A Review on Blockchain Technology: Concepts, Applications and Emerging Platforms

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***Abstract*—Blockchain technology has emerged as a revolutionary innovation in the field of computer science and information systems. Initially developed as the underlying technology for cryptocurrencies, it has evolved into a versatile tool with applications across multiple industries. This paper provides a comprehensive review of Blockchain technology, its fundamental concepts, major application areas, and different Blockchain platforms and technologies. It also discusses key features, advantages, and challenges associated with Blockchain systems.**

***Index Terms*—Applications, Blockchain, Challenges Platforms**

I. INTRODUCTION

Blockchain technology is a decentralized and distributed digital ledger system that records transactions securely across multiple nodes. Unlike traditional centralized databases, Blockchain ensures transparency, immutability, and trust without requiring intermediaries. The concept was first introduced in 2008 through Bitcoin, and since then, it has expanded into various domains such as finance, healthcare, supply chain, and governance

II. BLOCKCHAIN TECHNOLOGY

Blockchain is a distributed ledger technology that stores data in blocks, which are linked together in a chronological chain using cryptographic techniques. The key characteristics includes Decentralization – No central authority controls the system, Immutability – Data once recorded cannot be altered, Transparency – Transactions are visible to all participants, Security – Uses cryptographic hashing and consensus mechanisms, Consensus Mechanism – Ensures agreement among nodes (e.g., Proof of Work, Proof of Stake) [1]. Blockchain operates as a peer-to-peer network where each participant maintains a copy of the ledger, ensuring reliability and fault tolerance. Each block is linked to the previous block via a cryptographic hash, making the chain tamper-proof.

III. APPLICATION AREAS OF BLOCKCHAIN TECHNOLOGY

Blockchain has expanded far beyond cryptocurrency into numerous sectors

- Supply Chain Monitoring

In supply chain management managing the products, its stock is the biggest problem. Other concerns for organizations and consumers inclusion of fake or fraud items. Blockchain technology offers immutability and the ability to monitor the supply chain products throughout its journey. It also offers transparency for organization to track products [7]. Organizations can monitor their products and find out about inefficiencies that may be part of the supply chain. Ultimately Blockchain implementation in the supply chain will improve the monitoring of products.

- Payment Processing and Money Transfers

For making oversea money transfers banks and foreign exchange regulations impose certain restrictions. Blockchain Technology will ease this overseas transfer of money. Some overseas Banks also use cryptocurrencies to manage overseas funds as they are fast and impose less cost than doing it in a more traditional manner.

- Digital Identity

Identity is one of the biggest problems of our society. People have to carry documents even for doing small

work. People want to use identity in a secured way. Using Blockchain technology digital identity system can be created [6]. This may solve many problems associated with identity.

- Royalty Protection and Copyright

The one who is creator of the original contents and wants to protect his creations then there is a need for royalty protection and copyright. Sometimes mischiever are violating copywriting rules, but it is hard to detect and then punish them [8]. Using Blockchain technology copyright and royalty protection is possible. Blockchain offers a unique way to protect the data.

- Cyber Security

Cyber-attacks are the attempts to steal, expose, alter, disable or destroy information through unauthorized access to computer systems. Cyber security is the application of technologies, processes and controls to protect systems, networks, programs, devices and data from cyber-attacks. It aims to reduce the risk of cyber-attacks and protect against the unauthorized exploitation of systems, networks and technologies [9]. Blockchain plays a crucial role in solving a lot of system security issues. It can improve cyber security with the use of decentralized storage.

- Digital Voting

Transparent, immutable, and more secured voting systems or software can be implemented using Blockchain Technology [8].

- Real Estate

In Real estate a lot of documentation, verification is needed and it is time consuming. There is lot of paperwork involved in buying and selling property. Verification is very much necessary here. To solve all these issues related to property, Blockchain offers a tokenized real-world asset. Using Blockchain Technology real estate related fraud can be reduced and the system will ensure transparency, immutability, and security [4].

- Healthcare – Medical Recordkeeping

Sometimes patient record keeping is a tedious task as documents get complicated with time and become hard to maintain. With Blockchain technology patients' data can be stored in a secure way. It can be accessed from anywhere [7]. Doctors can also easily access the patient's data whenever patients visit them. So, it will be easier for all patients and doctors.

- Healthcare – Tracking Medicines

Original medicine tracking and stopping fake medicines from sale is the biggest challenge. Blockchain helps to keep track of medicine and helps to remove the fake medicine supply.

- Asset Management

Traders can manage and trade their assets in a secure way using Blockchain technology. It also reduces the risky trades and takes care of the records and ensures that no errors creep in when managing those records.

