iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 **Issue:** VIII **Month of publication:** Aug 2023

DOI: https://doi.org/10.22214/ijraset.2023.55186

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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 11 Issue VIII Aug 2023- Available at www.ijraset.com

Application of Blockchain in HealthCare: Overview

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Abstract: ***Blockchain technology, known for its decentralized and tamper-proof ledgers ensuring data security, has significant attention for its potential to revolutionize the healthcare sector. This paper explores the various applications, benefits, and significant challenges associated with integrating blockchain in healthcare. By enabling seamless data sharing and enhancing interoperability among diverse healthcare providers and systems, this transformative technology lays the foundation for substantial enhancements in patient care and overall healthcare efficiency. One of the key advantages lies in empowering patients by granting them greater control over their health data with informed consent, while fostering unwavering accountability and trust in healthcare transactions through blockchain's transparency. Valuable applications include accelerated clinical research and prevention of counterfeit drugs. However, successful implementation requires addressing scalability, integration, regulatory compliance, and education hurdles through collaborative efforts. In conclusion, blockchain's potential lies in creating a secure, patient-centric, and efficient healthcare ecosystem, ensuring the integrity of medical records and unlocking new possibilities for personalized medicine and data-driven treatment approaches.***
Keywords: Application, Blockchain, Challenges, Smart Contract, Fraud prevention.

I. INTRODUCTION

Blockchain technology has risen as a transformative innovation with the capacity to revolutionize numerous industries, and the healthcare sector is no different .With its decentralized and immutable nature, blockchain holds the promise of addressing some of the long-standing challenges in healthcare, ranging from data security and interoperability to patient privacy and supply chain management. In the healthcare industry, data plays a pivotal role in delivering quality care and making informed decisions. However, the traditional healthcare systems often suffer from fragmented data silos, hindering seamless data exchange and collaboration among stakeholders. Additionally, issues of data breaches, unauthorized access, and data tampering have raised concerns about patient confidentiality and trust. Blockchain's core principles of decentralization, transparency, and cryptographic security offer a unique opportunity to address these pressing issues. By creating a shared, distributed ledger that is updated and verified by multiple parties, blockchain technology can establish a single source of truth for medical data. This enables secure, real-time access to patient records, while ensuring that the data remains tamper-proof and private. Moreover, the healthcare sector faces challenges related to drug counterfeiting, supply chain inefficiencies, and fraud, leading to significant financial losses and potential threats to patient safety. Blockchain's ability to create an immutable and transparent record of the entire supply chain can help track pharmaceuticals from manufacturer to patient, ensuring the authenticity of drugs and preventing counterfeit products from entering the market. Another area where blockchain can make a transformative impact is in clinical trials and research. By utilizing smart contracts, the technology can facilitate automated and trustless agreements between researchers and participants, streamlining the recruitment process and enhancing the overall transparency and integrity of clinical data. While the potential benefits of blockchain in healthcare are undeniable, the technology is not without its challenges. Scalability, regulatory compliance, interoperability with existing systems, and legal implications surrounding data ownership and consent are some of the obstacles that need to be carefully navigated.

II. BLOCKCHAIN TECHNOLOGY

Blockchain is a decentralized and distributed digital ledger technology that allows data to be securely recorded, verified, and shared across a network of computers. It is the underlying technology behind cryptocurrencies like Bitcoin, but its applications go beyond digital currencies. Blockchain's fundamental concept is to create a chain of blocks, where each block contains a list of transactions, and these blocks are linked together in a chronological order, forming an immutable and transparent record of all transactions.

A. Types of Blockchains

1) *Public Blockchain:* These blockchains are open to anyone and allow any participant to join the network, validate transactions, and create new blocks. Public blockchains are fully decentralized and permissionless, meaning that no central authority controls the network.

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2) *Private Blockchain:* In contrast to public blockchains, private blockchains are restricted and accessible only to a specific group of participants. Permission to access the blockchain is granted by a central entity or administrator. Private blockchains are commonly used within organizations or consortiums to enhance security and privacy.
3) *Consortium Blockchain:* Consortium blockchains are a hybrid of public and private blockchains. They are controlled and operated by a group of organizations rather than a single entity. Consortium blockchains provide a middle ground where specific participants are given permission to participate in the network and validate transactions.
4) *Hybrid Blockchain:* Hybrid blockchains combine elements of both public and private blockchains. They allow for certain public-facing features while still maintaining some level of restricted access for certain transactions or participants.

