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Environmental Monitoring with Design of Wireless Sensor Node

Pranjal Singh[1] Prof. Rajakumar K[2].
[1]Vellore Institute of Technology, Vellore, Tamil Nadu
[2]Under the guidance of Vellore Institute of Technology, Vellore, Tamil Nadu

Abstract: The Internet of Things (IoT) shows a virtual view, using the Internet Protocols, including a huge variety of real objects, ranging from a van, to a cup, to a building, to plants in a forest. It provides us the generalized access to the status and location of any "object" or "thing" we may be interested in. Wireless sensor networks (WSN) are well suited for environmental data acquisition for a longer term and for IoT representation. This paper presents the implementation and functional design of a complete WSN platform that can be used for environmental monitoring IoT applications for a long-term. The application requirements for low cost, high number of sensors, fast deployment, long lifetime, low maintenance, and high quality of service are considered in the specification and design of the platform and of all its components. Low-effort platform reuse is also considered starting from the specifications and at all design levels for a wide array of related monitoring applications.
Keywords | Wireless sensor networks, Sensors, Peer-to-peer computing, Logic gates, Environmental monitoring, Servers

I. INTRODUCTION

A wireless sensor network (WSN) is a distributed system, usually consists of micro-controller, radio frequency transceiver, containing resource or constrained nodes that work in an ad- hoc manner [1]. A WSN type of system is getting increasingly used in both academia and industry due to its vast application area and profound potential in resolving various problems.

Technological advances in areas like computing platform miniaturization, low power radio transceivers have enabled the development of small, and configurable sensor platforms, with lasting for significant amount of time [2]. Due to the huge advancement and massive research, the WSN research for environmental monitoring has taken a bigger form. First and foremost, the improvements in sensor, battery, and semiconductor technology has made the design and deployment of WSNs possible [2]. Extensive research works in this field are being carried by both industry and colleges, leading to various designs and implementations. WSN acts as a key factor in the relationship between digital and analogue world, not only because of the sensor technology, but also the implementation of sensor networks.

WSN reveals its important application in environmental monitoring. Currently, though contamination in environment, especially pollution, imposes significant mortality on the urban communities globally, today's published data on pollution concentration do not comprise too accurate estimation of exposure to individuals [3]. According to WHO over 1.4 billion urban residents worldwide are living in areas with air pollution above recommended air quality guidelines [4]. However, there were several problems for WSN in building energy management. It is complex and difficult to install a vast number of sensors into buildings and the cost of maintenance makes them less popular [5]. The other problem focuses on the selection of wireless communication technologies. Currently, there are a multitude of wireless technologies available. Among them, Bluetooth, Wi-Fi and ZigBee are used extensively for WSNs, while all of them have a comparatively high power consumption which limits the battery life of nodes developed using these technologies [8]. Nowadays, the combination of environmental study and wireless sensor network (WSN) has become more and more popular in the relevant research field. Alongside the development of Bluetooth Low Energy (BLE), other low-power wireless solutions such as 6LoWPAN and Z-Wave have been getting famous in applications [9], yet these protocols are mainly intended for multi-hop networking. As a result, to tackle some of the existing problems, we proposed a design of portable WSN system for environment monitoring in real-time. This system is formed by multiple dispersed sensor nodes and a PC to process and store the data. Each sensor node is a portable and cost-effective device integrated t sensor, a temperature and humidity sensor, and UV sensor, gas sensor and a buzzer to warn.

The remaining of this paper is organized as follows: §II describes the related work of WSN systems. §III introduces the design of our WSN system. The evaluation of our system in multiple settings is explained in §IV. §V discusses several potential applications for our WSN system. Finally, §VI concludes our paper and suggests some future work

