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A Review on Patient Healthcare Monitoring System

B.Srimathi[1], Dr. T. Ananth kumar[2]
[1, 2]*Department of Electronics and Communication Engineering, IFET College of Engineering, Villupuram.*

Abstract: From last decade, healthcare monitoring of patients accomplished lots of attention. For the early observation of any physical deterioration in patient health, continuous health monitoring is needed. In this healthcare monitoring, some parameters are continuously monitored by a medical monitor that includes Hemodynamic (blood pressure and blood flow), Cardiac (Electrocardiogram), Blood Glucose level, Body temperature and Pulse Oximetry (Respiration rate) of a patient are monitored. In this paper, a detailed survey of healthcare monitoring is presented.
Keywords: ***Cardiac; Hemodynamic; Pulse Oximeter; Li-Fi; Healthcare monitoring.***

I. INTRODUCTION

The health status of a patient should be constantly monitored. The health status refers to heart rate, respiration rate, body temperature, glucose level, stress, hypertension and blood pressure. These parameters are continuously monitored by the corresponding sensors and the monitored information will be transmitted to the medical practitioner using different technologies like Wi-Fi, GSM and wireless sensor network. If any abnormalities or any variation from the normal value of such parameters are detected, then the alert or warning signal will be sent to the medical practitioner and nurse. So the medical practitioner can be able to provide treatment for the health disorder in the earlier stage.

Wi-Fi is a wireless technology based on IEEE 802.11 standard that use Radio Frequency waves i.e Electromagnetic waves to transmit the sensed data which is collected by the various sensors. Wi-Fi commonly uses 2.4 GHz – 5.8 GHz radio bands which work best for Light-of-Sight condition. Some common materials can absorb or reflect the radio waves that restrict the range of the signal. Wi-Fi use half duplex shared configuration where all station can transmit and receive the signal on the same channel. *GSM (*Global System for Mobile Communication) is a open, digital 2G cellular standard that provide data and voice services. It provides SMS, fax, voicemail, e-mail, incoming and outgoing call, video conferencing etc. It uses TDMA(Time Division Multiple Access) for transmission of data. TDMA allows multiple users to share the same frequency channel by dividing the channel into different time slots. The operating range of GSM is 900MHz to 1800 MHz and data transfer rate is upto 9.6 kbits/s. GSM divide the 200 KHz channel into 25 KHz channel of eight time slots.

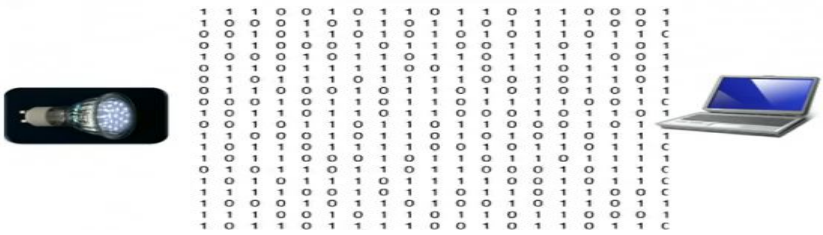

Figure 1: Data transmission in Li-Fi

Wireless sensor network is a group of sensors used to monitor and record the physical conditions of any environment and also used for health monitoring. Many health parameters can be monitored using sensor by placing them on the body of the patients in hospital or in home. It is a group of devices that communicate the collected features through wireless links. The measured data is delivered to other network through nodes and gateway. In WSN, sensor has low communication speed and sensor can distract the devices present around it. Light Fidelity (Li-Fi) technology is a wireless communication system based on visible light spectrum. Figure 1 shows the Data transmission in Li-Fi technology. The data will be send by using the light source(LED) in a well-defined way using on-off keying and non-return to zero modulation scheme. This on-off activity enables data transmission using binary data. If the LED is on, a digital '1' is transmitted and if the LED is off, a digital '0' is transmitted. In Li-Fi, the transmitter (LED) is connected to the data network (Internet through the modem) and the receiver (photo detector/light sensor) on the receiving end, which receives the data as light signal and decodes the information and then displayed on the device connected to the receiver.

