destination | end_destination |
+--------+-----------------+------------+-------------------+-----------------+
|      1 | NEO-6M GPS Model 1 | 101        | Katraj            | Shivaji Nagar   |
|      2 | NEO-6M GPS Model 2 | 102        | Katraj            | Pune Station    |
|      3 | NEO-6M GPS Model 3 | 103        | Aundh             | Shivaji Nagar   |
|      4 | NEO-6M GPS Model 4 | 104        | Baner             | Hadapsar        |
|      5 | NEO-6M GPS Model 5 | 105        | Viman Nagar       | Magarpatta      |
|      6 | NEO-6M GPS Model 1 | 101        | Katraj            | Shivaji Nagar   |
|      7 | NEO-6M GPS Model 1 | 101        | Katraj            | Shivaji Nagar   |
|      8 | NEO-6M GPS Model 1 | 101        | Katraj            | Shivaji Nagar   |
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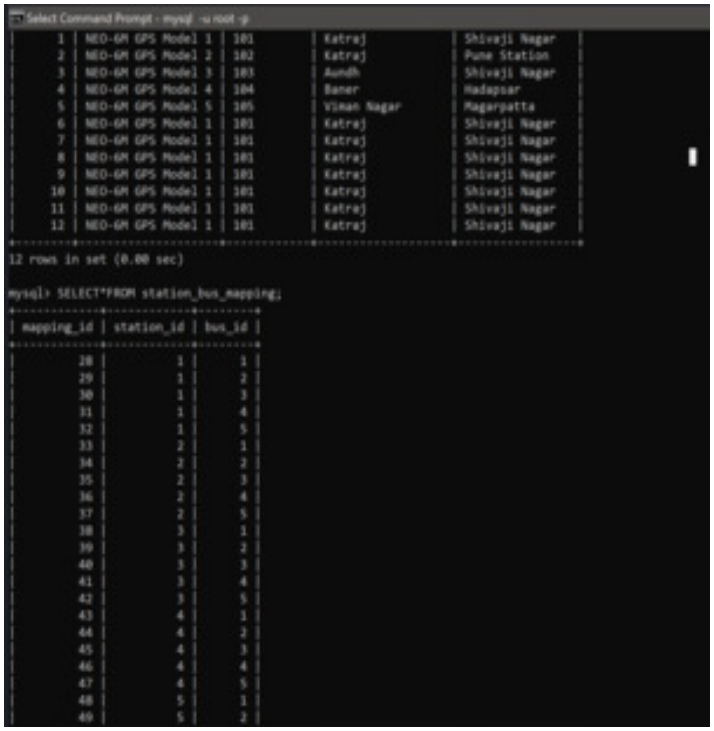

VI. CONCLUSION

GPS based bus tracking system is a client-side application based on the Android platform. The application is free and easy to install on the device. In the case where there is internet The system will be efficient. We have developed and tested a vehicle tracking system to track the exact location of moving or stationary vehicles in real time. This report describes the design and implementation of our vehicle tracking system specifically targeting buses. SMART bus tracking and timing system uses in-vehicle GPS/GSM/GPRS module, web server. And Android smartphone applications The vehicle's geographic coordinates and the vehicle's unique ID received from the vehicle device are recorded in a database table. And by creating a smartphone and web application to display vehicle location on Google Maps, we were able to experimentally demonstrate its effectiveness in locating vehicles anywhere, anytime. A vehicle's geographic coordinates and a vehicle's unique ID obtained from an in-vehicle device are recorded in a database table. And a Smartphone and web application was created to display a vehicle location on Google maps. We were able to experimentally demonstrate its effective performance to track a vehicle's location anytime from anywhere.

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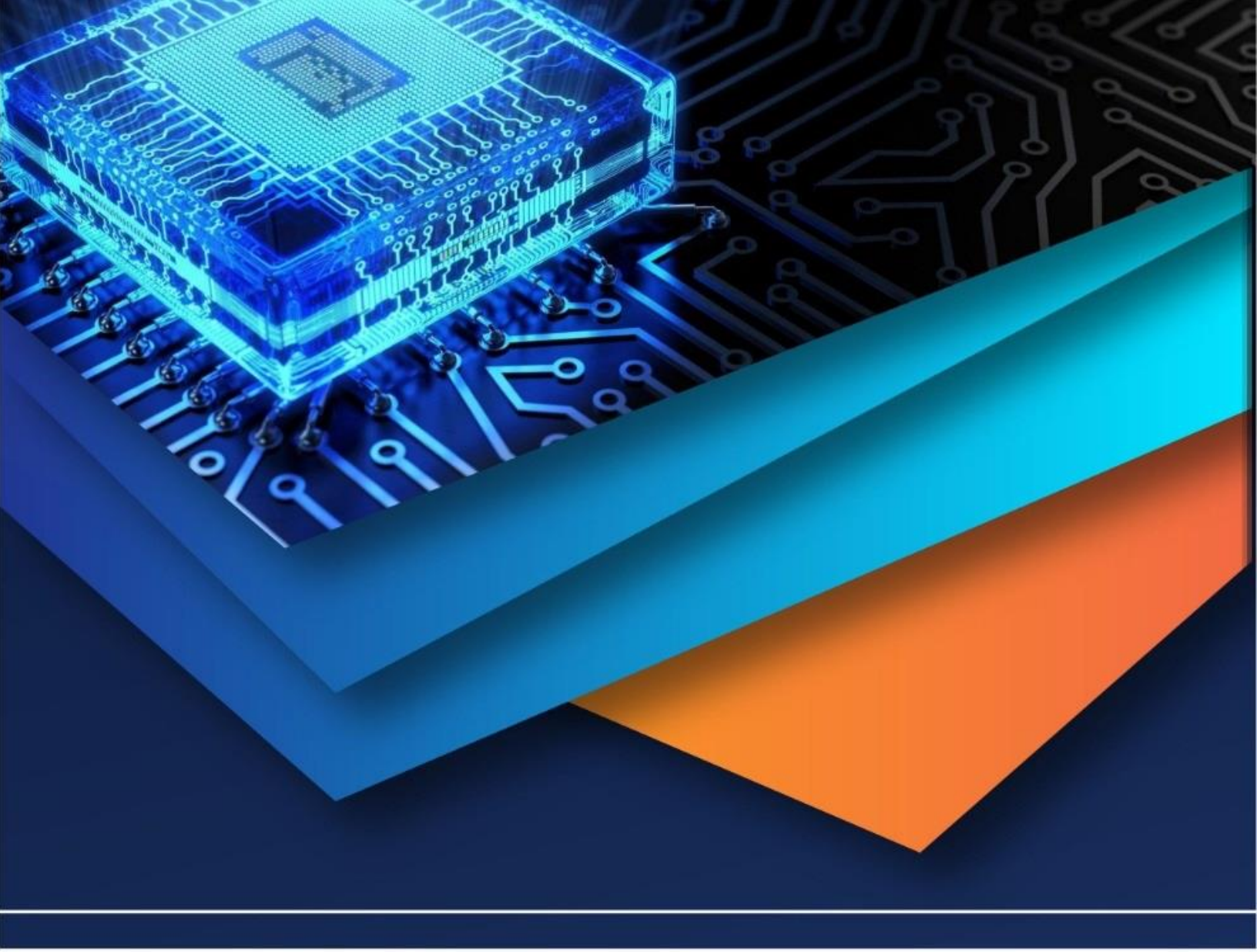

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