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II. RELATED WORK

Construction workers who are exposed to hot and humid environments are at high risk of heat stress. Excessive exposure to such environments can result in occupational illnesses and injuries. Acquisition of sensor data from such environments is essential to ensure improved Health and Safety (H&S) of workers. Building Information Modelling (BIM) offers a new epitome to provide comprehensive solutions for H&S and evacuation planning in buildings. In paper real-time environmental monitoring, visualization and notification system for construction h&s management by Muhammad Arslan, Zainab Riaz, Adnan Khalid Kiani, Salman Azhar. The rapid development and miniaturization of sensor devices, and the recent advances in wireless communication and networking technologies, are allowing scientists and engineers to develop networks of small sensors that can be used to continuously monitor the health and stability of the environment we live in. Wireless Sensor Networks (WSNs) consist of a number of spatially distributed sensors with computing, processing and communication capabilities that can continuously sense and transmit data to a base station, where data can be processed and observed in real time. In paper A Wireless Sensor Network for Environmental Monitoring of Greenhouse Gases by A Wireless Sensor Network for Environmental Monitoring of Greenhouse Gases. Nowadays, there is an increasing interest in wireless sensor networks (WSN) for environmental monitoring systems because it can be used to improve the quality of life and living conditions are becoming a major concern to people. This paper describes the design and development of a real time monitoring system based on ZigBee WSN characterized by a lower energy consumption, low cost, reduced dimensions and fast adaptation to the network tree topology. The developed system encompasses an optimized sensing process about environmental parameters, low rate transmission from sensor nodes to the gateway, packet parsing and data storing in a remote database and real time visualization through a web server. In paper A Low Consumption Real Time Environmental Monitoring System for Smart Cities based on ZigBee Wireless Sensor Network by Francisco Sanchez-Rosario, David S ´ anchez-Rodr ´ ´ıguez, Jesus B. Alonso-Hern ´ andez, Carlos M. Travieso-Gonz ´ alez. Greenhouses are often used for growing flowers, vegetables, fruits, and tobacco plants.

III. SYSTEM DESIGN

Our Designed WSN system is divided into two parts: sensor node side and user monitoring side. Fig. 1 demonstrates the architecture of the entire system. On the sensor node side, each sensor node having all the sensors which can sense various environment factors, including gas, temperature, relative humidity, and UV. The sensor data will be transmitted to the server side using Zig-Bee protocol. In threshold condition, buzzer will be active.

The server side comprises a PC with Zig-Bee module, a database, and a web server. The Zig-Bee module is responsible for transmitting environmental data from the sensor nodes to the Zig-Bee module connected to PC. The database stores all the data retrieved from the sensor nodes, and the web server provides web interfaces and APIs for the end users.

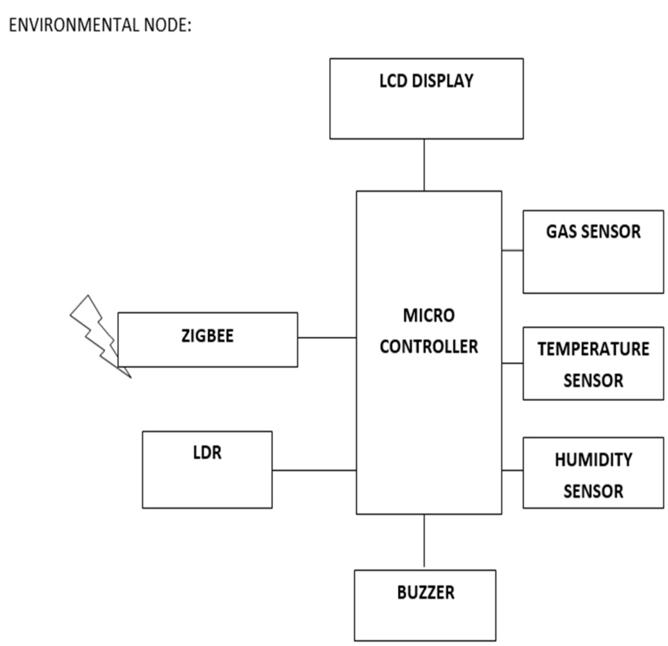

Fig. 1.Architecture of the proposed WSN System.

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A. Sensor Node Design

Fig. 2 displays the high-level structure of each sensor node. In our WSN system, each sensor node consists of 3 sensors, 2 modules and 1 microcontroller and a buzzer.

