iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 12 **Issue:** XI **Month of publication:** November 2024

DOI: https://doi.org/10.22214/ijraset.2024.65472

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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 12 Issue XI Nov 2024- Available at www.ijraset.com

Fingerprint-Authenticated Voting System with Real- Time Data Sharing via Android Application

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Abstract: ***This system presents a novel electronic voting solution tailored for college-level elections, integrating biometric authentication with real-time data transmission. The system is built around an ESP32 microcontroller, a fingerprint sensor for secure user authentication, and an OLED display for interaction. Upon successful authentication, the ESP32 activates Bluetooth to connect seamlessly with an Android application, providing users with a simple interface for voting, polling, or submitting feedback. This system improves security and transparency by ensuring only authorized individuals can vote, while real-time data transmission fosters immediate result processing and accountability. By combining biometric security, ease of use, and instantaneous communication, the system promotes an inclusive and participatory governance environment within educational institutions.***

Keywords: Biometric Voting, ESP32, Fingerprint Authentication, Electronic Voting Machine (EVM), Real-time Data Transmission, Android Application, College Governance, Secure Voting System, OLED Display.

I. INTRODUCTION

The evolution of technology has significantly impacted various aspects of society, including democratic processes. Electronic Voting Machines (EVMs) have become a cornerstone in modernizing electoral systems, offering efficiency, accuracy, and security. This project aims to leverage EVMs to enhance the voting experience within college campuses. By integrating biometric authentication and establishing a seamless connection with an Android application, the system aims to streamline the voting process while ensuring security and accessibility. The ESP32 microcontroller serves as the bridge between the EVM and the Android application, enabling biometric authentication through a fingerprint module. The ESP32 activates Bluetooth upon successful authentication, facilitating communication with the Android application. This connection enables users to log in and participate in voting activities, as well as real- time data transmission between the EVM and the application. The instantaneous transmission of data between the EVM and the application fosters transparency and accountability, empowering stakeholders to make informed decisions. The project aims to revolutionize the college-level voting experience by harnessing the potential of electronic voting technology, promoting inclusivity, efficiency, and integrity within college governance structures.

II. PROBLEM STSTEMENT

Educational institutions face challenges with manual attendance tracking, which is prone to inaccuracies, lacks security, and makes maintaining and accessing attendance logs inefficient. Additionally, conducting polls, providing timely notifications, and ensuring accessible records on a mobile platform are difficult to manage without an integrated system. There is a need for a reliable, secure, and user-friendly solution that automates attendance, maintains downloadable logs, facilitates polls, sends notifications, and allows seamless interaction on an Android app.

III. MOTIVATION

In universities where surveys and written feedback play a significant role in building student governance and participation, traditional surveys fail to impact quality and security concerns. Problems such as illegal voting, interference, and transportation delays in processing results affect the efficiency and transparency of this democratic process. Solutions to these issues, by integrating biometric authentication via a fingerprint sensor, we reduce the risk of fraud by ensuring only authorized students can participate.

The organization's ability to provide information now provides rapid results, increases accountability, and increases trust in the selection process. The program provides excellent interaction for both users and administrators. The use of OLED screens provides users with a good understanding, making it easy to access and operate even for those who do not know how to use the technology. The system not only makes it easier to manage elections, but also helps create an environment of good governance by promoting a culture of transparency, accountability and safety in schools.

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IV. OBJECTIVE

Create an attendance system that utilizes biometric authentication, such as fingerprint scanning, to securely and accurately record student attendance in class. Implement functionality to automatically generate and maintain attendance reports, allowing for easy access, analysis, and export of attendance data by authorized personnel.

Integrate a notification system to inform students of their attendance status or any updates, promoting transparency and accountability. Ensure the system is compact, portable, and easy to set up, allowing for flexible deployment across various college venues and classrooms.

Extend the system's functionality to support other academic and governance activities, such as conducting quizzes and secure electronic voting, enhancing the utility of the system in a college environment.