- Entertainment

Using Blockchain technology, musicians and event managers can directly connect with their audience and sell their music or tickets directly to them without a mediator's need. This secondary markets and illegal scalping of content or tickets.

- Insurance

Blockchain will reduce the fraud involved in insurance claims. Once the claims are uploaded using Blockchain technology the claims are transmitted to the right party.

- Education

Educational certificates and skills verification is a very hard task. It involves fraud and sometimes undeserved candidates get jobs. Using Blockchain technology's distributed verification systems educational documents can be easily verified anytime from anywhere. These documents will be more manageable and secured.

- Humanitarian Aid

There is a need for transparency in the charities. As a donator, one must also know how and where your donation is going to be used. It is possible using Blockchain technologies. All donations can be tracked and it can be made more transparent by removing middlemen or brokers and provide maximum benefit to the needy [8].

IV. TYPES OF BLOCKCHAIN

Blockchain technology can be broadly classified into different types based on access control, governance, and level of decentralization. The main types of Blockchain include public Blockchain, private Blockchain, consortium (or federated) Blockchain, and hybrid Blockchain. Each type is designed to meet specific requirements and use cases [3].

A public Blockchain is a fully decentralized and open network where anyone can participate without any restriction. In this type of Blockchain, users can join the network, validate transactions, and maintain the ledger. All transaction data is transparent and visible to every participant in the network. Public Blockchain rely on consensus mechanisms such as Proof of Work or Proof of Stake to ensure trust and security. These Blockchain are highly secure due to their decentralized nature, but they may suffer from scalability issues and slower transaction speeds. Public Blockchains are commonly used in cryptocurrencies and open decentralized applications [5].

A private Blockchain, on the other hand, is a restricted network controlled by a single organization. In this type of Blockchain, only authorized participants are allowed to join and perform activities such as reading, writing, or validating transactions. Private Blockchain offer higher efficiency, faster transaction processing, and better scalability compared to public Blockchain because they operate in a controlled environment. However, they are less decentralized and rely on a central authority, which may reduce transparency and trust to some extent. Private Blockchain are often used by enterprises for internal operations such as supply chain management, data sharing, and record keeping.

A consortium Blockchain, also known as a federated Blockchain, is a semi-decentralized network governed by a group of organizations rather than a single entity. In this model, multiple organizations collaborate to manage the Blockchain, and only selected nodes have the authority to validate transactions. Consortium Blockchain combine the advantages of both public and private Blockchain by offering improved efficiency and controlled access while maintaining a certain level of decentralization. These Blockchain are commonly used in industries such as banking, healthcare, and supply chain, where multiple organizations need to share data securely [12].

A hybrid Blockchain is a combination of both public and private Blockchain features. It allows organizations to maintain control over certain data while still benefiting from the transparency and security of a public Blockchain. In a hybrid Blockchain, some parts of the system are accessible to the public, while others are restricted to authorized users. This flexibility makes hybrid Blockchain suitable for applications where both privacy and transparency are important. Organizations can decide which data should be public and which should remain confidential, making this type of Blockchain highly adaptable to different business needs [13].

V. BLOCKCHAIN PLATFORMS

Blockchain technology has evolved significantly since its introduction, leading to the development of various platforms designed to serve different purposes and industries. These platforms differ in terms of architecture, consensus mechanisms, scalability, and use cases. Some are designed for cryptocurrencies, while others focus on enterprise solutions, smart contracts, or interoperability.

One of the earliest and most well-known Blockchain platforms is Bitcoin. It was the first successful implementation of Blockchain technology and was introduced as a decentralized digital currency system. Bitcoin uses the Proof of Work consensus mechanism, where miners solve complex mathematical problems to validate transactions and add new blocks to the chain. Although Bitcoin is highly secure and decentralized, it has limitations in terms of scalability and transaction speed, making it primarily suitable for financial transactions rather than complex applications [21].

Another major platform is Ethereum, which expanded the capabilities of Blockchain by introducing smart contracts. Smart contracts are self-executing programs that automatically enforce agreements when predefined conditions are met. Ethereum allows developers to build decentralized applications on its platform, making it highly versatile. It initially used Proof of Work but has transitioned to Proof of Stake to improve energy efficiency and scalability. Ethereum is widely used in

areas such as decentralized finance gaming, and digital assets [18].

