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Block Chain Technology in the Pharmaceutical Supply Chain: Enhancing Transparency and Security

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Abstract: ***Blockchain technology has been a key addition to the technology sector and its integration to various aspects of businesses has achieved immense success. Its implementation in the pharmaceutical industry continues to give promise of further optimizing the supply chain by increasing safety, efficiency, and transparency. This paper explores the fundamental concepts of Blockchain technology and its relevance to supply chain management, particularly within the pharmaceutical industry. It examines how Blockchain enhances transparency through real-time tracking and traceability of pharmaceutical products, thereby mitigating risks associated with counterfeiting and unauthorized distribution. This research will also look at various successful projects that have embraced the Blockchain technology such as the IBM and Walmart's Blockchain pilot and the Medi Ledger Project. It also highlights the challenges that companies need to address in the future so as to be able to successful implement the system. Overall, the research into how Blockchain technology is able to offer security and efficiency in the pharmaceutical supply chain is presented herein.***

Keywords: Blockchain, Pharmaceutical Supply Chain, Traceability, Counterfeit Drugs, IT in Pharma

I. INTRODUCTION

The pharmaceutical industry is a very large and complex system that has many moving parts. For instance, there are numerous stakeholders in the pharmaceutical supply chain such as the manufactures, pharmacies, healthcare providers, distributors and distributors. This intricate system is responsible for the production, transportation, and delivery of medications to patients worldwide. As such, there are several challenges that the industry faces including counterfeits drugs and lack of transparency and inefficiency in the movement of products. Other challenges pose security concerns and data theft further complicating the supply chain process. Blockchain technology has recently come into the picture to help deal with these challenges facing the pharmaceutical supply chain. This is a decentralized and distributed ledger system, that encompasses a chain of blocks with records of every transaction under the crypto graphical sector [18]. This has been helpful in that it has ensured accurate, reliable, and tamper-proof data traces in the supply chain. This research will analyze the application of Blockchain technology in the pharmaceutical supply chain and how it has been able to address the challenges of lack of transparency and security issues.

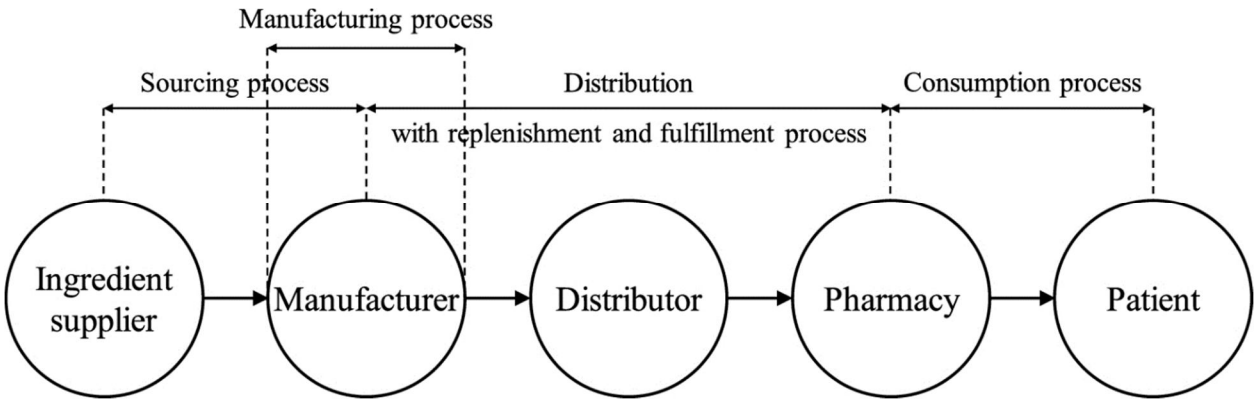


Figure 1: A diagram representing use of Blockchain tech in pharma (Wong et al., 2023)

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II. BLOCKCHAIN TECHNOLOGY

Blockchain technology entails an online database that is distributed in several places and which records transactions continuously. These records of transactions are called blocks and they are continuously duplicated and stored across a network of computers around the world. This, unlike the traditional ways of recording transactions in a computer, is very widely distributed and not in a single server or single point of access. Cryptography is the system under which these blocks are interconnected where it must record the timestamp and the data transacted. The decentralized nature of block chain makes it extremely hard to duplicate or manipulate the transactions [28]. The digital ledger used to store every transaction that is made under the block chain technology. One of the main cryptocurrencies and contributors to success of block chain technology is the Bitcoin that many users prefer and which can easily be mined. There are also other transaction denominations that are continously being generated and slowly gaining popularity.

