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Water Quality Monitoring Using Physical Web Concept and Alert via Whatsapp Messenger

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Abstract: ***Monitoring water quality plays a crucial role in safeguarding human health, Industrial equipment and aquatic life such as in aquarium. In this research paper we have present a low-cost and unique demonstration of real-time water quality monitoring using physical web concept and alert to user by WhatsApp if water quality is Low. Physical web concept is a broadcast and discovery service in that, smart object broadcasts relevant information that nearby mobile devices can discover to interact with that object. Using physical web user can digitally interact with object and service without much effort that user feels in conventional method of interaction with object. The TDS and Ph is the important factor for the water quality monitoring among the many other factors. This system utilizes the TDS and Ph sensors to measure and monitor the quality of water. The collected quality monitoring data is processed by the ESP32 and make the decision to sends low-quality alert via WhatsApp to designated users. The system aims to provide a reliable and user-friendly solution for monitoring water quality, enabling timely interventions and minimizing risks associated with it using the physical web concept and Internet of Things (IoT).***
Keywords: IoT, Wi-Fi, BLE, Physical web, Water Quality.

I. INTRODUCTION

The IoT is the extension of internet connectivity into physical devices and everyday objects embedded with electronics. With Internet connectivity and other forms of hardware, these devices can communicate and interact with each other over the internet, and they can be remotely monitored and controlled. The basic motive behind IoT is to provide advanced residential and enterprise solutions through the latest technologies in an energy efficient and reliable manner [1]. New services are now days deployed based on the IoT, as it is fore-seen that by the year 2025, IoT will encompass most of the appliances, food packaging, documentations, furniture and many more [2]. Key requirements in the Internet of Things (IoT) concept are context-aware computation, smart connectivity with existing networks and cost efficient low-power wireless solutions [3]. Due to this IoT has potential to be a practical solution for various real-life use cases. One key challenge in realizing this potential is to making it easy for user to deal with this technology. We are using Physical web concept and WhatsApp messengers to solve this problem.

Bluetooth v4.0 was emerged as a significant innovation in the realm of Internet of Things. Its suitability for ultra-low power sensors with limited battery capacity makes it a noteworthy solution. Bluetooth v4.0 is widely adopted in mobile phones and tablets, and its low power mode enhances its energy efficiency. The tiny Bluetooth v4.0 compatible devices, capable of broadcasting for very long periods on a single coin cell battery. Use of standard Bluetooth v4.0 for broadcasting, making it accessible to all devices equipped with Bluetooth support. [4]. Bluetooth 4.0 and higher version are the key to Physical web concept. In physical web concept researcher are trying to extend the IoT and web technology into the physical world around us. So, one can interact with physical world digitally and more interactively. The Physical Web is meant to develop an open standard that will eventually be built into the OS of every Smartphone and tablet. This involves creating an open ecosystem where smart object can broadcast URLs into the area around them. Any nearby device such as a phone or tablet can then see these URLs and offer them up to the user by notifications [5].

One of the most interesting instant message applications on the market today is WhatsApp. The phenomenal growth of internet-based mobile messaging service WhatsApp, which Facebook has acquired for $19 billion [6], not only undermined the messaging initiatives of Facebook and Google, but they also had a huge adverse effect on traditional mobile messaging service SMS [7],[8]. According to Nielsen India Consumer Rankings WhatsApp messenger is the leading application of smartphone [9]. WhatsApp is a cross- platform instant messaging application for smartphones. It enables users to send and receive location information, images, videos, audio and text messages in real-time to individual and group of friends at no cost. At present WhatsApp handles over 10 billion messages per-day and is one of the most popular paid for apps across all mobile platform [10].

Water quality monitoring involves the collection and assessment of various parameters to determine its overall quality.

These parameters are measured to ensure that water meets the required standards for human consumption, environmental protection, and industrial use. Here are some common parameters and methods used in water quality monitoring for domestic and aquarium use case.

