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Blockchain Technology for Intelligent transportation Systems: A Systematic Literature Review

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Abstract: ***The transportation industry is a crucial part of the global economy, facilitating the movement of goods and people worldwide. Technological advancements have significantly impacted the industry over time, and one such emerging technology with the potential to revolutionize it is blockchain technology. Blockchain is a decentralized, distributed ledger that enables secure and tamper-proof recording and sharing of data. In this study, we conducted a comprehensive literature review to investigate the use of blockchain technology in the transportation system. Our analysis identified three main themes: blockchain in logistics and supply chain management, smart contracts in transportation systems, and blockchain in transportation security. The literature suggests that the use of blockchain technology in the transportation industry can enhance its efficiency, transparency, and security. The technology can provide a secure and tamper-proof system for tracking goods and shipments, reducing the risk of fraud and theft. Additionally, it can streamline logistics and supply chain operations, reducing associated costs and time. The use of smart contracts can automate the process of verifying and approving shipments, reducing the potential for disputes and legal issues. Furthermore, blockchain technology can be used to create secure digital identities for vehicles and drivers, ensuring that only authorized personnel have access to sensitive data. Despite the potential benefits, there are several challenges that need to be addressed for widespread adoption of blockchain technology in the transportation industry, such as scalability and interoperability. Further research is required to fully explore the potential of blockchain technology in the transportation system.***

I. INTRODUCTION

The transportation industry is an important part of the global economy, facilitating the movement of people and goods across the world. With the emergence of new technologies, such as blockchain technology, the industry has undergone significant advancements. Blockchain technology is a decentralized and distributed ledger that has the potential to revolutionize the transportation industry by providing a secure, transparent, and tamper-proof method of recording and sharing data. This systematic literature review investigates the use of blockchain technology in the transportation system.

To conduct this literature review, the electronic databases Google Scholar, ScienceDirect, and IEEE Xplore were analyzed for articles published between 2015 and 2021 using the related terms "blockchain technology," "transportation system," "logistics," "supply chain," "smart contracts," "decentralization," and "security." The inclusion criteria for the articles were a focus on the use of blockchain technology in the transportation system. After screening, 18 articles were included in the final review, which were categorized into three themes: blockchain technology in logistics and supply chain management, blockchain technology in smart contracts, and blockchain technology in transportation security.

The use of blockchain technology in logistics and supply chain management has been extensively researched. Blockchain technology can provide a transparent and secure method of tracking goods and shipments, reducing the risk of fraud and theft. By automating and streamlining manual processes, such as the verification and approval of shipments, the time and cost associated with logistics and supply chain management can be reduced. Blockchain technology can also create a shared ledger between all parties involved in the logistics and supply chain process, which can reduce the likelihood of errors and disputes.

Smart contracts are self-executing contracts with the terms of the agreement between buyer and seller being directly written into codes. The use of smart contracts in the transportation industry can automate the process of verifying and approving shipments, reducing the time and cost associated with manual processes. Smart contracts can also reduce disputes between parties by clearly defining the terms of the agreement. Moreover, the use of smart contracts can reduce the likelihood of fraud and theft.

Blockchain technology can also enhance transportation security by providing a tamper-proof method of recording and sharing data. Blockchain technology can prevent cyber-attacks, data breaches, and other security threats. For example, blockchain technology can be used to create secure digital identities for vehicles and drivers, ensuring that only authorized personnel have access to sensitive data. Blockchain technology can also create secure communication channels between parties involved in the transportation process, reducing the risk of cyber-attacks and data breaches.