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II. REVIEW OF LITERATURE

This literature survey present the various technologies and methodologies used for transmitting the monitored and measured health status information of a patient to the medical physician. It also show that each technology has its own advantages and disadvantages of the technology used for data transmission.

In 2005, T. K. Kho, Rosli Besar, Y. S. Tan, K. H. Tee, K. C. Ong, Jalan Ayer Keroh Lama proposed a wireless patient monitoring system that monitor ECG signal by 2 lead ECG sensor and the signal is transmitted using Bluetooth. [1] In 2007, Junho Park, Jongman Cho, Junghyeon Choi and Taewoo Nam developed a monitoring system which monitor heart rates by taking rehabilitation exercise [2]. In 2009, Y.M Huang, M.Y. Hsieh, H.C chao stated that the wearable sensor systems and an environmental sensor network was used to monitor chronic patients through Bluetooth (IEEE 802.15.4) protocols [3].

In 2010, Wun-Jin Li, Yuan-Long Luo, Yao-Shun Chang, and Yuan-Hsiang Lin developed ARM-based blood pressure monitor to measure blood pressure value and heart rate, then forward the information through ZigBee [4]. In 2010, Hairong Yan, Hongwei Huo, Youzhi Xu, and Mikael Gidlund presented a WSN(fixed and mobile sensor) to monitor elderly person, then mixed positioning algorithm is proposed to determine the location of a elderly person. The measured data sent to doctor through email or SMS[5].

In 2011,Yun-Sheng Yen, Wen-chen chiang, Sheng-Feng Hsiao, Yi-per Shu developed new health care service to home-dwelling chronic hypertension patients. The authors achieved long distance transmission and high bandwidth capacity [6]. In 2011, Zafar A. Khan and Won Sohn presented a video based abnormal HAR system using R-transform and KDA for elderly home care [7].

In 2012, Apoorva Jindal and Mingyan Liu discussed problem of distributed computation over a wireless network of resource constrained sensor nodes used for structural health monitoring [8]. In 2012, Kyung-Ah Kim, Soo-Yeon Shin, Jae-Won Suh, Chansik Park, Eun-Jong Cha, Hyeon-Deok Bae, Chungbuk, Cheong-ju, Korea implemented dwelling self healthcare monitoring system to monitor breathing, blood sugar level, urinary flow and body temperature using ZigBee [9].

In 2013, Syed Furqan Qadri, Salman Afsar Awan, Muhammad Amjad, Masood Anwar, Suneel Shehzad provide a overview, applications, challenges and security issues of Wireless Body Area Networks (WBAN) and functionality of ZigBee[10]. In 2013, Narjes Torabi and Victor C. M. Leung provided unobtrusive monitoring of health conditions and centralized body area network access scheme (CBAS) is proposed to reduce access delay in BAN (Body Area Netwok) at the presence of coexistent systems. [11].

In 2013, Deepesh Rathore, Ankita Upmanyu and Deepanshu Lulla introduced a real-time health monitoring of multiple patients using ZigBee module for data transmission [12].

In 2013, Jaiee sitaram, Adivarekar, Amisha Dilin Chordia and Hari Bavistar introduced the methodology for monitoring the patients remotely using GSM network and VLSI technology at regular intervals of time with low power and high performance [13]. In 2013, Media Aminian and Hamid Reza Naji developed a Wireless Body Sensor Network (WBSN) to monitor heart rate, blood pressure and so on with emergency rescue mechanism [14].

In 2014, Xuefeng Liu, Jiannong Cao, Wen-Zhan Song, Peng Guo and Zongjian He proposed traditional health monitoring system using SHM algorithm [15]. In 2014, Prajakta A. Pawar developed a system to monitor the heart rate and data sent directly to a doctor through SMS using GSM module[16]. In 2014, Yee-Yong Tan and Wan-Young chung proposed a system to monitor ECG and PPG signal transmitted via LED with more precise and accuracy rate. [17].