A. Physical Parameters

1) *Temperature:* Water temperature is an essential parameter as it influences the aquatic ecosystem and the solubility of various substances. High temperatures can negatively impact aquatic organisms and increase the growth of certain harmful bacteria. It can be Measured using a thermometer or temperature sensors. They can employ thermistors, resistance temperature detectors (RTDs), or thermocouple to detect temperature changes.
2) *Turbidity:* Turbidity is a measure of water clarity or the presence of suspended particles or solids. High turbidity can be an indication of pollution or sediment runoff, which can impact light penetration, aquatic plant growth, and the behaviour of fish and other organisms. It is determined using a turbidimeter. They employ light scattering or absorption techniques to estimate the turbidity level, typically reported in nephelometric turbidity units (NTU) or formazin nephelometric units (FNU).
3) *Electrical Conductivity (EC):* Electrical Conductivity measures the ability of water to conduct an electric current, which is related to the presence of total dissolved solids (TDS) and minerals. It is commonly used to assess water salinity, contamination by industrial or agricultural activities, and the overall mineral content. Electrical Conductivity is measured by Conductivity sensors, which is related to the concentration of dissolved salts or ions present. They are commonly used to assess salinity and estimate total dissolved solids (TDS) in water.

B. Chemical Parameters

1) *pH:* pH level determines the acidity or alkalinity of water. It is an important parameter because it affects the solubility of nutrients and heavy metals in water. Most aquatic organisms have specific pH requirements, and extreme values can be harmful to them. It is measures using a pH meter or pH Sensors or litmus paper. pH sensors measure the acidity or alkalinity of water. They use a glass electrode that generates a voltage proportional to the hydrogen ion concentration, which is then converted into a pH value.
2) *Dissolved Oxygen (DO):* Dissolved Oxygen refers to the amount of oxygen dissolved in water, Indicates the amount of oxygen available for aquatic life. which is crucial for the survival of aquatic organisms of aquatic life. Insufficient DO levels can lead to hypoxia, causing stress or death of aquatic life. DO levels can be influenced by temperature, water flow, and organic matter decomposition. The acceptable range of dissolved oxygen varies depending on the specific aquatic ecosystem and the organisms present. For example, Coldwater fish species require higher levels of dissolved oxygen compared to warm-water species. Generally, a dissolved oxygen concentration above 5 mg/L is considered healthy for most aquatic life, while levels below 2 mg/L can be stressful or lethal. Do is Measured using a dissolved oxygen meter or sensor. DO sensors measure the amount of oxygen dissolved in water. They can be based on optical or electrochemical principles. Optical sensors utilize fluorescence or luminescence to measure oxygen levels, while electrochemical sensors rely on oxygen-permeable membranes and an electrochemical cell to measure the oxygen concentration.
3) *Total Dissolved Solids (TDS):* TDS represents the total concentration of in-organic and organic substances dissolved in water, such as salts, minerals, and organic compounds. Elevated TDS levels can indicate pollution, contamination, or high mineral content, affecting water quality and taste. TDS is determined by measuring conductivity or by evaporation and weighing the residue. This is the most common parameter among the various parameters to assess the water quality.
4) *Heavy Metals:* Monitoring heavy metals like lead, mercury, arsenic, and cadmium is crucial as they are toxic to both humans and aquatic life. These metals can enter water bodies through industrial discharges, runoff from mining sites, or leaching from contaminated soils. To Measures the heavy metals various respective sensors are used.

C. Biological Parameters

Testing for microbiological contaminants, including bacteria, viruses and parasites, are essential to assess the safety of water for drinking, swimming and for aquatic life. Following are the biological parameters to measure quality of water.

1) *Biological Oxygen Demand (BOD):* Measures the amount of oxygen required by microorganisms to decompose organic matter in water. It is an indicator of organic pollution.
2) *Total Coliforms and Escherichia coli (E. coli):* Presence of these bacteria indicates contamination from faecal matter and potential pathogens.

3) *Algal Blooms:* Monitoring the presence of harmful algal species that can produce toxins harmful to humans and aquatic life.
4) *Aquatic Macroinvertebrates:* These organisms can indicate the overall health of aquatic ecosystems. Assessing the presence and diversity of small organisms like insects, crustaceans, worms, and molluscs can indicate water quality.