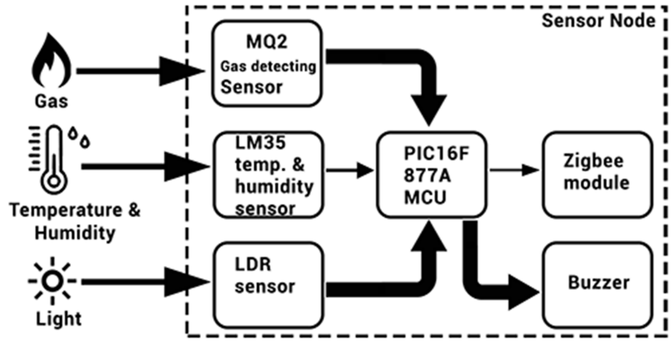


Fig. 2. High-Level Structure of each sensor node

Table I and II list all the major electronic components being used in each sensor node. All the components are cost efficient and cheap.

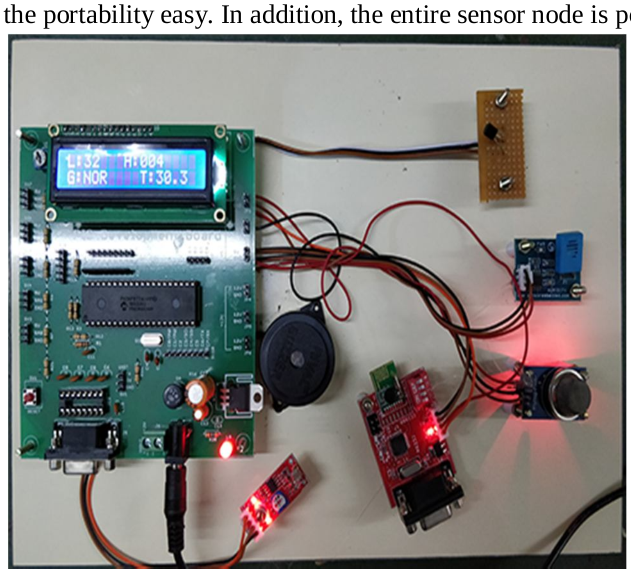
TABLE I. MODELS OF SENSORS

SENSORS	MODELS
Temperature & Humidity Sensor	LM35
Gas Detecting Sensor	MQ2
LDR Sensor	

TABLE II. MODELS OF MODULES AND MICROCONTROLLER

MODULES	MODELS
Microcontroller	PIC16F877A
ZigBee	CC2500

These sensors and modules are compacted on a PCB together with a microcontroller. All components are placed into a 14 x 5 x 6 cm board, as shown in Fig. 3, to make the portability easy. In addition, the entire sensor node is powered by a adapter.



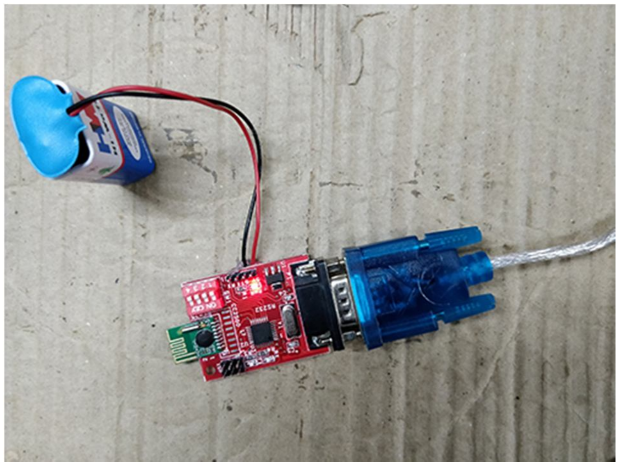


Fig. 3. An Assembled Sensor Node

B. Firmware Design

The firmware is the program executed inside the microcontroller, which is responsible for driving sensors, reading data, controlling the data transmission and storage, and managing the entire sensor node.

1) Firmware Architecture: The firmware architecture is displayed in Fig. 4. As can be seen, the firmware is divided into three layers. The bottom layer, which is the communication protocols, is responsible for communicating with and retrieving data from the sensors and extra modules. The upper layer has data storage, and time synchronization. Finally, on the top layer, there are data transmission and data display functions. All the data, after being processed, will be transmitted through the Zig-Bee module to the module at the server, and will also be displayed on the on-board LCD screen.