B. Blockchain Features

1) *Decentralization:* Blockchain operates on a distributed network of nodes, eliminating the need for a central authority. This decentralization enhances security, transparency, and resilience.
2) *Immutability:* Once data is recorded in a block, it cannot be altered or deleted. The immutability of blockchain guarantees data integrity and establishes a reliable record of transactions.
3) *Transparency:* All transactions on the blockchain are visible to all participants in the network. This transparency promotes accountability and trust among users.
4) *Security:* Blockchain uses cryptographic techniques to secure transactions and prevent unauthorized access or tampering.
5) *Consensus Mechanisms:* To validate and add new blocks to the chain, blockchains use consensus algorithms like Proof of Work (PoW) or Proof of Stake (PoS). These mechanisms ensure agreement among network participants about the validity of transactions.
6) *Fast and Low-Cost Transactions:* Depending on the blockchain's design and consensus mechanism, transactions can be processed quickly and at a lower cost compared to traditional financial systems.
7) *Smart Contracts:* Blockchain platforms like Ethereum enable the execution of smart contracts, which are self-executing contracts with the terms directly written into code. Smart contracts automatically execute actions when specific conditions are met, without the need for intermediaries.

These features have led to the exploration of various use cases beyond cryptocurrencies, such as supply chain management, voting systems, digital identity verification, and more. However, it's essential to consider the specific characteristics of different blockchain types when choosing the right technology for a particular application.

III. APPLICATION OF BLOCKCHAIN IN HEALTHCARE

Blockchain technology has the potential to revolutionize the healthcare industry by addressing various challenges related to data security, interoperability, privacy, and transparency.

Below are some of the key applications of blockchain in healthcare :

1) *Medical Records Management:* Blockchain can enable secure and decentralized management of electronic health records (EHRs). Each patient's data can be stored in a tamper-resistant and encrypted block, and access to this information can be controlled through cryptographic keys. Patients can grant permission to specific healthcare providers, ensuring data privacy and reducing the risk of unauthorized access or data breaches.
2) *Interoperability:* Blockchain can facilitate seamless data exchange between different healthcare providers and institutions. Since blockchain allows for a standardized and distributed ledger, it can help reconcile discrepancies in data formats and protocols, making it easier for different systems to communicate with each other and improve patient care coordination.
3) *Supply Chain Management:* Blockchain can be used to track pharmaceuticals and medical supplies throughout the supply chain. This can help verify the authenticity of drugs, prevent counterfeit medications from entering the market, and reduce the distribution of substandard products.
4) *Clinical Trials and Research:* Blockchain can enhance the integrity and transparency of clinical trials by providing an immutable record of trial data, results, and consent forms. This can improve the reliability of research outcomes and prevent data manipulation or selective reporting.
5) *Healthcare Payments and Billing:* Blockchain technology can streamline and secure healthcare payments by enabling real-time verification of insurance claims and reducing administrative overhead. Smart contracts on the blockchain can automatically execute payment agreements when specific conditions are met.

6) *Medical Credentialing:* Blockchain can facilitate the verification and sharing of medical practitioner credentials, certifications, and licenses. This can help healthcare organizations quickly verify the qualifications of their staff and improve the hiring process.
7) *Health Data Analytics and AI:* Blockchain can support data aggregation from various sources while maintaining patient privacy and data ownership. It can enable researchers and data scientists to access large, diverse datasets for population health analytics and the development of AI-driven healthcare solutions.
8) *Personal Health Records (PHRs):* Blockchain can empower individuals to manage their health data through secure and portable personal health records. Patients can control access to their health information and share it with healthcare providers as needed, enhancing patient engagement and empowerment.
9) *IoT Integration:* Blockchain can provide a secure infrastructure for connecting Internet of Things (IoT) devices in healthcare settings. This can enable secure data transmission from wearable devices and medical sensors, ensuring the integrity and confidentiality of patient-generated health data.
10) *Research Collaboration:* Blockchain-based platforms can facilitate secure collaboration and data sharing between healthcare institutions and researchers globally. It can foster a more open and cooperative approach to medical research while maintaining data privacy. While the potential benefits of blockchain in healthcare are significant, there are still challenges to overcome, including regulatory concerns, scalability, and the need for industry-wide adoption. As blockchain technology continues to advance and evolve, we can anticipate witnessing a proliferation of groundbreaking applications within the healthcare industry. These innovative uses are expected to leverage the unique features of blockchain to address various challenges and transform how healthcare data is managed, shared, and utilized.