D. Other Parameters

1) *Pesticides and Herbicides:* This includes the testing for the presence of agricultural chemicals, which can contaminate water sources.
2) *Organic Compounds:* Analysis for various organic pollutants like polycyclic aromatic hydrocarbons (PAHs) and volatile organic compounds (VOCs)
3) *Microplastics:* Examination for the presence and abundance of microscopic plastic particles in water samples
4) *Nutrients:* Monitoring nutrients like nitrogen and phosphorus and ammonia is important as they are essential for plant growth but it can cause excessive growth of algae and aquatic plants, leading to eutrophication if they are present in excessive amounts. Thus, high nutrient levels can disrupt the balance of aquatic ecosystems and degrade water quality.

Water quality monitoring data is typically collected through continuous sampling the water at specific interval using automated sensors.

The collected samples are then analysed using various techniques determine the concentration of specific parameters. The data collected is crucial for maintaining clean and safe water resources for both human use and the preservation of aquatic ecosystems.

The frequency, measuring parameters and method of water quality monitoring vary depending on the specific water body, regulatory requirements, and the purpose of monitoring (e.g., drinking water supply, recreational use, or specific aquatic life).

II. MATERIAL AND METHOD

To accomplice the aim this implementation requires Bluetooth low energy (BLE) support that broadcast web URL, Wi-Fi capability to connect to internet and a low-cost microcontroller to collect and process the water quality data. The ESP32 module, with its integrated BLE and Wi-Fi capabilities, offers a cost-effective and versatile solutions for collecting, processing, and transmitting the collected data over Internet.

It also required cloud based IoT server to store water quality data and to host the web Interface/web page. A protocol that ensures the communication between the software application and hardware, it also need service in mobile device that can see the broadcast, display it and open the web interface if user want it, for this one can use any physical web Application. This implementation also requires APIs that send WhatsApp alert to the user if water quality is lower than certain threshold.

TDS and pH are the most common parameter to determine water quality in domestic and aquarium use case. So, to measure the quality of water we are using TDS and Ph sensors. TDS and pH sensors are connected to the ESP32, which continuously gathers data and performs necessary computations and store it.

To enable real-time monitoring, the ESP32 establishes a Wi-Fi connection with the internet router, then the collected water quality data is sent to a cloud-based server, where it is stored and further processed.

This implementation uses a web-based interface that allows users to visualize the water quality parameters in real-time for analysis and evaluation.

To access the web-based interface easily and more interactively we are using BLE for realizing the physical web concept. For that broadcasting of URL associated with web-based interface is accomplished by BLE advertising feature. These broadcasted advertisements can be seen as in-app notifications using any physical web App on android based mobile device. One has to just tap on that notification, to open the web-based interface. So, there is no need to typing URL in browser or scanning any QR code to open web-based interface.

In addition to real-time monitoring, our system incorporates alert notifications through the popular messaging platform WhatsApp. When critical water quality parameters exceed predefined thresholds, the ESP32 triggers an alert mechanism that sends an instant alert to the user's WhatsApp account.

Third party server are used for forwarding alert message to the user. This feature ensures timely awareness and facilitates swift response to any potential water contamination incidents. Following Fig. 1. depicts the concept of this proposed system.