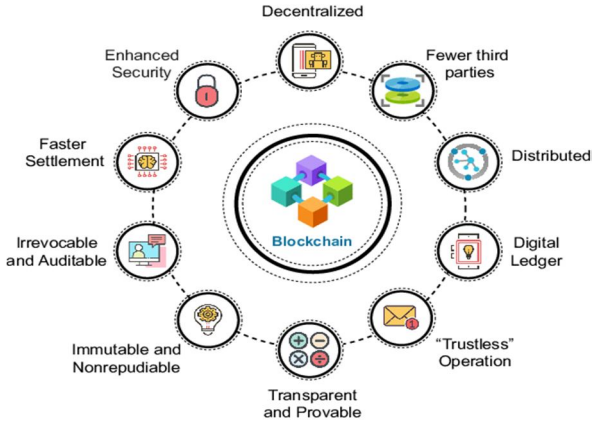
II. OVERVIEW OF BLOCKCHAIN SYSTEM

The transportation industry is a critical component of the global economy, facilitating the movement of goods and people across the world. In recent years, the industry has experienced significant technological advancements, and blockchain technology is one such emerging technology that has the potential to revolutionize the transportation industry. Blockchain technology is a decentralized, distributed ledger that can be used to record and share data in a secure and tamper-proof manner. In this paper, we conduct a systematic literature review to investigate the use of blockchain technology in the transportation system. We identify three main themes that emerge from the literature: blockchain technology in logistics and supply chain management, smart contracts in transportation systems, and blockchain technology in transportation security. We discuss the potential benefits of using blockchain technology in each of these areas and highlight the challenges that need to be addressed for its widespread adoption.

A. Blockchain Technology

Blockchain technology is a decentralized, distributed ledger that can be used to record and share data in a secure and tamper-proof manner. It provides a transparent and immutable record of transactions that can be accessed and verified by anyone in the network. The technology was first introduced in 2008 as the underlying technology behind Bitcoin, a digital currency. Since then, it has evolved to become a versatile technology that can be used in various industries, including transportation.

One of the key features of blockchain technology is its decentralized nature. Unlike traditional centralized systems, where data is stored in a single location and controlled by a central authority, blockchain technology uses a network of computers to store and verify transactions. Each computer, or node, in the network has a copy of the ledger, which is constantly updated and verified by the other nodes in the network. This makes it difficult for any single entity to manipulate or tamper with the data stored on the blockchain. Another important feature of blockchain technology is its security. Transactions on the blockchain are secured using cryptographic algorithms, which ensure that the data is tamper-proof and cannot be altered after it has been recorded. The use of cryptography also ensures that transactions are authenticated and authorized, reducing the risk of fraud and theft.



B. Features of Blockchain

1) *Decentralization:* Blockchain technology is decentralized, meaning that there is no central authority or intermediary controlling the system. Instead, all participants in the network have equal rights and can verify and validate transactions. This eliminates the need for intermediaries such as banks or governments, which can increase efficiency and reduce costs.
2) *Distributed Ledger:* Blockchain technology uses a distributed ledger to record transactions or data. A distributed ledger is a database that is spread across multiple nodes or computers in the network. Each node has a copy of the ledger, and any changes to the ledger are replicated across all nodes. This ensures that the ledger is always up-to-date and prevents any single point of failure.

3) *Cryptography:* Blockchain technology uses cryptography to ensure the security and integrity of the system. Cryptography is the practice of secure communication in the presence of third parties. Blockchain technology uses a combination of public and private keys to secure transactions and data on the network.
4) *Consensus:* Blockchain technology uses a consensus mechanism to ensure that all participants in the network agree on the validity of transactions. Consensus is achieved through a process called mining or validation, where participants compete to solve a complex mathematical puzzle. The first participant to solve the puzzle adds a new block of transactions to the blockchain and is rewarded with cryptocurrency.
5) *Immutability:* Once a transaction or data is added to the blockchain, it cannot be altered or deleted. This is because each block in the chain contains a cryptographic hash of the previous block, linking them together in a chain. Any attempt to change a previous block would require changing all subsequent blocks, which is computationally infeasible.
6) *Smart Contracts:* Smart contracts are self-executing contracts that are programmed to automatically execute when certain conditions are met. They are built on top of blockchain technology and allow for the automation of various processes, such as payment processing and supply chain management.

C. System Types Of Blockchain

In the literature, there are three primary types of Blockchain systems commonly discussed, including private, public, and consortium. The permissioned or private Blockchain is a restricted and closed system that only allows pre-verified individuals who meet specific requirements to perform actions on the Blockchain. This Blockchain type is preferred by small organizations and business Blockchains; however, it is not suitable for trading scenarios. On the other hand, the public Blockchain is an open and permissionless system that allows anyone to join and have full rights to use it. This type of Blockchain is appreciated for its auditability and transparency because there is no access limitation imposed. However, it has high costs related to mining operations, delay, and synchronization among all participating nodes. Public Blockchains are not recommended for energy-sensitive domains or long delays. These two Blockchain types are easy to understand. The third type is the consortium Blockchain, which is a hybrid of the private and public Blockchain. It is a semi-private and semi-open system where only organizations or participants with the same goals can join the group. This type of Blockchain ensures scalability, acceptable delay, and reasonable costs.