IV. BENEFITS OF BLOCKCHAIN IN HEALTHCARE

Blockchain technology offers several benefits to the healthcare industry due to its decentralized, secure, and transparent nature.
Some of the key advantages of using blockchain in healthcare include:

1) *Data Security and Privacy:* Blockchain uses advanced cryptographic techniques to secure data, ensuring that patient information remains private and tamper-proof. It enables data to be stored across multiple nodes, reducing the risk of data breaches and unauthorized access.
2) *Interoperability and Data Exchange:* Healthcare systems often face challenges when it comes to sharing patient data across different institutions and platforms. Blockchain's distributed ledger technology can facilitate secure and seamless data exchange between healthcare providers, improving interoperability and collaboration.
3) *Patient-centered Care:* Blockchain empowers patients to have greater control over their medical records. With patient consent, data can be securely shared with different healthcare providers, enhancing care coordination and leading to more personalized treatment plans.
4) *Improved Data Integrity:* Traditional databases are susceptible to data corruption or tampering. In contrast, blockchain's immutability ensures that once data is recorded, it cannot be altered without consensus from the network. This feature increases trust in the accuracy and reliability of medical records.
5) *Drug Traceability and Supply Chain Management:* Blockchain can be used to track pharmaceuticals and medical devices from their origin to the end-user, ensuring authenticity and reducing the risk of counterfeit products in the healthcare supply chain.
6) *Clinical Trials and Research:* Blockchain can streamline the process of conducting clinical trials by securely recording and managing consent forms, data, and results. It can also enhance transparency and auditability in research studies, promoting more reliable and reproducible findings.
7) *Revenue Cycle Management:* Blockchain's smart contract capabilities can automate and streamline healthcare billing and payment processes, reducing administrative costs and improving revenue cycle efficiency.
8) *Fraud Prevention:* Blockchain's transparent and traceable nature can help identify fraudulent activities and duplicate claims, reducing instances of medical identity theft and insurance fraud.
9) *Disaster Recovery:* Decentralized storage of healthcare data on a blockchain makes it less vulnerable to single points of failure, increasing resilience against data loss due to natural disasters or cyber-attacks.
10) *Regulatory Compliance:* Blockchain's tamper-resistant nature and transparency can aid healthcare organizations in meeting compliance requirements, such as those outlined in data protection regulations like GDPR (General Data Protection Regulation).

While the adoption of blockchain in healthcare is still in its early stages, these potential benefits show promise for transforming the industry and improving patient outcomes through enhanced data security, interoperability, and trust.

V. NEED OF BLOCKCHAIN IN HEALTHCARE

The healthcare sector is experiencing a rapid need for development to provide high-quality facilities and advanced technologies. Blockchain emerges as a critical tool in transforming healthcare by supporting accessible services and appropriate healthcare resources with a patient-centered approach. It efficiently addresses the time-consuming and costly process of Health Information Exchange, benefiting the entire health industry.

Blockchain's implementation allows citizens to participate in health study programs, leading to better research and shared data, ultimately improving treatment for various communities. In the past, challenges in data protection, sharing, and interoperability in population health management have persisted, but Blockchain offers a reliable solution. By enhancing security, data exchange, interoperability, integrity, and real-time updating and access, this technology overcomes these hurdles effectively.

Furthermore, concerns about data protection in personalized medicine and wearables are significant. To ensure the safe and straightforward recording, sending, and consulting of data over networks without compromising safety, Blockchain technology is being implemented to address these issues. By doing so, healthcare organizations can provide adequate patient care, high-quality health facilities, and advance the healthcare landscape towards a patient-centered approach supported by cutting-edge technologies.

Some key reasons why there is a need for blockchain are as follows:

1) *Decentralization:* Traditional centralized systems rely on a single authority or intermediary to manage and validate transactions. This centralized control can lead to single points of failure, security vulnerabilities, andpotential data manipulation. Blockchain's decentralized nature distributes data and control across a network of nodes, enhancing security, transparency, and resilience.
2) *Immutability:* In a blockchain, once data is recorded and verified, it becomes nearly impossible to alter or delete it. This immutability ensures data integrity and authenticity, making it highly valuable in applications where tamper-resistant records are crucial, such as financial transactions, supply chain management, and healthcare records.
3) *Transparency and Auditability:* Transactions on a blockchain are recorded in a transparent and publicly accessible ledger. This transparency fosters trust among participants, as anyone can verify the transactions and track the history of assets. In sectors like supply chain management, this feature helps trace the origin and movement of goods throughout the supply chain.
4) *Security:* Blockchain uses cryptographic techniques to secure data and transactions. As data is distributed across multiple nodes and encrypted, it becomes significantly more resistant to hacking and unauthorized access compared to centralized systems that rely on a single database.
5) *Trust and Disintermediation:* Blockchain's consensus mechanisms enable parties who may not trust each other to reach agreement without the need for a trusted intermediary. This disintermediation can reduce costs, eliminate the need for middlemen, and streamline processes in various industries.
6) *Data Ownership and Control:* In many centralized systems, users often surrender ownership and control of their data to service providers. Blockchain enables users to have greater ownership of their data and allows them to grant selective access to their information, enhancing privacy and data control.
7) *Cross-Border Transactions:* Blockchain's decentralized and borderless nature allows for efficient and seamless cross-border transactions. This feature is particularly valuable in the realm of international trade, remittances, and financial services.
8) *Smart Contracts:* Blockchain supports the execution of self-executing smart contracts, which are programmable agreements with predefined rules. These contracts automatically execute when the specified conditions are met, eliminating the need for intermediaries and ensuring trustless execution.
9) *Reducing Frauds and Counterfeits:* In industries like finance, supply chain, and intellectual property rights, blockchain can significantly reduce fraud and counterfeit activities by providing a transparent and immutable record of transactions and asset ownership.

As with any technology, blockchain has its own set of challenges and limitations, such as scalability, energy consumption, and regulatory concerns. However, its unique attributes make it a promising solution to address various inefficiencies and vulnerabilities in existing centralized systems across diverse sectors.

VI. USE OF SMART CONTRACTS IN BLOCKCHAIN

Smart Contract plays a vital role as an agreement among various parties involved in the system. It is essentially a computer protocol that follows predefined rules and codes agreed upon by all participants in the network. For example, in healthcare systems, a Smart Contract can define the terms and conditions for data access and sharing among hospitals, doctors, pharmacists, and other stakeholders.

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Compared to traditional contracts, Smart Contracts are more efficient, faster, and less resource-consuming since they are self-executing when the specified conditions are met. They provide a decentralized and secure environment, ensuring that medical data remains tamper-proof and accessible only to authorized individuals.

While Smart Contracts offer numerous advantages, there are also challenges that need to be addressed for successful implementation. Writing error-free code is crucial, as mistakes in the programming can lead to issues in the execution. Additionally, legal frameworks may need further validation, and Smart Contracts may require invoking support to perform certain tasks.

Despite these challenges, the potential of blockchain in healthcare is promising. It can enhance the security and interoperability of electronic health records, leading to improved medical services and a more efficient healthcare industry. However, practical implementation and concrete solutions are still being explored to ensure secure data storage, address various security measures, and cater to specific healthcare use cases that require anonymity, transparency, and repudiation. The future of blockchain in healthcare looks visionary, empowering patients to take control of their medical data and facilitating better overall healthcare management.

VII. INTEGRATING BLOCKCHAIN WITH MOBILE APPLICATION

In this innovative user-centric health data sharing solution, mobile and wearable technology play a crucial role in collecting personal health data from various sources such as wearable devices, manual inputs, and medical devices. This data is then synchronized to a cloud database for sharing with healthcare providers and health insurance companies. To address privacy concerns and ensure data integrity, a decentralized and permissioned blockchain is utilized.

The blockchain system employs a channel formation scheme, which allows secure and convenient sharing of personal health data while preserving the user's control over their data through the concept of self-sovereign data ownership. Membership services supported by the blockchain enhance identity management, ensuring only authorized parties can access the shared data.

To maintain the integrity of health data, each record is equipped with a proof of integrity and validation, which is permanently retrievable from the cloud database and anchored to the blockchain network. This provides an auditable trail for all data interactions and ensures that any tampering or unauthorized changes are easily detected.

To handle large datasets efficiently, a tree-based data processing and batching method is adopted. This approach allows the system to manage and process extensive amounts of personal health data collected and uploaded by the mobile platform, ensuring scalability and optimal performance.

Overall, this solution empowers users with greater control over their health data while facilitating secure and seamless collaboration within the healthcare industry. By leveraging blockchain technology, privacy concerns are addressed, and data integrity is safeguarded, fostering trust between users, care providers, and medical researchers.