In 2014, Yena Kim, Seung Seob Lee and SuKyoung Lee proposed an adaptive load control algorithm that control Wi-Fi load because ZigBee channels overlap with Wi-Fi channels which reduce the reliable delivery of monitored physiological signals (ECG, EEG) with minimum delay [18]. In 2014, Neal Patwari, Lara Brewer, Quinn Tate, Ossi Kaltiokallio, and Maurizio Bocca estimated the breathing rate while the person was sitting, lying down, standing, or sleeping using RSS measurements [19]. In 2014, Alumona T.L., Idigo V.E., and Nnoli K.P introduced a remote monitoring of patients using wireless sensor network and transmit it to Intelligent Personal digital Assistant (IPDA) using ZigBee/IEEE802.15.4 [20].

In 2015, Amna Abdullah, Asma Ismael, Aisha Rashid, Mohamed Tarique proposed a mobile device based wireless patient monitoring system for, who are either in hospital or leading their daily life regular actions can able to send alarm messages to doctor using ZigBee [21]. In 2015, Abdulla Al-Qahtani, Hamad Al-hajri,Saad Al-kuwari, Naseer Al-yaarabi, Abdulrahman Al-hababi, EssaAl-kubaisi, Abdulla Ahmed, Mohamad Kashef and Qammer H. Abbasi presented a remote health monitoring system to monitor ECG signal and transmit using VLC [22]. In 2015, Nabil Alshurafa, Jo-Ann Eastwood, Suneil Nyamathi, Jason J. Liu, Wenyao Xu, Hassan Ghasemzadeh, Mohammad Pourhomayoun, and Majid Sarrafzadeh proposed a technique to improve battery consumption of a wearable smartphone used for detection of physical activities [23]. In 2015, Fadel Adib, Hongzi Mao, Zachary Kabelac, Dina Katabi, Robert C.Miller introduced a wireless sensing technology that monitor breathing and heart rate without body contact using Vital-Radio by inhalation and exhalation. [24].

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In 2016, Daniel Aranki, Gregorij Kurillo, Dosu Yan, David M. Liebovilz, Ruzena Bajcsy presented a smartphone-based system for real-time tele-monitoring and collected data were securely transmitted to a central server for real time processing and medical intervention was provided if needed [25]. In 2016, Ting Liang and Yong J Yung developed wearable mobile medical monitoring devices able to monitor patients health status. The authors used textile and wireless sensing networks (WSN) [26]. In 2016, A. Zrelliand T. Ezzedine developed the different strategies of node deployment to report current state of the optimized node in WSNs [27]. In 2016, Andreas K. Triantafyllielis, Vassilis G. Koutkias, Ioanna Chouvarda, Ilia Adami, Angelina Kouroubali, Nicos Maglaveras provided extensible and usable monitoring services in the scope of pervasive patient care using sensor based health monitoring system [28]. In 2016, Puvaneshwari S and Vijayashaarathi S developed a monitoring system that measures the pulse rate, heart rate, temperature, oxygen saturation rate and blood pressure. The author concentrated on reducing the stress and strain of doctors/patients and reduces medical errors, man power and increases the overall flexibility of staffs and doctors [29]. In 2016, T.P.Rani, N.Geetha Priya, S.Mahalakshmi and B.Anees proposed an automatic billing system to reduces human effort and to avoid standing in queues through android application using Li-Fi module attached to mobile, trolley and gate section and the payment is done in mobile itself using mobile banking system[30].