D. Advantages And Disadvantages

1) Advantages

a) *Security:* Blockchain technology provides a high level of security through its decentralized structure and the use of advanced cryptographic techniques. The network is protected by complex algorithms and consensus mechanisms that make it very difficult to hack or manipulate the system. Once data is recorded on the blockchain, it cannot be altered or deleted, ensuring that the information remains secure and tamper-proof.
b) *Transparency:* Blockchain technology enables transparency in transactions by allowing all network participants to view and verify data in real-time. This provides an additional layer of security and accountability, making it easier to identify fraudulent or malicious activity.
c) *Efficiency:* Blockchain technology has the potential to increase the efficiency of transactions by eliminating the need for intermediaries and reducing the time and cost associated with verifying and settling transactions. Smart contracts can automate the process of executing agreements, reducing the need for manual intervention and increasing the speed and accuracy of transactions.
d) *Decentralization:* Blockchain technology is decentralized, meaning that there is no central authority controlling the network. This makes it resistant to censorship and provides greater control and ownership of data for users.

2) Disadvantages

a) *Scalability:* One of the biggest challenges facing blockchain technology is scalability. As the number of network participants grows, the speed and efficiency of the system can be compromised, leading to slower transaction times and increased costs.
b) *Energy Consumption:* Blockchain technology is notorious for its high energy consumption, particularly in the case of proof-of-work (PoW) consensus mechanisms used by cryptocurrencies such as Bitcoin. This has raised concerns about the environmental impact of blockchain technology.
c) *Lack of Regulation:* Blockchain technology is still in its early stages of development, and there is a lack of regulation governing its use. This can lead to uncertainty and risk for businesses and consumers, particularly in the case of ICOs and cryptocurrencies.

d) *Complexity:* Blockchain technology is complex and can be difficult for non-technical users to understand. This can create a barrier to entry for businesses and consumers, limiting the adoption of the technology.

E. Blockchain Use Cases

The blockchain technology has been integrated into numerous industries and may be incorporated into many more in the coming decades. Some examples of these applications are introduced below:

1) The banking and payments sector gives access to financial services that can include countries without traditional banking systems. Payment and other financial operations are made easier, more efficient, and more secure.
2) The cybersecurity sector helps in protecting and securing data using advanced cryptography. The data are less prone to hacking or revision without authorization. Unlike typical traditional heritage systems, an authorized third party or a mediator becomes unnecessary.
3) The supply chain operation sector aids in establishing deals in an endless decentralized record and covering them in a secure and transparent manner. This reduces delays and prevents the further introduction of criminal activities. Blockchain is also employed to reduce costs, labor, etc. in the supply chain and to confirm the authenticity or fair trade status of products.
4) Prediction provides a decentralized platform for consulting, analysis, and prediction operations in various disciplines, such as choices, sports, stock requests, and energy consumption
5) Networking and IoT requests propose decentralized networks of IoT bias using Blockchain. Because the Blockchain operation is analogous to a public tally for multitudinous bias, the need for a central authority to handle all IoT communication bias is eliminated.
6) The global insurance request is grounded on trust operation. Because Blockchain presents a new way of managing trust, it can be applied to confirm various types of data in insurance contracts, such as the identity of the insured person.
7) Online data storage using Blockchain allows data storage to be more secure and robust against attacks, hacking, data loss, or criminal activities.
8) Charitable associations that use Blockchain can be more certain that financial aids and donations reach those who deserve it; Blockchain technology can assist in reducing inefficiency and corruption.
9) Voting presents an area where Blockchain has the greatest potential. It can be used for name registration, identity verification, and electronic vote counting, ensuring that votes haven't been altered, and only valid votes are counted. It can potentially reduce organizational costs significantly while increasing voter turnout.