VIII. BLOCKCHAIN ROLE IN COUNTERFIT PHARMACEUTICALS

Blockchain technology is utilized for counterfeit medicine authentication to ensure the safety and legitimacy of pharmaceutical products. By leveraging its decentralized and immutable nature, blockchain creates a transparent and tamper-proof system for tracking the entire supply chain of medicines, from production to distribution. Each medicine is assigned a unique digital identity, containing essential information such as its origin, manufacturing date, batch number, and expiration date. These details are recorded as blocks on the blockchain, forming an unchangeable chain of custody. Pharmaceutical companies, regulators, and consumers can access this blockchain to verify the authenticity of medicines at any point during their journey. Any attempt to introduce counterfeit products into the supply chain will be immediately detectable, as the blockchain would not have the corresponding valid records. This enhanced transparency and traceability significantly reduce the risk of counterfeit medicines reaching consumers, thus safeguarding public health and bolstering trust in the pharmaceutical industry. By leveraging blockchain for counterfeit medicine authentication, we can take a crucial step towards creating a safer and more reliable global healthcare ecosystem.

IX. CHALLENGES IN BLOCKCHAIN IN HEALTHCARE

While blockchain technology offers numerous advantages in healthcare, it also faces several challenges that need to be addressed for successful implementation.

Some of the key challenges include:

1) *Scalability:* Blockchain networks, especially public blockchains like Bitcoin and Ethereum, can suffer from scalability issues. As the volume of healthcare data and transactions grows, the blockchain may experience slower transaction processing times and higher fees. Scaling solutions and advancements like sharding and layer-two protocols are being developed to address this challenge.

2) *Integration with Existing Systems:* Most healthcare organizations already have established systems for managing patient records, billing, and other processes. Integrating blockchain solutions with these legacy systems can be complex and may require significant effort to ensure seamless data flow and interoperability.
3) *Regulatory Compliance:* The healthcare industry is highly regulated to protect patient data and ensure proper standards of care. Implementing blockchain technology in healthcare must comply with existing regulations, such as the Health Insurance Portability and Accountability Act (HIPAA) in the United States, to safeguard patient privacy and security.
4) *Data Standardization:* Healthcare data comes in various formats and standards, making it challenging to maintain a uniform structure within the blockchain. Ensuring consistent data standards and compatibility across different healthcare providers and systems is crucial for effective data sharing and analysis.
5) *Patient Identification and Privacy:* While blockchain can enhance patient privacy and control over their data, it also poses challenges in verifying patients' identities on the blockchain securely. Striking the right balance between patient identification and maintaining anonymity when necessary is an ongoing concern.
6) *Interoperability between Blockchains:* In a multi-blockchain environment, where different healthcare entities might be using various blockchain networks, achieving interoperability can be complex. Seamless data exchange between different blockchain platforms is essential for the technology's full potential to be realized.
7) *Governance and Consensus Mechanisms:* Determining the governance structure and consensus mechanisms for a healthcare-focused blockchain network can be challenging. Balancing the interests and responsibilities of different stakeholders while maintaining decentralization is a significant consideration.
8) *Education and Adoption:* Blockchain technology is relatively new and complex, and it requires a considerable effort to educate healthcare professionals and organizations about its benefits and implementation. Resistance to change and the need for significant investment in infrastructure and training can slow down adoption.
9) *Legal and Liability Issues:* The use of smart contracts in healthcare may raise legal and liability concerns, as the outcomes of self-executing contracts may not be easily reversible in case of errors or disputes.
10) *Cost and Resources:* Implementing blockchain solutions in healthcare can involve considerable upfront costs, including technology infrastructure, security measures, and skilled personnel. Smaller healthcare organizations may find it challenging to justify the investment.
11) *Energy Consumption:* Some blockchain networks, particularly proof-of-work-based systems like Bitcoin, can be energy-intensive. Healthcare organizations must consider the environmental impact of adopting such networks and explore more energy-efficient consensus mechanisms like proof-of-stake

Addressing these challenges requires a collaborative effort between technology developers, healthcare providers, regulators, and other stakeholders. As blockchain technology continues to mature and its potential becomes better understood, solutions to these challenges are likely to emerge, making blockchain a valuable asset in revolutionizing the healthcare industry.

X. CONCLUSION

In conclusion, blockchain technology shows great potential for transforming the healthcare sector. Its decentralized and tamper-proof nature ensures data security and integrity, addressing crucial challenges faced by traditional healthcare systems. By facilitating seamless data sharing and interoperability among diverse healthcare providers and systems, blockchain has the potential to significantly enhance patient care and overall healthcare efficiency.

One of the key advantages lies in empowering patients by granting them greater control over their health data through informed consent, promoting patient-centric healthcare approaches. The transparency and immutability provided by blockchain foster unwavering accountability and trust in healthcare transactions, benefitting both patients and providers alike.