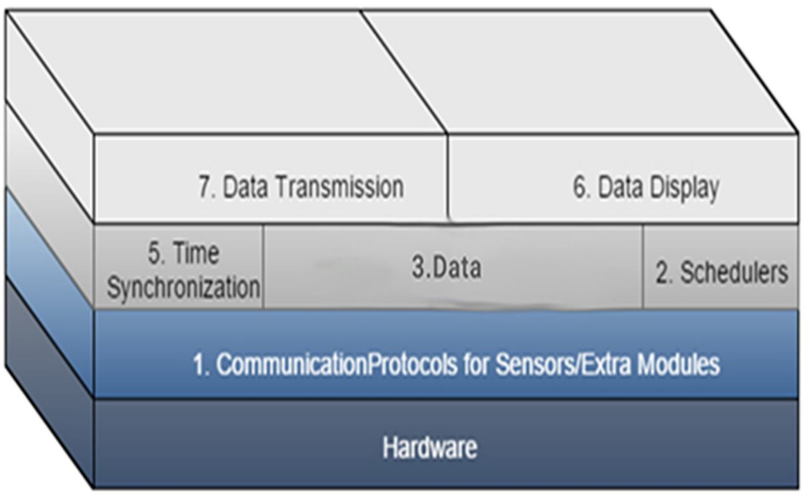


Fig. 4. Architecture Diagram of the Firmware

2) Scheduler: The main and important function of schedulers is to set the components into off mode and activate them up at an appropriate frequency. Because if all the components are working continuously all the time, they will consume a considerable amount of power, which makes the battery drains very fast, hence scheduler is one of the options to reduce the power consumption. In our proposed system, the scheduler executes in the following 3 steps repeatedly.

The DS3231 RTC module is functioning as an alarm to trigger the external interrupt of the microcontroller and wake it up from rest mode every minute interval.

Based on the rules of scheduling, the microcontroller will select the sensors and extra modules which are in rest mode to be waked up. It then reads the data from these sensors and modules, and transmits them to the Zig-Bee module on the server before setting the sensors and modules into rest mode again.

The microcontroller sets itself into rest mode again and waits for next activation trigger from DS3231 RTC.

Fig. 7 demonstrates the real-time data displaying from sensor node. The real-time sensor readings are correctly displayed in the LED screen. The web interface provides a list of currently working sensors that can be selected to display the readings.

Fig. 7. Real-Time Data Plotting of a Sensor Node

IV. PERFORMANCE EVALUATION

In this section, we evaluate the performance of our WSN including the correlation between the data on our node web interface and readings displayed in LED by sensor node.

A. Evaluation of Tested system for accuracy

1) *Project Name*: Environment Monitoring System
2) *Test Case ID:* EMS_1 : Test Priority (Low/Medium/High): High
3) *Module Name*: Environment monitoring website
4) *Test Title:* Verify actual environment data with data on website
5) *Description:* Test the website and hardware
6) *Test Designed by:* Pranjal Singh
7) *Test Execution date:* 26-03-2016
8) Pre-conditions: User has module and knows the actual data

Step	Test Steps	Test Data	Expected Result	Actual Result	Status (Pass/ Fail)	Buzzer
1	High Temperature	Fig 8	T: 60.2 °C	T: 60.2 °C	Pass	Not active
2	Lethal Gas	Fig 9.	G: ABNO	G: ABNO	Pass	Active
3	High Light Intensity	Fig 5.1.4.	L: 77%	L: 77%	Pass	Not active

Table iii. Models of sensors

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Fig. 8, Fig. 9, Fig. 10 compares the data displayed on the web interface with the data displayed on the LED display. To consider LED display as a reference reading point, we have crossed checked the LED display data with actual readings acquired from internet.