III. OBJECTIVE AND GOALS

The growth of smart vehicles and vehicular applications is expected to produce significant amounts of data and network traffic, creating challenges related to security, management, and cloud-based storage in the Internet of Vehicles (IoV) context. Ensuring compatibility and interoperability among different service providers is essential for the IoV platform's secure, scalable, flexible, interoperable, distributed, and decentralized storage and data exchange. This integration can greatly enhance security, intelligence, big data storage, and efficient management of the IoV. Blockchain technology, known for its decentralized, immutable ledger, has transformed digital currencies and can provide a trustworthy, secure environment for the IoT. By adopting blockchain technology, the IoV can benefit from enhanced security and trust, cost-saving optimization and automation of information handling, and improved management. However, challenges such as storage limitations, inflexibility, and high costs must be considered when implementing blockchain technology in the IoV. Blockchain technology has several applications in the transportation system, including supply chain management where it can track goods and their movement, ensuring transparency and effectiveness in the logistics chain. Asset tracking is another application, where blockchain can track the position and status of transportation vehicles, containers, and cargo, reducing the risk of theft and loss. Smart contracts can automate contract execution, ensuring compliance with the agreement's terms and reducing the risk of disputes. Additionally, blockchain can produce secure and efficient payment systems for transportation services, reducing the risk of fraud and increasing transaction speed. Secure data sharing between transportation stakeholders, such as shippers, carriers, and logistics providers, can also be facilitated by blockchain, improving collaboration and reducing data silos. Blockchain can also ensure regulatory compliance by providing an immutable and auditable record of transportation conditions. Finally, blockchain can enable secure and decentralized communication between autonomous vehicles, allowing them to coordinate and make decisions in real time. patterns.

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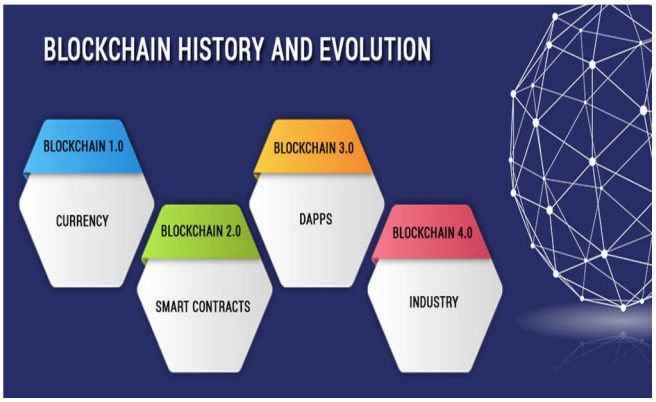
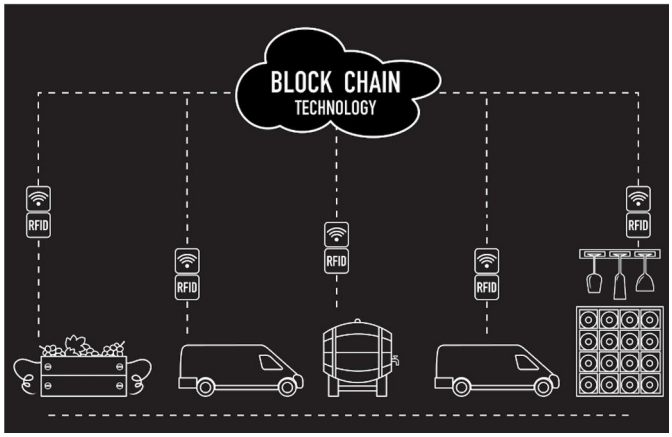
IV. HISTORY AND EVOLUTION



The concept of a decentralized ledger that could record transactions without the need for a central authority dates back to the early 1990s. However, it wasn't until the emergence of Bitcoin in 2009 that the blockchain technology gained widespread recognition. Bitcoin was created by an unknown individual or group using the pseudonym Satoshi Nakamoto.

The blockchain technology underpinning Bitcoin was designed to enable secure, peer-to-peer transactions without the need for a central authority like a bank or government. The first block in the Bitcoin blockchain, known as the genesis block, was mined on January 3, 2009. Each subsequent block contains a cryptographic hash of the previous block, which makes it extremely difficult to alter previous blocks without altering the entire chain. Since then, blockchain technology has been used for a wide range of applications beyond cryptocurrency, including supply chain management, voting systems, and digital identity verification. There are also a number of different types of blockchain, including public, private, and permissioned blockchains, each with their own unique characteristics and use cases. Despite some challenges and concerns, such as scalability and energy consumption, the potential of blockchain technology to enable secure, decentralized, and transparent transactions continues to drive innovation and investment in the field.