Furthermore, blockchain's valuable applications, such as accelerated clinical research and prevention of counterfeit drugs, can pave the way for transformative advancements in healthcare practices.

However, successful implementation requires collaborative efforts to address scalability, integration, regulatory compliance, and education hurdles.

Blockchain technology in healthcare may unlock new possibilities for personalized medicine and data-driven treatment approaches, revolutionizing the way healthcare is delivered and experienced. Overall, blockchain has the potential to create a secure, efficient, and patient-centered healthcare ecosystem, shaping a brighter future for the healthcare industry.

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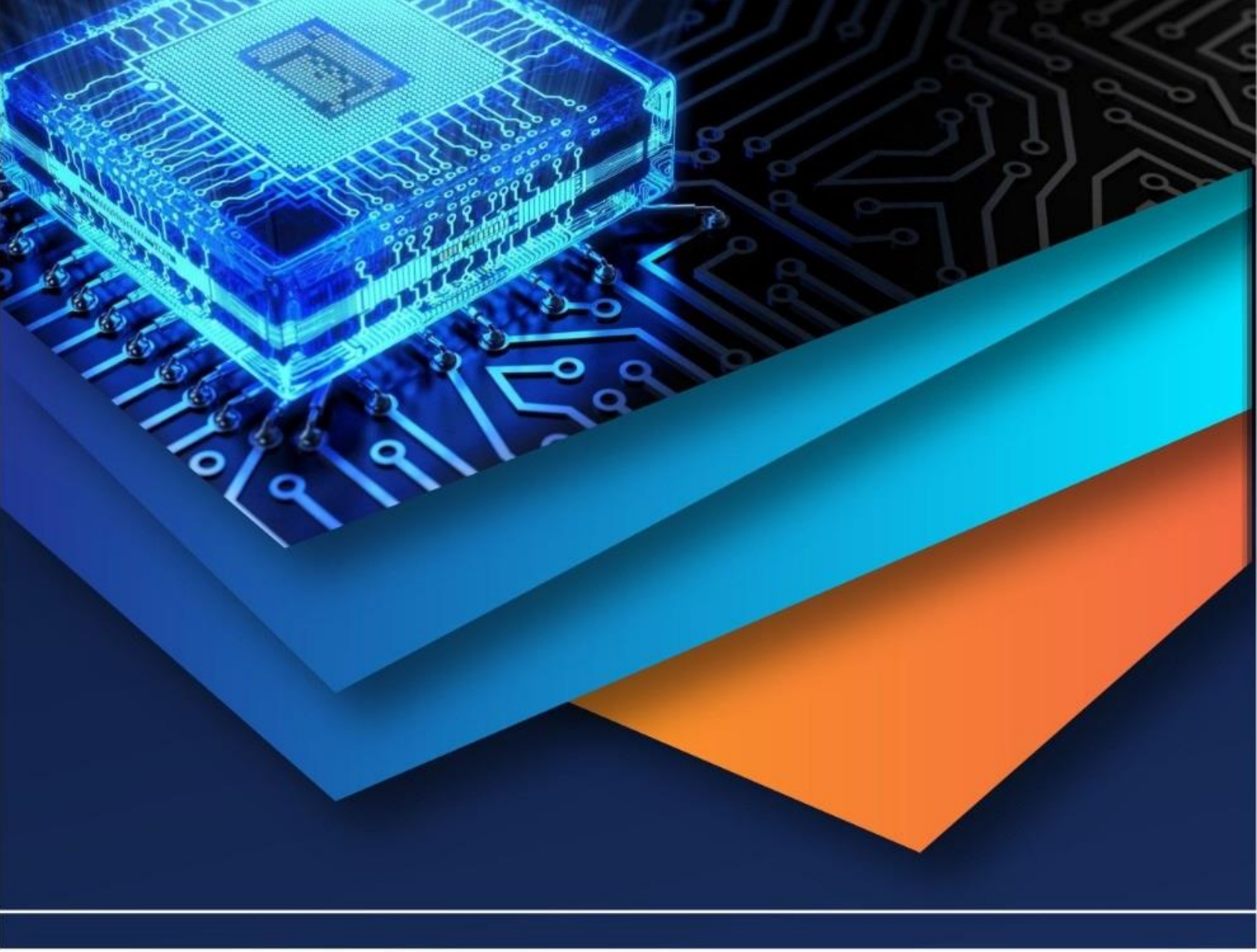

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