There are several types of block chain networks including the public Blockchain network. The public blockchain networks are easily accessible since they are all open to the public to participate in such as trade and produce. For instance, cryptocurrencies such as Bitcoin and lite coin present opportunities for people to mine and trade easily and does not require special permissions to deal in [11]. There is also the private blockchain networks or managed blockchains whereby a single organization owns the rights for use and transact. This makes them to be partly decentralized as they are controlled from one single entity. Ripple, a digital currency exchange network owned and controlled by Ripple labs, is an example of a private Blockchain. There is also the hybrid blockchain networks which is a blend of both public and private networks. In most cases, companies control some aspect of the public system by imposing security permissions in the system. They are allowed to protect specific data within the public network. The general public can check for completed transaction by use of smart contracts [4]. For instance, it's possible for bank owned currencies to remain private while hybrid blockchains can remain public. Lastly is the consortium blockchain networks which are controlled by several organizations. These organizations come together and they are all responsible for advertising and controlling the network. One example of the consortium Blockchain is the Global Shipping Business Network Consortium which aims to simply the shipping industry by digitizing it which would facilitate better collaboration among the operators. [25].

III. ENHANCING SECURITY VIA BLOCK CHAIN TECHNOLOGY IN PHARMACEUTICAL INDUSTRY

The first and most important aspect of Blockchain technology that makes it very secure is the aspect of decentralization. Unlike the traditional methods of storing data, block chain technology takes advantage of cloud servers all around the world to store and support their transactions [26]. The blocks are stored in a distributed network where they are linear and chronological. This is to mean that the transactions pile up as they are made. This also means that the only block that can be altered with is the last block. There are hundreds of transactions that are conducted every minute and therefore piling up each other. Since only the last block can be written or interfered with, it makes it hard for hackers to change it. This ensures that the transactions have very minimal chances of interference and therefore cannot be interfered with [23].

Another key aspect of the Blockchain technology is the electronic ledger. The electronic ledger is such that when data is changed in one part of the technology, it changes in the hash of the block it is in. Since each block is connected to the next block, any changes can affect the blocks adjacent to it and therefore, it's impossible to change all the blocks in the chain. This makes it impossible to alter, or manipulate existing transactions [22]**.** The only block that can be changed is the top most level or the newest in the chain. However, if hackers were to attack it, it would be impossible since there are hundreds of transactions every minute which would change the order of the blocks.

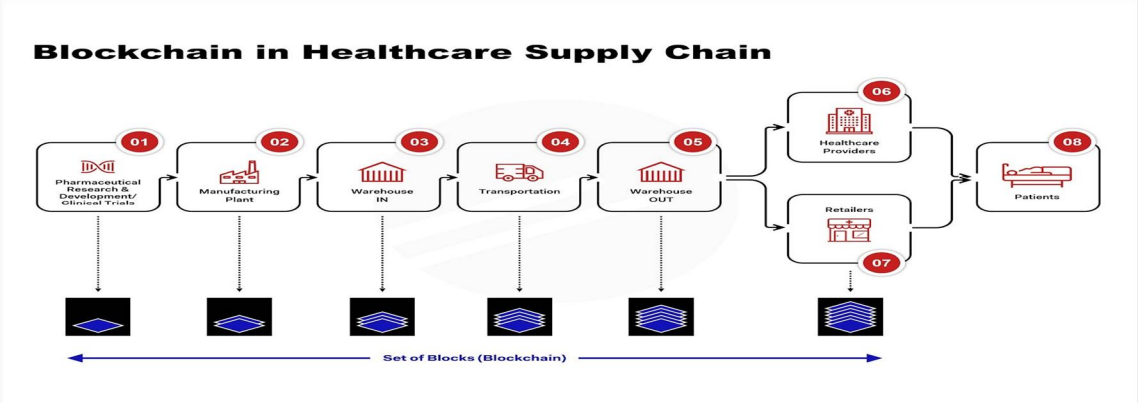


Figure 2: Diagram showing Blockchain in healthcare supply chain (Prove, 2021)