In 2017, Minglei Shu, Meiyu Tang, Ming Yang, Nuo Wei monitored daily vital signs includes the heart rate, the breathing rate and sleep state through the mobile and transfer to the cloud through Wi-Fi, and the cloud platform server can screen, analyze and calculate vital signs data and the dynamic change of vital signs state [31]. In 2017, Nilajan Dey, Amira.S, Fuqian shi, Simon James and R. Simon sherret developed a home-based wireless Sensor Network for ECG monitoring system using ZigBee technology [32]. In 2017, Varun Sharma and Somesh Sharma proposed a monitoring system with improved performance of Health Monitoring Network by reducing the Packet Loss Ratio and Energy Consumption by LEACH (Low Energy Adaptive Clustering Hierarchy) Protocol [33]. In 2017, Usman Mahmood Khan, Zain Kabir, Syed Ali Hassan introduced a 2D phase extraction system to monitor three basic elderly care activities including breathing rate, essential tremor(unintentional or rhythmic muscle movement involving to-and-fro movements) and falls [34]. In 2017, Sonal chakole, Ruchita and Anju V. Choudhari developed a Health monitoring System using werable sensors for early warning of physiological deterioration, thus any assistant doctor or nurse were not required to log the health of the patient manually therefore reducing any possible human error. [35]. In 2017, Madhuri Baswa, R Karthik, P B Natarajan, K Jyothi and B Annapurna implemented a monitoring system using GSM for the real time analysis of the patient health condition through WSN and mobile devices [36]. In 2017, M. Sindhu, M. Priyanka, A.K. Swedha, RA. Ranjana and Mrs.R.Sujatha ,M.E,(PhD) provided a patient privacy and emergency healthcare service using Li-Fi because Wi-Fi was not used in hospitals due to its electromagnetic waves.[37] In 2018, Sangyoun Lee, Young-Deok Park and Young-Joo suh proposed a new method to identify the changes in breathing and heart rate of a person using Dynamic Time Warping algorithm [38].

In 2018, Shubaham Purri and Nirbhay Kashyap discussed, how IoT was used in the healthcare system and proposed a model of healthcare system using IoT[39]. In 2018, Joel J. P. C. Rodrigues, Dante B. R. Segundo, Heres A. Junqueira, Murilo H. Sabino, Rafael M. Prince, Jalal Al-Muhtadi, and Victor Hugo C. de Albuquerque presented review of techniques based on IoT for healthcare and ambient assisted living, defined as the Internet of Health Things (IoHT) for identifying the advancement in technologies and then to analyze and overcome the challenges[40].

Li-Fi is a wireless communication system of standard IEEE 802.15.7 proposed by German physicist Harald Haas in 2011 TED(Technology, Entertainment, Design) Global Talk on Visible Light Communication[30]. Li-Fi is based on the use of visible light between the violet (800THz) and red (400THz). It is 80% efficient and can reach speed of up to 1 Gbps and even beyond. Li-fi was used in the applications of educational system, cheaper internet in aircrafts, underwater applications, disaster management, applications in sensitive areas, traffic management, mobile connectivity and replacement for other technologies where Bluetooth, infrared and Wi-Fi were banned. Now Li-Fi is preferred to use in medical applications because, Wi-fi is not allowed in operation theatre due to its radiation concerns[36].

III.SUMMARY

The papers listed in literature survey use some communication protocols for transmitting the collected the health data of a patients to doctor or medical practitioner such as Wi-Fi, GSM, WSN network, ZigBee etc. Each protocols have some pros and cons. In Wi-Fi, the health data can be transmitted using radio waves with the Wi-Fi router. The cons of Wi-Fi are, the electromagnetic waves generated are harmful to the human body such as lack of sleep pattern i.e insomnia, reduced brain activity, affects the child growth development, cardiac stress etc. It has more interference issues and cannot pass through more dense area. The GSM is a mobile communication service that support voice and data transmission, worldwide connectivity with high capacity so health data can be transmitted and received from anywhere in the world. But the cons are, it requires multiple repeaters to establish worldwide

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connectivity. The WSN is a network of sensors that communicates with the other network through gateway. The cons of WSN are low communication speed, distract other devices around it and it has power issues. ZigBee is a communication protocol with some pros of power saving, reliability, short time delay, large network capacity and safety and the cons are short range, low data speed and low complexity.

IV. PROPOSED SYSTEM

The proposed methodology includes the Li-Fi module with transmitter and receiver section. Here, the transmitter section transmits the data through Visible Light Communication using LED. Then the data is demodulated and amplified in the receiver section which consists of photodetecter and amplification module. Finally, the information will be displayed on the LCD or the system. Figure 2 shows the block diagram of patient monitoring using Li-Fi technology.