V. LITERATURE REVIEW

Several approaches to electronic voting systems (EVS) have been explored, focusing on integrating emerging technologies like biometrics and blockchain to enhance security and transparency. [1] discuss the impact of decentralization on electronic voting systems, emphasizing how distributed systems can improve trust and data integrity in the voting process. [2] Developed a smart-voting machine using fingerprint sensors and face recognition, ensuring secure voter authentication by leveraging biometrics, a similar approach to the fingerprint-based system proposed in this project.

Other research has investigated the use of blockchain technology to solve trust issues in e-voting [6]. Their blockchain-based system ensured transparency and immutability of votes, critical for ensuring fair elections. Additionally, studies on low-cost electronic voting systems,

[5] highlight the practical design of real-time Arduino-based EVMs, providing inspiration for designing cost-effective voting platforms. This project integrates real-time data transmission to allow for continuous monitoring and timely issue resolution, as suggested by various studies that emphasize the importance of real-time oversight in voting systems

VI. PROPOSED SYSTEM DESIGN

The proposed electronic voting system is designed to enhance security, transparency, and efficiency in college-level elections. The system integrates biometric authentication, real-time data transmission, and a user-friendly interface. Key components of the system include an Electronic Voting Machine (EVM) powered by an ESP32 microcontroller, a fingerprint sensor for authentication, and an OLED display for interaction. The system connects to an Android application through Bluetooth, enabling seamless communication and real-time result updates.

A. System Architecture

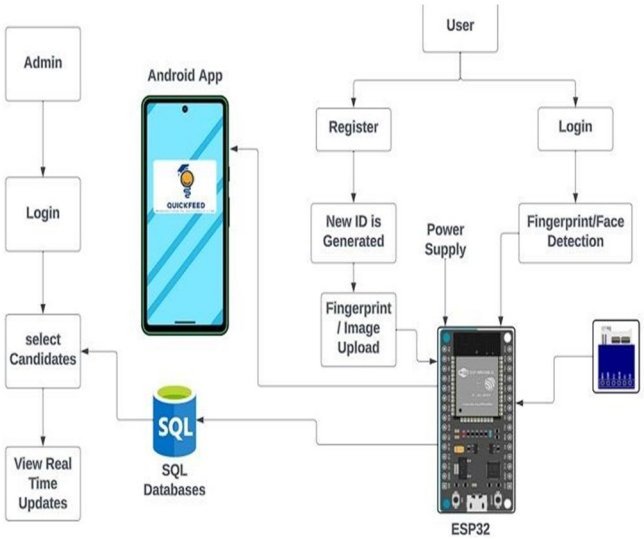

Figure 1:- Block Diagram

The system architecture consists of the following components:

B. Hardware

1) ESP32 Microcontroller: The core of the system, responsible for managing biometric authentication, establishing Bluetooth communication with the Android application, and controlling the OLED display. The ESP32 provides low- power operation with integrated Wi-Fi and Bluetooth, ensuring efficient communication.

Figure 2:- ESP32

TABLE I. ESP32 SPECIFICATIONS

Specification	Details
Core	Dual-core processor
Architecture	32-bit architecture
Clock Speed	160 MHz (can be increased to 240 MHz)
Bluetooth	Supports both Classic Bluetooth and BLE 4.2
Wi-Fi	Compatible with TCP/IP and supports full 802.11 b/g/n/e/i WLAN protocol
RAM	512 KB
Flash Memory	4 MB, expandable up to 16 MB
Peripherals	ADC, DAC, PWM, UART, SPI, I2C, I2S, CAN, Capacitive GPIO

2) Fingerprint Module (R307): This module is responsible for securely identifying users through their biometric data. The system verifies the stored fingerprints with those provided by the voter, ensuring that only authorized individuals can access the voting system.