V. TRANSPORTATION SYSTEM USING BLOCKCHAIN



The transportation industry is responsible for managing multiple procedures to successfully deliver a package from a warehouse to a customer's location. These procedures require constant monitoring and inspections to ensure they are carried out with the utmost care. Implementing blockchain technology in transportation can lead to shorter processing times, efficient data management, and real-time monitoring and tracking. Therefore, incorporating blockchain technology can enhance the effectiveness and reliability of the transportation industry.

A. *Efficient Supply Chain*

The effective operation of the supply chain involves the movement of goods or services from their origin to their destination. Managing the various stages of this process, from storage to delivery, can be challenging when data is dispersed across a vast network involving multiple companies and individuals. Blockchain technology offers a consolidated and secure system for storing all relevant information. The transportation industry must monitor the location, method, and quantity of their products, while also mitigating risks along the way. Blockchain technology minimizes disruption by automating data processing and providing real-time status updates. Digitizing the supply chain helps prevent stock-outs and allows for immediate shipping when needed. With a well-managed registry, suppliers can monitor their inventory and update their stocks to avoid order cancellations.

B. *Transparent Data Logs*

The entire blockchain network is accessible to registered users, who have the ability to track and trace the stored data, but cannot alter it. This ensures credibility and authenticity of all parties involved in the trade. The chain is made immutable through cryptographic security methods and hashed pointers to each block. Despite being in its early stages, blockchain technology is expected to exhibit significant potential in the future. Players in the transportation industry can collaborate to build scalable, blockchain-based systems and transform the way business is conducted in the field.

C. *Payments*

The topic of payments is explored in this content, with a focus on unconventional, smart, and decentralized payment and billing methods for IoV users. The payment order enables secure and efficient transactions, optimized pricing, and energy consumption. Various proposals have been put forward in the IoV processing subcategory, including a blockchain-based billing service for secure transactions between EVs and charging stations, and a Hyperledger system that uses a unique tally enrollment structure for tamper-proof payments. The optimization of EV battery exchange stations for efficient cargo and cost of power generation was also studied. In addition, a smart contract-based rental auto platform with optimized costs was proposed. In the IoV communication subcategory, a new topology was designed to reduce verification detainments and costs in Bitcoin deals in a private network. An optimization approach was conducted to maximize the output of deals in a Blockchain-based IoV network with security and detention constraints, using DRL to determine acceptable sizes, intervals, and directors of blocks that satisfy assessed constraints. Finally, the IoV security subcategory used Blockchain technology to secure payments for IoV services and ensure the confidentiality, trustworthiness, and authenticity of transactions and sensitive information. Certain agreement approaches such as the PBFT algorithm and smart contracts were suggested for verifying sale information.

D. *Transport Applications*

Smart transport operations for the Internet of Vehicles (IoV) and vehicular systems are in high demand. Researchers have proposed and tested APIs for various purposes such as traffic avoidance, in-vehicle entertainment, and mobility services. These APIs are used to detect, unlock, and read the odometers of buses across different brands. Transport operation research related to vehicular systems is mainly included in the IoV processing subcaste combined with the IoV security subcaste for security and sequestration purposes. Blockchain-based platforms are used for various smart auto services such as auto parking, auto leasing, training and literacy independent buses, and establishing trusted multiparty insurance. They are also used for secure selling and buying of used buses and the transparent dispersion of operation history of motors for trading. A smart contract-based platform for arising transport services was proposed. With this platform, data regarding the benefits of motorists and vehicles are stored, participated, and also deleted after completing the service. To secure the data stored in the built-in defined coffers of smart vehicles, a secure content caching scheme using private Blockchain and deep underpinning literacy approach was designed. A dependable frame for multi-vehicle collaborative positioning corrections was designed to enhance system security and robustness, and a Blockchain armature was employed to link detector-rich vehicles, common vehicles, and RSUs. A proposed system that applies a group hand algorithm and ElGamal encryption algorithm was developed to disable the transmission of vicious and fake dispatches among vehicles in a network. The performance evaluation results show that the encryption, hand, verification, and batch verification algorithms of the proposed system are superior to other algorithms and have lower computational costs, demonstrating the effectiveness of the proposed scheme. A reliable business operation medium must be able to intelligently switch business lights, allocate the duration of green lights, and improve road business safety.