In the same manner, pharmaceutical industry can enhance security of their operations. For instance, since the supply chain involves several players in the industry from manufacturers to distributors and wholesalers, it can easily be interfered with and can attract fraudulent activities [30]. Therefore, security and transparency are maintained by Blockchain technology as it tracks the journey of pharmaceutical products from production to the end user. It also ensures that the supply chain entities can access the records of pharmaceutical products movement by having a single record of transactions that is immutable [24]. With Blockchain, every transaction is time-stamped and cannot be altered retroactively, making it easier to verify the authenticity of a drug and trace it back to its origin thus winning against counterfeiting [31].

IV. UNDERSTANDING TRANSPARENCY IN PHARMACEUTICAL INDUSTRY THROUGH BLOCKCHAIN TECHNOLOGY

Blockchain technology was invented to spearhead technology advancement in the early 21st century and has transformed how businesses interact and communicate. For instance, Blockchain technology has brought about decentralization of the distribution network [6]. Unlike the traditional database systems where the information and data was stored in a central data point, block chain technology enabled storing of data in a distributed network of computers maintained through a central ledger that can be accessed by anyone with access to the network, ensuring consistency and transparency [10]. Transactions in the Blockchain can be validated by use of documentations such as the Proof of Work (PoW) and Proof of Stake (PoS). It also relies on the smart contracts where contracts of sale are electronically and automatically generated and agreements signed electronically [14]. This ensures that intermediaries are done with and a contract is clean between the buyers and sellers.

Given the above mechanism of the Blockchain technology, the pharmaceutical supply chain has greatly tapped into the technology. For instance, the aspect of immutability has ensured that the transactions of sale and buy cannot be altered or interfered with ensuring transparency and accountability [19]. These records are kept in multiple cloud servers which ensures permanency and tamper proof records. This system of decentralized ledger, allows stakeholders to verify the authenticity and status of pharmaceutical items at any point in the supply chain [16]. This also walks hand in hand with prevention of counterfeits by ensuring that authentication of products can be done at every stage of supply chain [12]. Through verification of supply chain participants and the use of smart contracts for automated compliance and quality checks, Blockchain ensures that only legitimate products pass through the supply chain [17].

Traceability is also a key feature used by the pharmaceutical companies since suppliers or any company can trace movement of products through the supply chain from dispatch to delivery. Blockchain enables real-time tracking and visibility of products, providing end-to-end traceability from production to delivery [7]. This leaves a credible audit trail which is in compliance with regulatory framework. Lastly, Blockchain technology offers security for data and safeguarding of sensitive information, ensuring data integrity [2]. This ensures that only authorized participants can access specific information, safeguarding the integrity of the supply chain data. Blockchain technology uses cryptographic techniques that protect data from being accessed by unauthorized persons [1]. By tapping on these key features of the Blockchain technology, pharmaceutical companies can enhance reliability, transparency, security and efficiency in their operations.

V. SUCCESS STORIES

The claims of Blockchain technology revolutionizing the pharmaceutical industry can be certain with prior clear examples that have been successful. For instance, one notable example is the IBM and Walmart's Blockchain pilot project. This project was aimed at achieving food traceability and safety through a decentralized ledger. The project was able to achieve improved transparency and efficiency in accurate and faster tracking of their food products to the markets [13]. Another great example of Blockchain technology being integrated into the supply chain was the case of Ford Motor Company. The company implemented the use of Blockchain technology to follow the cobalt supplies that were in transit from the suppliers to their factory in order to ensure that quality is not compromised [6]. Another good example is the MediLedger Project, which brought together key industry participants to implement Blockchain for drug traceability and security [4]. This technology facilitated compliance with Drug Supply Chain Security Act (DSCSA) as well as increasing the whole supply chain integrity. The transformation of the respective supply chains as a result of integrating Blockchain technology showcase the immense advantages that companies can accrue. In the same manner, pharmaceutical companies can integrate the Blockchain technology into the supply chain and achieve faster, secure and more efficient distribution of products [8].