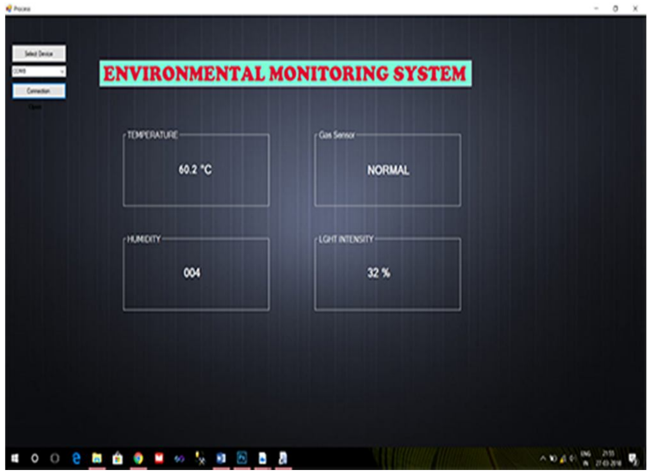

Fig. 8. Error Comparison with web interface temperature node

Fig. 9. Error Comparison with web interface gas node

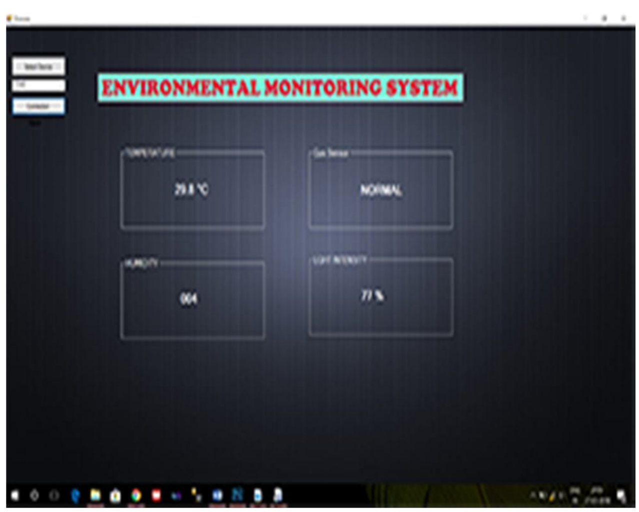

Fig. 10. Error Comparison with web interface LDR node

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B. Evaluation the data obtained from all Sensors

Zig-Bee module is a crucial component of this system, to evaluate the performance of this sensor, web interface data has to be compared with an accurate reference source. In this work, we use the mobile sensors to calculate the room conditions and environment details like, temperature, humidity and light intensity and make sensor node board as reference will specifically discuss two potential applications with significantly different requirements.

V. DISCUSSION

We demonstrated that our proposed WSN system is capable of sensing different environmental factors, thus enables various applications to be deployed. In this section, we will specifically discuss two potential applications with significantly different requirements.

A. Participatory Environmental aspect of system

The greenhouse effect occurs when solar radiation which is sun heat, is trapped by the gases in the earth's atmosphere and reflected back from the earth. Thus, it will heat the surface of earth and leads to global warming. Therefore, greenhouse monitoring system is important to ensure the stabilization of the environment.

The climate change of the world nowadays have brought many effects such as the breaking of sea ice, increasing in sea water level, heat waves, glacier melting, lake temperature warming, and many more. Thus, in an effort to control and monitor the climate change, [33] develop a monitoring system that manages and keeps data in real time and focuses on the processing of spatiotemporal query.

B. Personal Health Aspect

Our environment plays a pivotal daily role in our health and well-being. The air we breathe, the water we drink, the noise levels we're exposed to, and the weather we experience, all directly affect us in terms of our quality of life, our life expectancy, and the prevalence of certain diseases or other aspects of our personal health.

Poor air quality, for example, has been linked to premature death, cancer, and respiratory conditions such as chronic obstructive pulmonary disease (COPD).

VI. CONCLUSION

In this paper, we have designed a portable and low-cost WSN system, and we also prototyped a sensor node and performed evaluations to demonstrate the correctness of our design. The sensor node embedded multiple sensors, a temperature and humidity sensor, a barometer, a UV sensor, and a gas sensor with a buzzer functionality.

The Environment Monitoring System project aims to the deployment of a WSN for automatically and continuously monitoring and control the environment of museums. The use of WSNs for environmental monitoring of a museum is, indeed, a more reliable solution. It is also less expensive than manual data collection or than a wired central monitoring system. This project has proposed several contributions, among them the environment monitoring website. This website allows the environmental monitoring based on wireless sensor networks via any PC.

owever, there are two limitations of this system which need to be noted. First of all, the data is limited to a single place, it needs to be cross checked with different cities to make it more efficient. Secondly, the security of our WSN system has to be re-considered. Because data transmission is not encrypted and could be manipulated during the transmission from the Zig-Bee module.