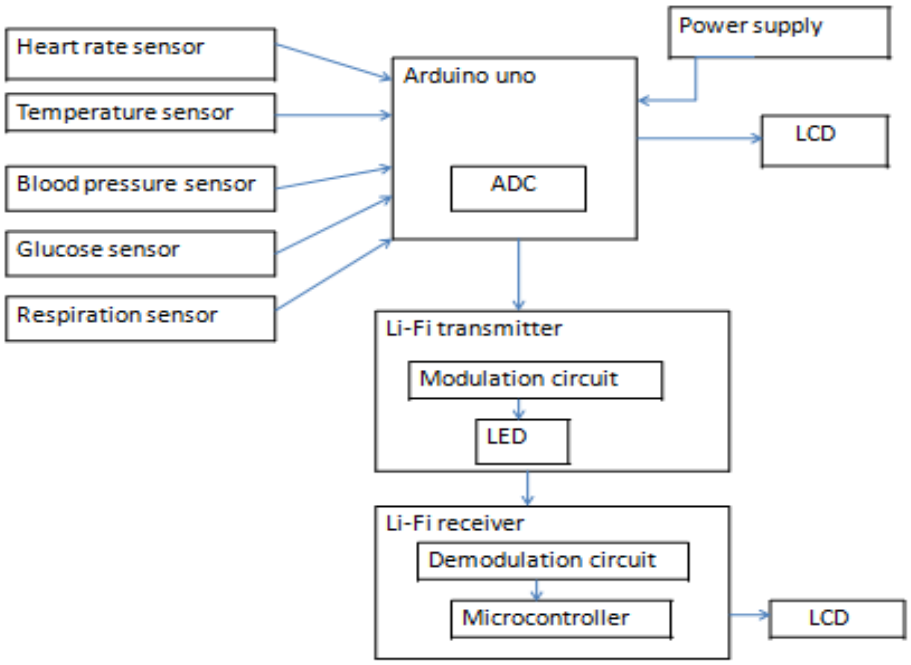

Fig 2: Block diagram of patient monitoring

A. *Components Used*

1) *Heart Rate Sensor*: It is based on the concept of photophlethysmography (PPG) to measure one's heart rate in real time. The LED present adjacent to this sensor illuminate the blood capillaries to track blood to measure frequency at which the blood pumps.
2) *Respiration Sensor:* This sensor measures the respiration rate of a human per minute. The respiration is not same as breathing. The normal respiration rate is 12-25 breaths per minute for the adult. If the rate is above 25 or below 12 is considered as abnormal respiration rate.
3) Temperature Sensor: It is a thermocouple or Resistance Temperature Detector that measure the body temperature. It is necessary to measure the temperature because it reveals hormonal health and body metabolic rate
4) *Glucose Sensor*: Glucose in a body is a blood sugar level. Our body regulates blood glucose level as part of metabolic homeostasis. The glucose is stored as glycogen in normal level of 5.5mmol/L.
5) *Blood Pressure Sensor:* The blood pressure is created when the blood in the artery in pumped to the body. During heart beats, blood pushes to the body through artery which creates pressure in the arteries.

B. *LI-FI Module*

1) *Li-Fi Transmitter:* The transmitter module has 2 sections: Modulation circuit and White LED. In modulation circuit, on-off keying non return to zero modulation scheme is used. The LED operates based on-off keying(LED transmit health data by switching between on and off states). Then the data will be sent to the receiver using white LED(data rate is 500mbps) as optical pulses.

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2) *Li-Fi Receiver:* The receiver module has 2 sections: demodulation and amplification circuit. The transmitted optical pulse is retrieved back into electrical signal using photodiode which is inbuilt in the demodulation circuit. The converted signal is weak and plagued by noise so signal conditioning has to be performed before processing. So it undergoes amplification and passed through envelope detection to demodulate the data from the carrier signal. Then voltage comparator transforms the signal into digital format before fed to microcontroller that transmit the data serially to another device.