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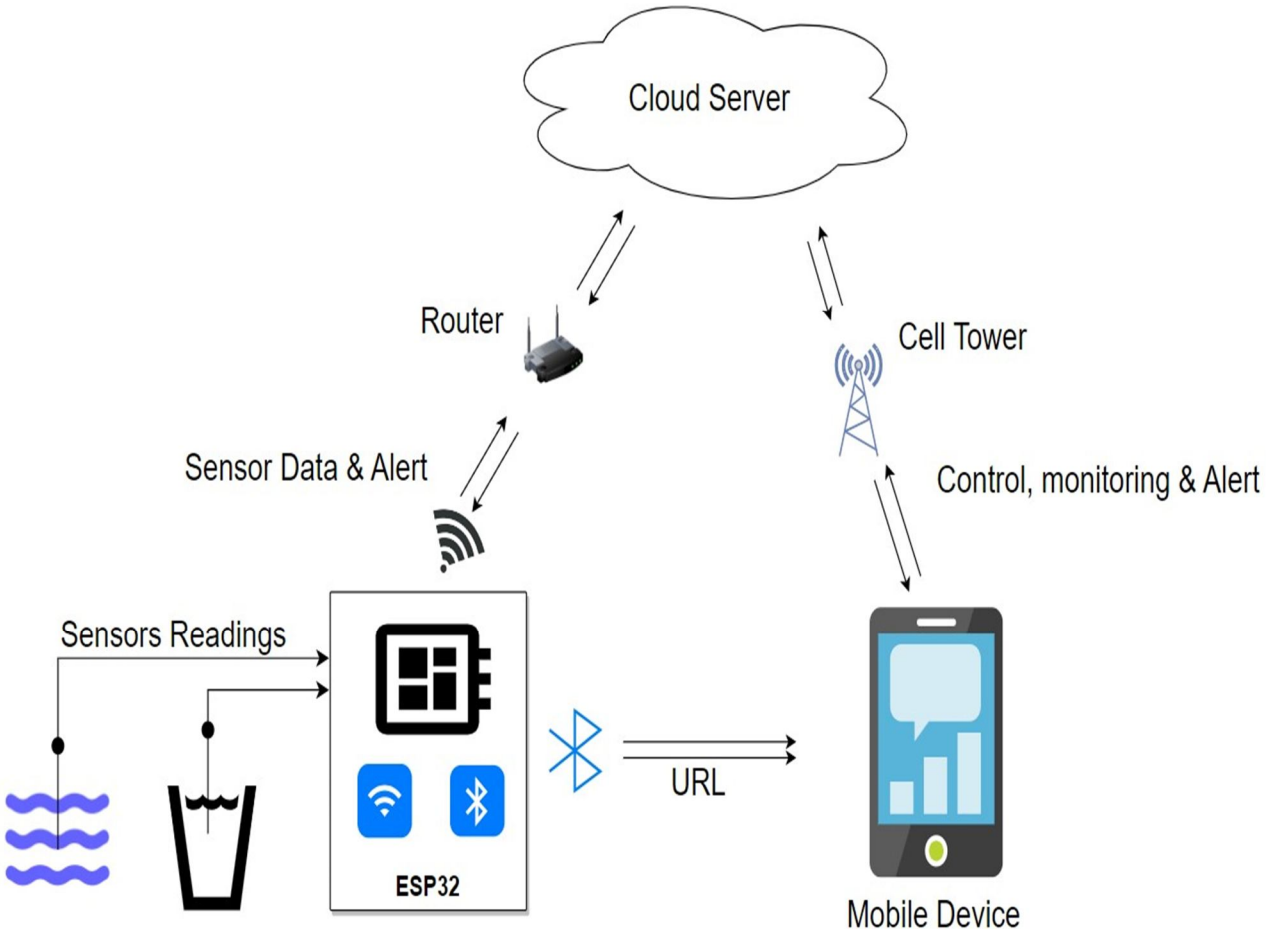
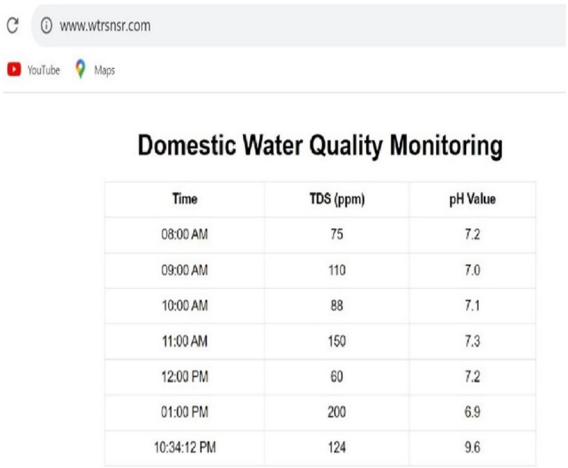


Fig. 1 Working concept of this proposed system

Fig. 2 Discovery of broadcast in physical web app



Time	TDS (ppm)	pH Value
08:00 AM	75	7.2
09:00 AM	110	7.0
10:00 AM	88	7.1
11:00 AM	150	7.3
12:00 PM	60	7.2
01:00 PM	200	6.9
10:34:12 PM	124	9.6