VII. ACKNOWLEDGMENT

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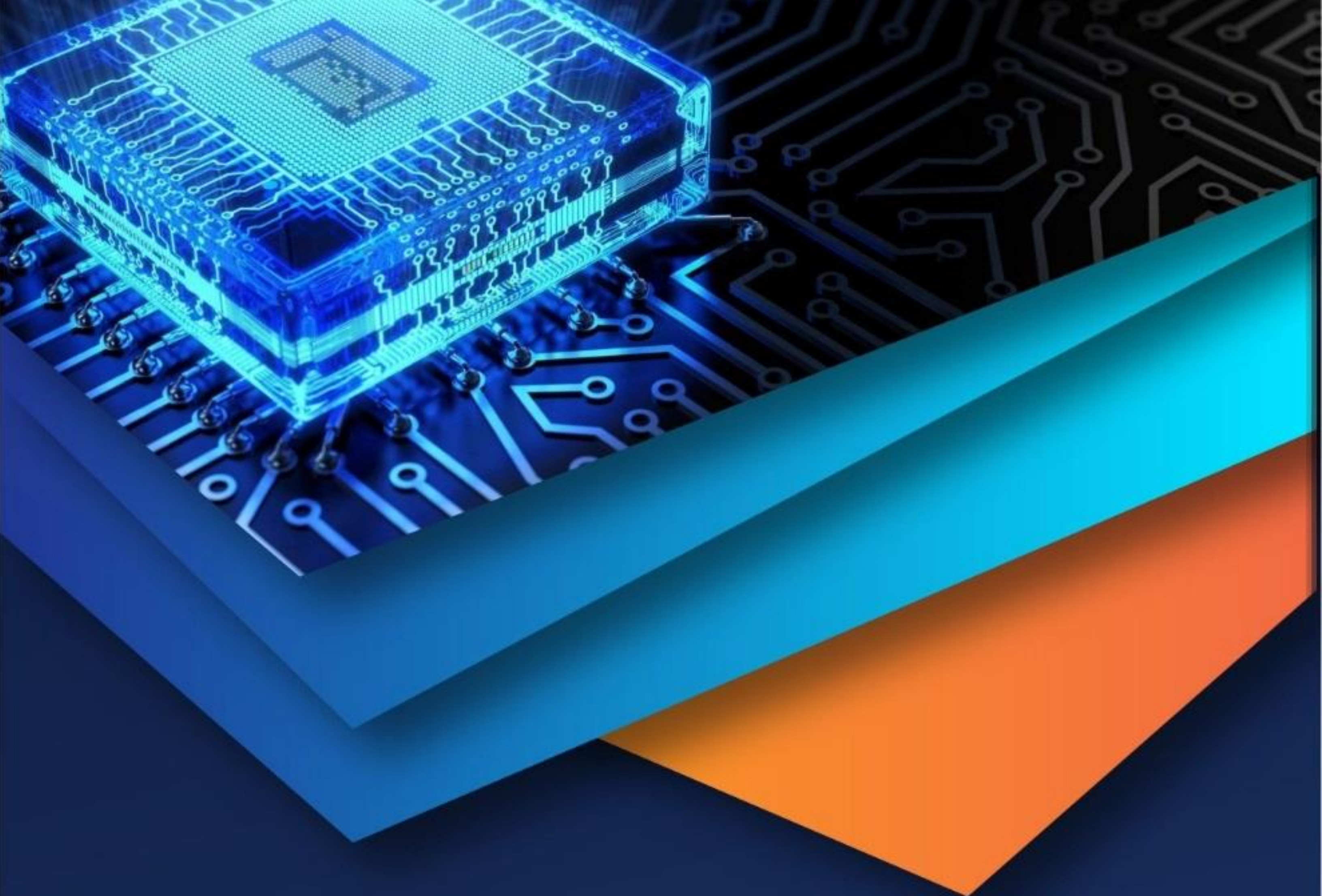

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