VI. CHALLENGES AND FUTURE WORK

A. Challenges

Blockchain technology has the potential to revolutionize the transportation system by providing secure, transparent, and decentralized transactions. However, it also faces several challenges that need to be addressed, including:

Scalability: As the number of transactions and users in the transportation system increases, the blockchain network needs to be able to handle the load without compromising speed and efficiency.

Interoperability: Different transportation systems may have their own blockchain networks, and it is important to ensure that these networks can communicate with each other seamlessly to enable cross-system transactions.

Privacy and security: While blockchain technology provides a secure and transparent platform for transactions, it also poses privacy concerns. It is important to ensure that sensitive information is not exposed to unauthorized parties, while also maintaining the integrity of the system.

Adoption: Blockchain technology is still relatively new, and its adoption in the transportation system requires significant investment and coordination between different stakeholders.

Regulation: As with any new technology, there is a need for clear regulatory frameworks to ensure that blockchain-based transactions are legal and comply with existing regulations.

Energy consumption: Blockchain technology requires significant energy consumption for processing transactions and maintaining the network, which can be a challenge in the transportation system where energy conservation is a priority.

Addressing these challenges is critical for the successful integration of blockchain technology into the transportation system, and will require collaboration between industry players, regulators, and technology experts.

B. Future Work

As the demand for same-day and on-demand delivery rises and consumer expectations escalate, commercial transportation firms are encountering a growing necessity to be innovative. While many trucking companies have invested in advanced tracking technology, expanding this technology to meet more complex user demands has been challenging, especially with regards to authentication.

1) Improving Blockchain Performance for Future BIoV

Improving Blockchain performance is expected to be a significant concern in the near future, particularly for applications like BIoV. This section focuses on the challenges related to enhancing Blockchain performance.

a) *Performance Limitations and Possible Directions:* Traditional database systems surpass Blockchain in terms of performance because of their centralized nature. This section presents an overview of the primary performance limitations of Blockchain that hinder its use in digital relationships.

b) *Throughput:* Commercial Blockchain platforms presently underperform compared to traditional database systems. However, their performance must be improved to make processing business transactions in the real world more efficient and effective. For example, on average, VISA processes 1700 transactions per second, whereas Bitcoin processes only 4.6 transactions per second. Hence, reducing processing latency is essential to ensure security.

c) *Network Congestion:* This pertains to any condition where data inflow becomes limited due to inadequate computer or network resources. Because the number of Blockchain systems is increasing, the problem of network congestion must be resolved.

2) Machine Learning With BioV

Machine literacy is a useful method to support BIoV. Machine literacy is a form of artificial intelligence used in areas such as speech recognition, medical analysis, and computer vision. It has also transformed BIoV services by allowing them to learn from data and make data-driven decisions, provide decision support, and predict improvements in network performance. Interdisciplinary research should focus on integrating machine literacy and BIoV, particularly in designing smart agents and analyzing the Blockchain-based IoV system using literacy-based methods. Smart agents can manage the Blockchain system and detect abnormal actions, which is critical for the public chain's security. The proper operation of the network is essential for the private and institute chains, which require collaboration among users. Literacy-based analysis of the Blockchain-based system can provide important information on the system's design and timely prediction models. Blockchain must support anonymous data sharing, which requires sophisticated data authorization for different users. The Blockchain mining process is similar to the Markov decision process, and multi-agent RL can model complex pool mining operations and allow miners to determine optimal mining strategies.

Cryptocurrency plays a critical role in the public chain, and different chains use different cryptocurrencies. Cryptocurrencies have been established as investment options similar to traditional financial products, but their prediction performance can be poor. Therefore, research should focus on using RL, DRL, or inverse RL to investigate the investment return of cryptocurrencies.