Fig. 3: Web interface to monitor the water quality data

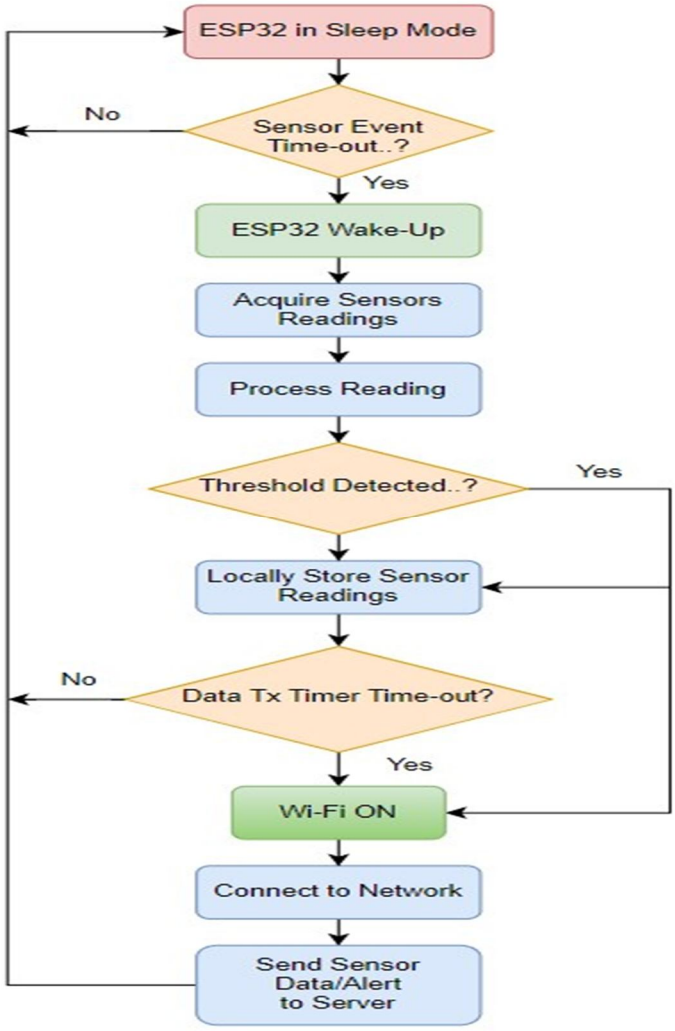


Fig. 4 Flow chart of proposed system

ESP32 is programmed for broadcasting URL of web page which is hosted by cloud IoT Server and to collect, process and to connect to the internet and send water quality data to IoT server. This URL broadcasting is in a format that can be discovered by service in mobile device. Discovery of URL in mobile device using physical web app is shown in Fig. 2, by tapping on that notification one can access the web interface hosted by the server as shown in Fig. 3.

III. RESULTS AND DISCUSSION

Basic motive behind this system is to monitor and alert the user about water quality in very user-friendly way during their day-to-day life. This can be achieved by various way. This system uses physical web concept based on BLE and popular WhatsApp messenger to achieve this. The water quality monitoring system using BLE and WhatsApp Messenger is a significant step forward in the field of water quality monitoring. Using this basic concept and work one can develop numerous stand-alone IoT applications. This platform employs a method that facilitates seamless interaction, enabling multiple users to access and monitor water quality very user-friendly way using their mobile devices, and take required actions if water quality is low.

Furthermore, this work also demonstrates that the inclusion of physical web concept with ESP32 has the potential to be a viable solution for IoT device discovery and interaction. Overall, the paper showcases that low-cost ESP32 chip can be used effectively for physical web concept to enable various IoT applications and services. This work provides the good understanding about physical web concept used for digitally interact with object using IoT and web technologies.

We believe that our demonstration of the water quality monitoring and alert system with Physical Web concept using the ESP32 will serve as a valuable resource for those interested in exploring the potential of this technology for IoT applications.

IV. CONCLUSIONS

In conclusion, our research paper presents a unique demonstration of a real-time water quality monitoring system utilizing the ESP32 microcontroller and Wi-Fi internet connectivity. The integration of multiple sensors, cloud-based data storage, and WhatsApp alert notifications ensures efficient monitoring and prompt response to any water quality issues. This research contributes to the advancement of water quality monitoring technologies and provides a valuable tool for safeguarding human health and environment.