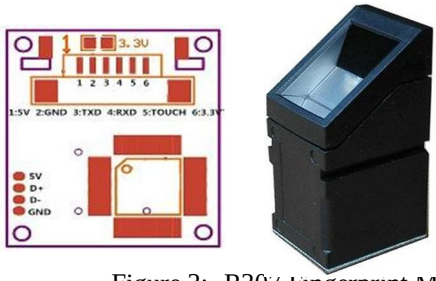

Figure 3:- R307 Fingerprint Module

3) OLED Display (0.96"): The display provides visual feedback during the authentication and voting process. It guides users through the voting interface, displaying instructions, vote confirmation, and result updates.

Figure 4: - OLED Display

TABLE II. OLED DISPLAY SPECIFICATIONS

OLED Display	Specification
OLED Driver IC	SSD1306
Resolution	128 x 64
Visual Angle	>160 degree
Input Voltage	3.3 v-6v
Compatible 1/0 Level	3.3 v, 5 v
Mini Size	2.7 x 2.8 cm
Working Temperature	-300c 700c
Module Volume	27.0 x 27.0 x 4.1 mm

4) *TP4056 Lithium Battery Charger Module:* The charging module manages power delivery and recharging for the system's battery. It ensures the device remains operational in portable settings, offering convenience and uninterrupted functionality for extended periods.

TABLE III. Lithium Battery Charger ModulSpecifications

Lithium Battery Charger Module Input Interface	Specifications
Current	Mini USB
Charge Precision	1 A adjustable
Input Voltage	1.50%
Full Charge Voltage	4.5 v -5.2 v
Battery over-current protection	4.2 v
The battery Undervoltage Protection	2.5 v

5) *MT3608 2A Max DC-DC Step Up Power Module Booster Power Module:* The MT3608 is a DC-DC step-up power module capable of providing a maximum output current of 2A. It is designed to boost input voltages to higher levels, making it useful for applications where a higher voltage is required. The module is compact and easy to use, making it suitable for a variety of projects and applications.

Figure 5: - MT3608

C. *Software*

1) *Android Studio:* Android Studio is the official IDE for Android development, used to design and develop the Android application for the system. It provides a comprehensive environment for building user-friendly interfaces and implementing features such as notifications, polling, and interaction with the ESP32 via Bluetooth.
2) *Programming Languages:* The system utilizes a combination of programming languages, including C++ for ESP32 firmware, Java/Kotlin for Android application development, and HTML, CSS, and JavaScript for web-based components. These languages ensure robust functionality and seamless integration across devices.
3) *Visual Studio Code (VS Code):* VS Code is a versatile text editor used for writing and debugging code, particularly for front-end web development and scripting. Its extensive extensions and lightweight interface make it ideal for managing different codebases efficiently.

4) *Arduino IDE:* The Arduino IDE is employed to program the ESP32 microcontroller. It provides a simple interface for writing, compiling, and uploading code, enabling features such as biometric authentication, data processing, and real-time communication with external devices.
5) *Google Firebase:* Google Firebase is a versatile platform that provides developers with tools to create, enhance, and scale their applications. It offers a range of services, such as real-time databases, user authentication, analytics, cloud storage, and hosting, all of which integrate smoothly with both web and mobile apps. Firebase simplifies backend development, allowing developers to focus more on creating great user experiences. Its benefits include real-time data synchronization, robust user authentication, scalable cloud infrastructure, and powerful analytics, which together enable faster development, easier scaling, and data-driven insights to optimize app performance and user engagement.

VII. EXPERIMENTAL ANALYSIS

A. *Result Analysis*

The Fingerprint Biometric Attendance System is an IoT- based system that uses an ESP32, a 0.96" OLED Display, and an R307 Fingerprint Sensor. The system captures fingerprint data and sends it to a website for authentication. A PHP- developed website manages attendance records, storing personal information and timestamps. This system is widely used in educational institutions and workplaces for precise attendance tracking and security. It also includes instructions for setting up a global/local website.