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In summary, given the benefits that accrue to companies using Blockchain technology, it will not be a surprise if more companies embrace the use of Blockchain. For instance, with better efficiency in operations, better security and reliability of processes, Blockchain technology gives business an edge in the industry. Blockchain technology ability to offer accountability with data sharing ensures that investors and business partners can increase their trust in businesses that are integrating Blockchain aspects in their day to day operations. It has also enabled integration of data into a single system where anyone with access to the network would be able to access it this eliminating siloed data [29]. At the same time Blockchain technology has ensured high levels of security for data by reducing the need for a third party entity or intermediary during transactions. It is also keen on reducing tampering of records in real time by limiting the number of participants in any given transaction. It has also been beneficial in enabling secure movement and tracking of goods pharmaceutical products within the supply chain [28].

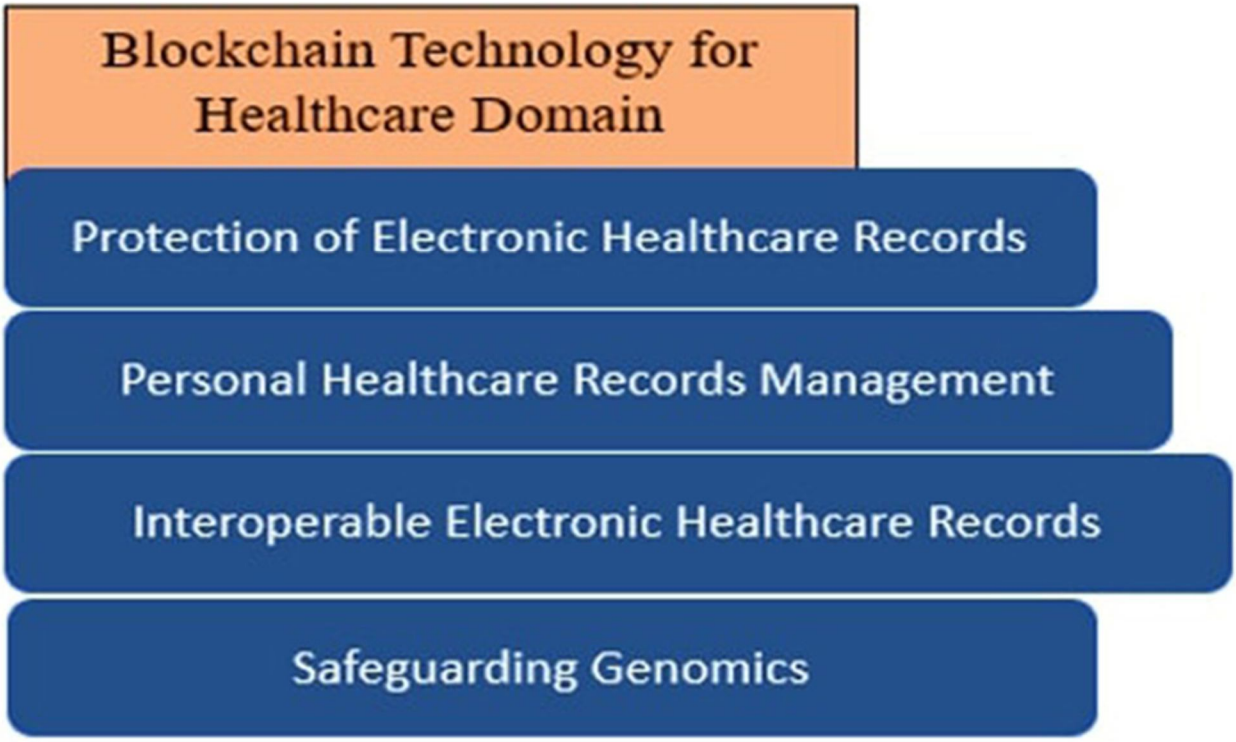


Figure 4: Diagram of some of the importance of Blockchain technology in healthcare (Amanat et al., 2022)