This work clearly demonstrates the feasibility of using the Physical Web concept in IoT applications. Using this concept there are numerous applications are possible in real life scenario. We believe that this work can inspire further research in the field of using Physical Web in IoT application.

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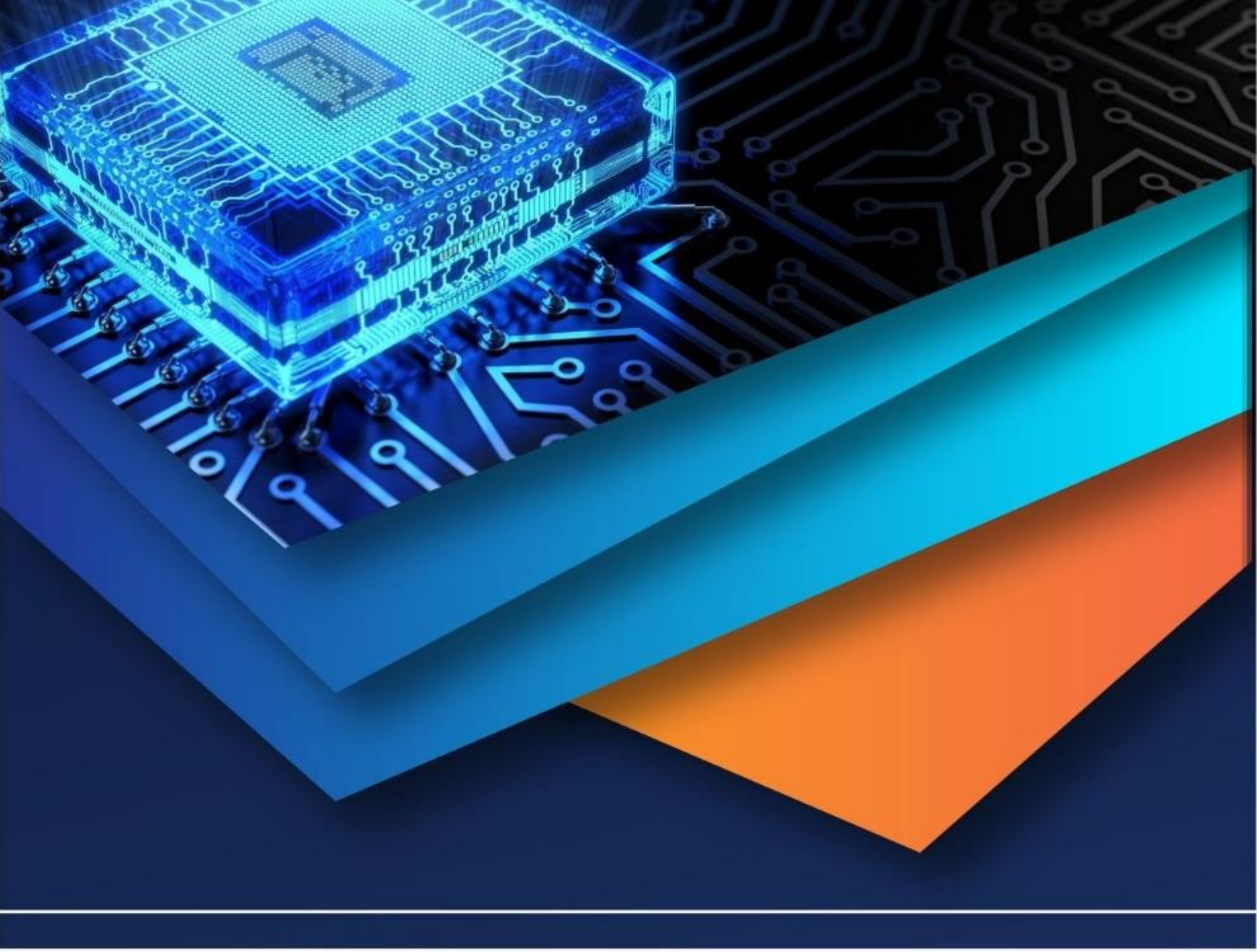

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