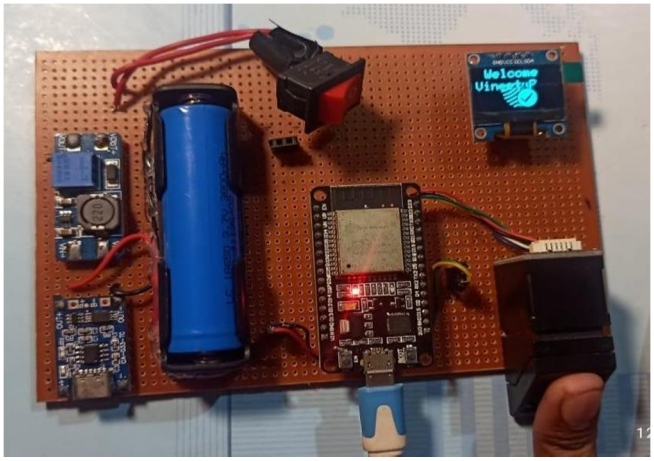

Figure 6: - Student Marking Attendance

The admin can switch between Attendance and Enrollment modes based on the current requirement. This provides flexibility to either register new users or log the attendance of existing ones.
The student places their finger on the biometric sensor. The system operates in Attendance Mode, which checks if the fingerprint matches an existing record in the system's database. If the fingerprint is authenticated, the system marks the student's attendance and logs the time and date.

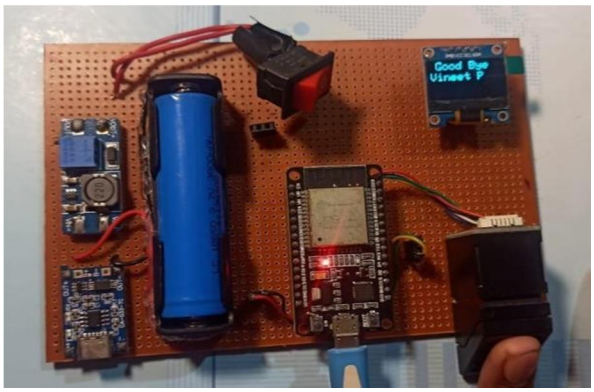

Figure 7:- Successful Attendance Logging

Once the fingerprint is recognized, a confirmation is shown, either via an OLED display or a similar visual indicator. The system logs the student's attendance, potentially transmitting the data to a centralized server using IoT connectivity.

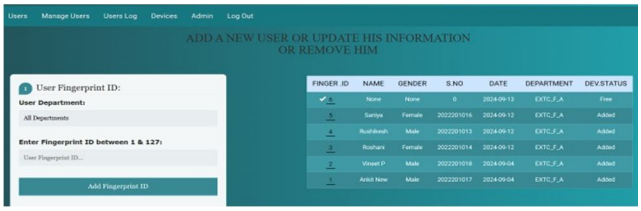

Figure 8:- Manage User Webpage

The above figure 8, presents the Manage Users Webpage of the IoT-based fingerprint biometric attendance system. This page enables the admin to add, update, and remove users. It includes a user list displaying details such as Name, Fingerprint ID, and Department. The admin can enroll new users, edit existing user information, and delete inactive users. Search and filter options assist in finding specific users. The page provides full control over user management within the system.