Blockchain technology has been instrumental in shaping the healthcare domain especially in offering enhanced security, interoperability, and safeguarding of sensitive genomic data. It has particularly been instrumental in protection of electronic health records which form one part of the most valuable assets of healthcare industry. This is facilitated by the Blockchain characteristics of being stored in a decentralized point where immutability and encryption occur making it hard to interfere with [32]. Since healthcare data is very valuable and any exposure to unauthorized persons would be detrimental, Blockchain technology helps safeguard the same by ensuring the integrity of patient data as well as ensuring that the data cannot be deleted or even altered with. In the same manner, Blockchain technology has been able to safeguard genomic data which is highly sensitive and valuable, making its protection a top priority for both individuals and healthcare organizations [29]. It has achieved this through secure data sharing, data ownership and consent management as well as immutable records.

Blockchain technology has also helped manage personal Healthcare Records by enabling individuals to take control of their personal healthcare records by providing a secure and transparent platform for managing their data [20]. It has been able to ensure patient empowerment by allowing patients to allow or deny access to the healthcare providers and researchers. It has also facilitated data portability which means that patients can easily share their healthcare information with different providers, facilitating continuity of care across different healthcare settings [27]. Blockchain allows the interoperability of Electronic Healthcare Records because it has a standard format that provides easy sharing and seamless interoperability, allowing healthcare providers to access comprehensive patient data regardless of where it was originally recorded.

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VI. CHALLENGES IN BLOCKCHAIN TECHNOLOGY IMPLEMENTATION

Just like most systems that have been dominantly used by industries for a long time, Blockchain technology faces challenges such as integrating it with the old systems. Most of the pharmaceutical companies have well established systems in place which means that shifting to seamless Blockchain technology would be complex and require intense capital [3]. Scalability and increasing the performance would present concerns with integrating Blockchain technology. Blockchain networks, particularly public ones, often face challenges related to transaction speed and processing capacity, which can be exacerbated by the high volume of transactions in the pharmaceutical supply chain [5]. This means that companies must invest heavily in ensuring that the system can handle many simultaneous transactions to avoid interruptions.

Another key challenge is maintaining and adhering to regulatory and legal concerns. The pharmaceutical industry is heavily regulated, and navigating the diverse regulatory frameworks across different regions can be daunting. It therefore means that there is need to have a bullet-roof plan in the implementation of Blockchain technology so as to ensure companies adhere to the law [9]. Security, data privacy and protection are also another very crucial aspects of technology. There is always an aspect of traceability for the Blockchain technology which leads to security concerns about how safe the private data is. Block chain's transparent nature, while advantageous for traceability and transparency, can potentially conflict with data privacy laws, such as the General Data Protection Regulation (GDPR) in the European Union [13]. These companies embracing Blockchain technology need therefore to design their systems to balance between data privacy and traceability of transactions by everyone, which is a key element of Blockchain technology. All in all, building trust and fostering collaboration among all participants in the supply chain are essential for achieving the full potential of Blockchain technology in enhancing transparency and security in the pharmaceutical industry [10].

The future of Blockchain technology in the pharmaceutical supply chain is poised for transformative advancements, driven by emerging trends and the integration with other cutting-edge technologies. Blockchain technology continues to transform the industry by facilitating scalability, interoperability as well as efficiency in pharmaceutical supply chain [11]. One area that holds high promise is in the area of integrating Artificial Intelligence (AI) with the Blockchain technology [2]. This integration would bring about real-time monitoring, predictive analytics, and automated decision-making, which would also facilitate better synchronization with the supply chain. The long term goal in the Blockchain technology would be to create a system of full transparent transactions that can be audited and followed through by anyone in the system [15]. It would also mean opening up the whole industry to bigger and global market.

VII. CONCLUSION

The Blockchain technology brings about solutions to long term issues that look promising to the pharmaceutical industry. The fact that it offers decentralized ledgers that can be accessed by anyone in the world brings about the aspect of transparency and efficiency as well as security. The system also facilitates clean audit trails that ensure that transactions are well documented which strengthens the regulatory compliance and consumer safety. Real-world applications, such as IBM and Walmart's pilot project and the MediLedger initiative, demonstrate tangible benefits in terms of traceability and supply chain integrity. Despite technological, regulatory, and adoption challenges, the potential for Blockchain to revolutionize pharmaceutical supply chains is substantial, promising a future of enhanced trust, collaboration, and security across global healthcare networks.