V. CONCLUSION

The proposed method, Li-Fi based healthcare monitoring system has advantages over the Wi-Fi and GSM technology. On compared to Wi-Fi and GSM, Li-Fi technology provides faster and secured data transmission on low power. Without any harmful effects on human body, the health parameters are measured and transmitted to the physician in faster and secured way using Li-Fi technology.

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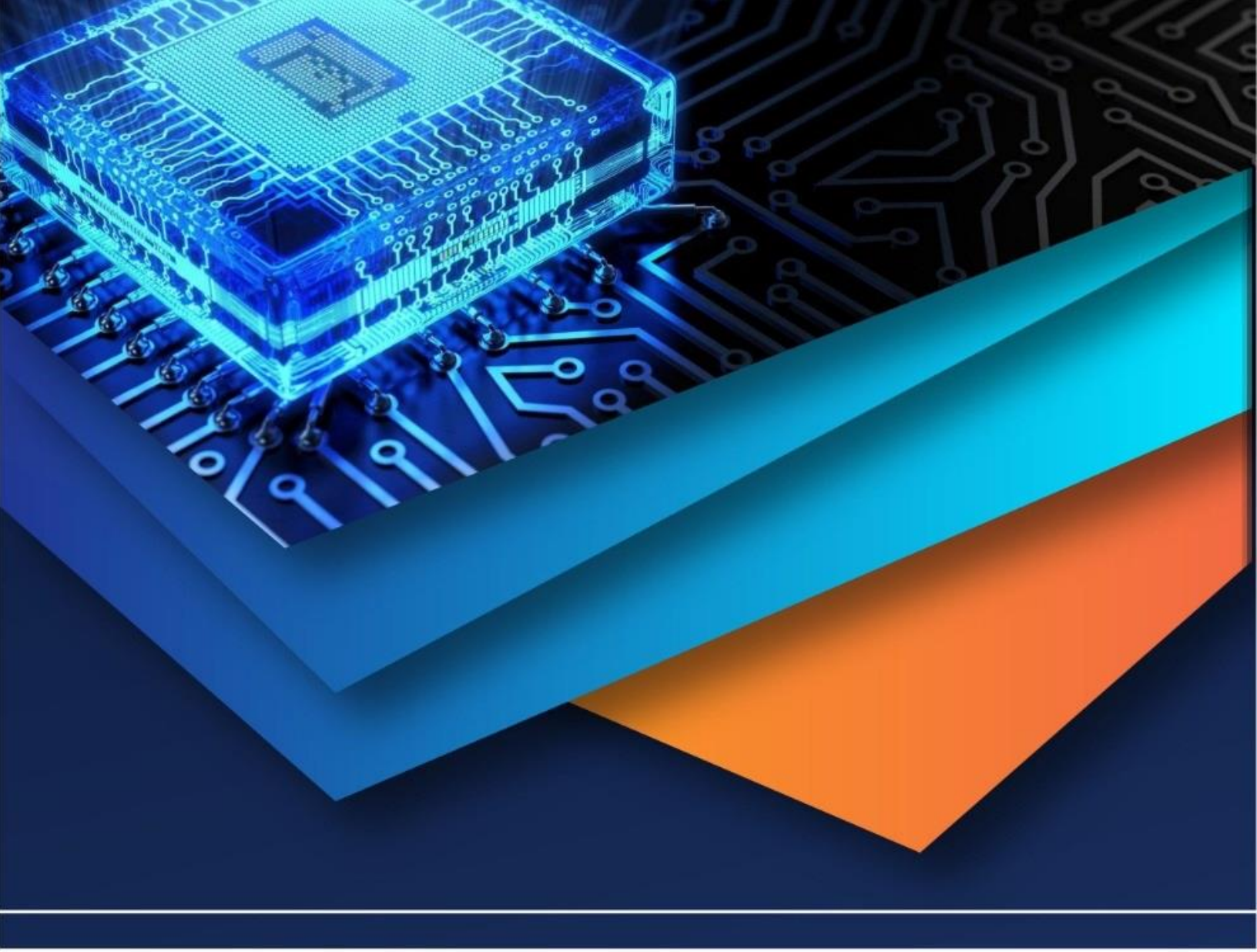

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