ID	NAME	SERIAL NUMBER	FINGERPRINT ID	DEVICE DEP	DATE	TIME IN	TIME OUT
106	Vineet P	2022201018	2	EXTC_F_A	2024-09-12	08:56 PM	08:56 PM
105	Vineet P	2022201018	2	EXTC_F_A	2024-09-12	08:55 PM	08:55 PM
104	Saniya	2022201016	5	EXTC_F_A	2024-09-12	08:01 PM	08:02 PM
103	Rushikesh	2022201013	4	EXTC_F_A	2024-09-12	08:01 PM	08:02 PM
102	Roshani	2022201014	3	EXTC_F_A	2024-09-12	08:00 PM	08:02 PM
101	Vineet P	2022201018	2	EXTC_F_A	2024-09-12	07:59 PM	08:00 PM
100	Ankit New	2022201017	1	EXTC_F_A	2024-09-12	07:53 PM	07:53 PM

Figure 9:- Students Log

The above figure 9, illustrates the Students Log, showing attendance records with details like Student Name, Fingerprint ID, Date, Time, and Department. The admin can filter these logs by various parameters, facilitating efficient attendance tracking and analysis.

Figure 10:- No. of Devices

Figure 10, shows the Number of Devices connected to the system, including details such as Device Name, Department, UID, Date, Mode (Attendance/Enrollment), and Configuration. This helps the admin track and manage device status and settings.

B. Software Analysis

The Feedback System, built using Android Studio, allows students to log in using their college email ID and access the platform. It provides a straightforward process for submitting feedback on courses or faculty, ensuring an intuitive experience with minimal confusion. This organized structure helps in gathering precise data for comprehensive feedback reports, enhancing the system's efficiency and ease of use.

Figure 11:- Login Page

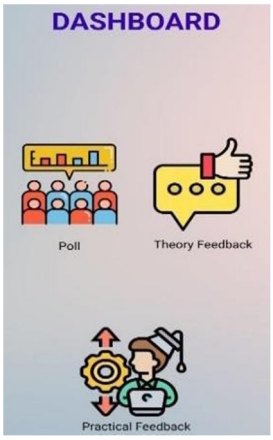

Figure 11:- Login Page

I. COMPARISON

Comparison of Existing Biometric Attendance Systems and the Proposed System

TABLE IV. COMPARISON TABLE

Feature	Existing Systems	Proposed System
Authentication	Basic fingerprint for attendance only	Biometric for both attendance and voting
Data Transmission	No real-time sync	Real-time transmission
Accessibility	Fixed machines	Mobile integration, vote anywhere
Cost	Expensive hardware	Low-cost components
Scalability	Limited locations	Easily scalable
Fraud Prevention	Minimal, prone to duplicates	Real-time updates prevent fraud

VIII. FUTURE SCOPE

In future iterations, the system can be enhanced by incorporating advanced biometric methods, such as facial recognition, to strengthen security. Additionally, integrating blockchain technology would provide immutability and decentralization, ensuring that votes cannot be altered once cast. A web-based platform could further extend accessibility, allowing voters to participate from any internet-connected device. The system could also be expanded for use in large- scale elections, such as national or corporate votes, by increasing server capacity and implementing distributed ledger technologies to maintain the integrity of votes across multiple locations.

IX. CONCLUSION

Fingerprint-Authenticated Voting System with Real-Time Data Sharing via Android Application enhances security, transparency, and efficiency in college-level elections by integrating fingerprint authentication and real-time data transmission. Powered by the ESP32 and an Android app, the system ensures only authorized voters participate and provides instant, accurate results. Its scalability and adaptability make it a valuable solution for improving voting integrity in educational settings. Future enhancements could include additional biometric methods like facial recognition to further strengthen security accuracy, security, and transparency.

X. ACKNOWLEDGMENT

With warm regards, we extend our heartfelt appreciation to Professor Deepak C. Karia for his unwavering support and guidance throughout our project.

His insightful mentorship has been instrumental in shaping our progress, helping us overcome challenges with confidence and ensuring the successful execution of our ideas. We are deeply grateful for his encouragement and expertise, which have been invaluable throughout this journey. We would also like to thank the Sardar Patel Institute of Technology for their continued commitment to excellence, providing the infrastructure and resources that have made the realization of this project possible. The institute's culture of innovation has allowed us to explore and develop our ideas freely, fostering both creativity and growth.