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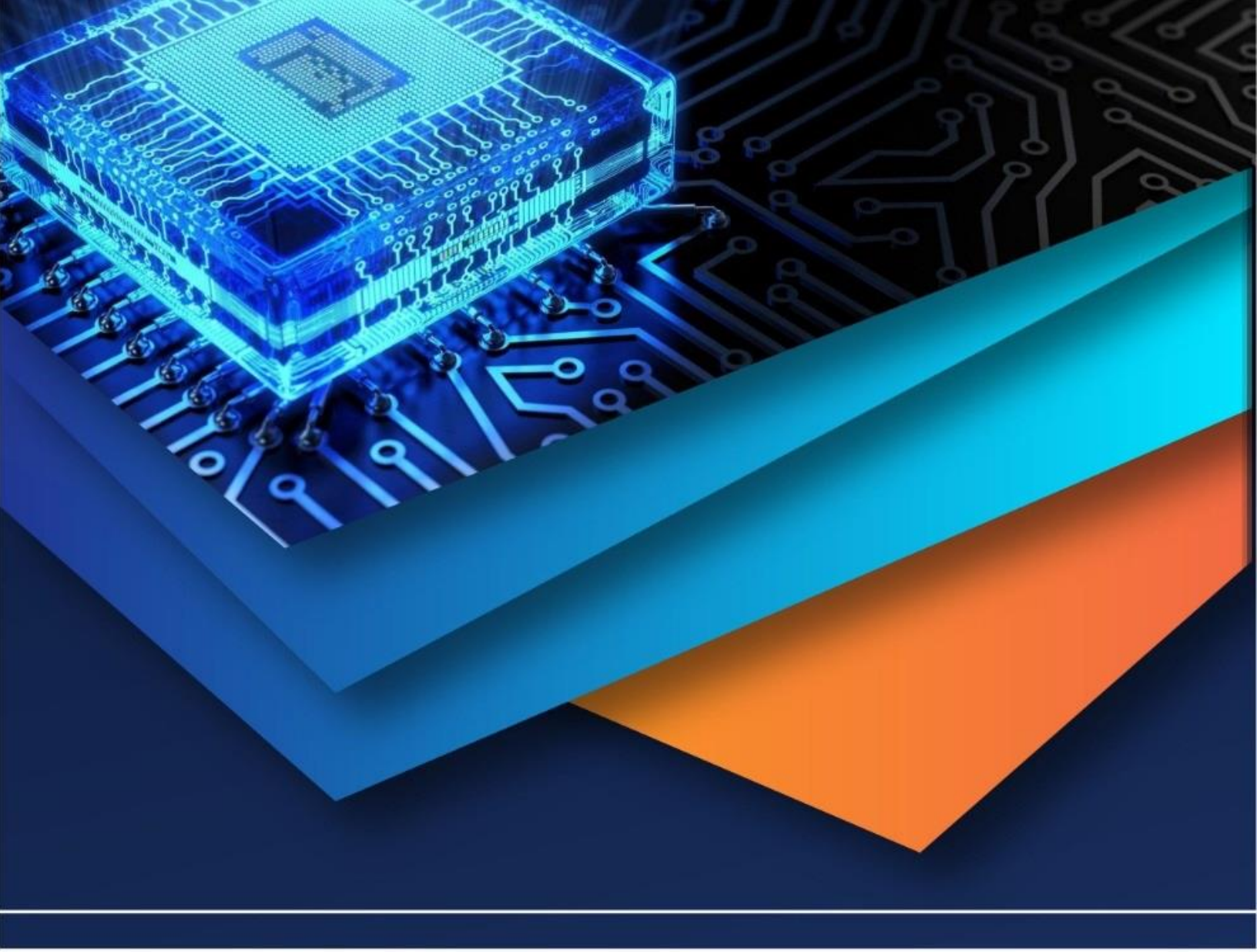
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