VII. CONCLUSION

This article provides a comprehensive review of the current state-of-the-art in Blockchain technology. The review covers the evolution of Blockchain development from its early stages to the current phase, which includes Hyperledger, Ethereum, and smart contracts. The paper then focuses on the use of Blockchain technology in intelligent transport operations for the IoV network, with research work classified into six areas: security, transport operations, energy, communication and network, data operations, and payments and optimization. For each area, the research findings are classified according to the IoV layers, with most of the benefits observed in the processing, communication, and security layers. The article also compares this review to previous literature checks, highlights its added value, and identifies open problems in Blockchain operations.

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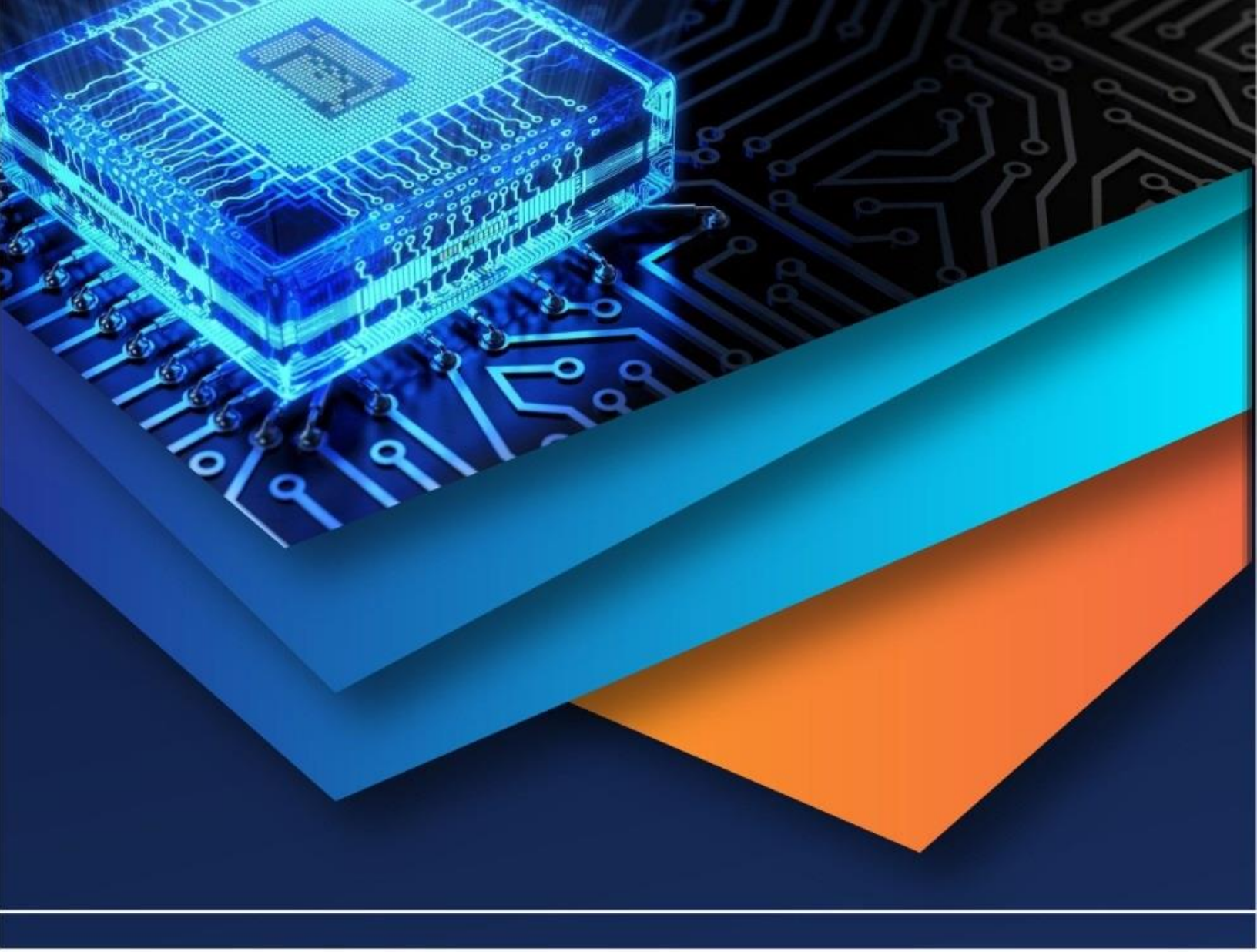

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