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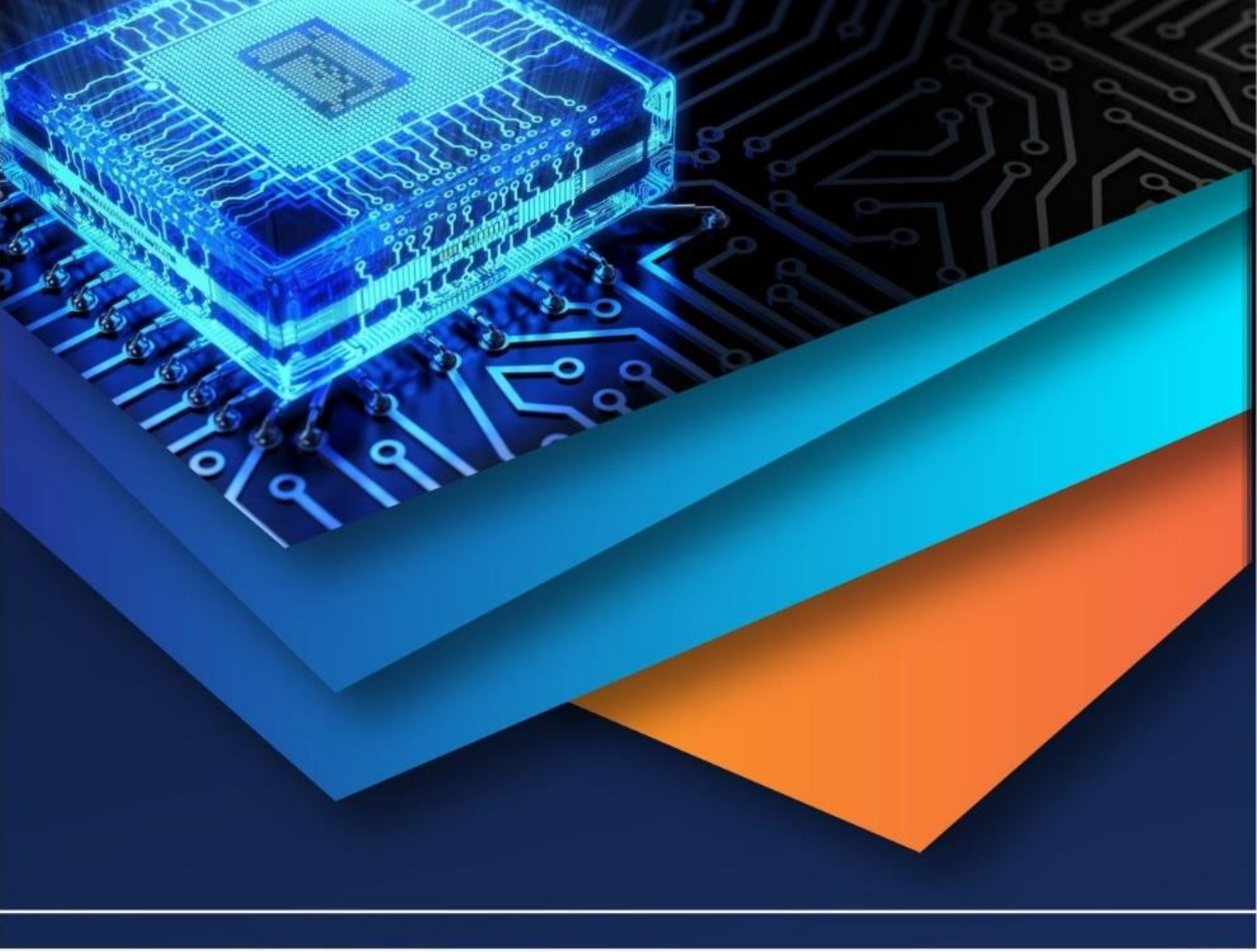

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