Hyperledger Fabric is a permissioned Blockchain platform developed under the Hyperledger project, which is hosted by the Linux Foundation. Unlike public Blockchain, Hyperledger Fabric is designed for enterprise use and allows organizations to create private and secure Blockchain networks. It features a modular architecture, enabling customization of components such as consensus mechanisms and identity management. This platform is widely used in industries like supply chain, healthcare, and finance, where data privacy and controlled access are important [23].

Ripple, also known as the XRP Ledger, is a Blockchain platform specifically designed for fast and low-cost cross-border financial transactions. It is primarily used by banks and financial institutions to facilitate real-time payment settlements. Ripple does not rely on traditional mining; instead, it uses a consensus protocol that enables faster transaction processing with minimal energy consumption. This makes it an efficient solution for global payment networks.

Polkadot is an advanced Blockchain platform that focuses on interoperability between different Blockchain. It enables multiple Blockchain to connect and communicate with each other through a shared network. Polkadot uses a multi-chain architecture, allowing data and assets to be transferred across different Blockchain securely. This capability addresses one of the major limitations of traditional Blockchain systems, which often operate in isolation.

Cardano is another modern Blockchain platform that emphasizes security, scalability, and sustainability. It is built using a research-driven approach and is based on peer-reviewed academic principles. Cardano uses a Proof of Stake consensus mechanism called Ouroboros, which is designed to be energy-efficient. The platform aims to provide a balanced and secure ecosystem for smart contracts and decentralized applications.

Corda is a Blockchain platform developed primarily for use in the financial sector. Unlike traditional Blockchain, Corda is designed to share data only between relevant parties rather than broadcasting it to the entire network. This enhances privacy and efficiency, making it suitable for industries where confidentiality is crucial. Corda is commonly used for banking, insurance, and trade finance applications.

VI. CHALLENGES AND LIMITATIONS OF BLOCKCHAIN TECHNOLOGY

Blockchain technology, despite its numerous advantages, faces several significant challenges and limitations that restrict its widespread adoption across industries. One of the primary issues is scalability. Blockchain networks, particularly public ones, struggle to process a large number of transactions efficiently. Unlike traditional centralized systems that can handle thousands of transactions per second, many Blockchain systems have limited throughput. As the number of users increases, the network becomes congested, leading to slower transaction processing times and increased transaction fees. This limitation makes Blockchain less suitable for high-volume applications without additional scaling solutions [19].

Another major concern is high energy consumption, especially in Blockchain systems that use Proof of Work as a consensus mechanism. In such systems, miners must solve complex mathematical problems to validate a transaction, which requires substantial computational power and electricity. This not only increases operational costs but also raises serious environmental concerns due to excessive energy usage and carbon emissions. Although alternative mechanisms like Proof of Stake are being developed, energy efficiency remains an ongoing challenge. Regulatory and legal uncertainty is another critical limitation of Blockchain technology. Since Blockchain operates on a decentralized and global scale, it is difficult for governments and regulatory bodies to establish consistent rules and policies. Different countries have different legal frameworks regarding Blockchain and cryptocurrencies, which creates confusion and compliance issues for organizations. Furthermore, the immutable nature of Blockchain records can conflict with data protection laws that require the ability to modify or delete personal data [24].

The integration of Blockchain with existing systems also presents a significant challenge. Most organizations currently rely on traditional centralized systems, and transitioning to a decentralized

Blockchain -based system requires substantial changes in infrastructure, processes, and skills. This integration process can be costly, time-consuming, and technically complex. Additionally, there may be resistance from organizations due to the disruption of existing workflows and business models [14].

Although Blockchain is inherently secure, it is not entirely free from security vulnerabilities. A potential risk is the 51% attack, where a group of miners gains control of the majority of the network's computing power, allowing them to manipulate transactions. Moreover, users are responsible for managing their private keys, and losing these keys can result in permanent loss of access to their assets [15].

Data privacy is another important concern in Blockchain systems. While transparency is a key feature of Blockchain, it can conflict with the need for confidentiality. In public Blockchain, transaction data is visible to all participants, which may expose sensitive information. Additionally, the immutability of Blockchain makes it difficult to comply with privacy regulations that require data to be erased or modified.

Blockchain also faces storage limitations due to its continuously growing size. As more transactions are added, the Blockchain ledger expands, requiring nodes to store increasing amounts of data. This can lead to higher storage costs and may discourage participation in the network, particularly for smaller nodes with limited resources.

Another limitation is the lack of standardization in Blockchain technology. Since the field is still evolving, there are no universally accepted standards or protocols. Different Blockchain platforms use different architectures and consensus mechanisms, making it difficult to achieve compatibility and consistency across systems. This lack of standardization also contributes to interoperability issues, where different Blockchain networks are unable to communicate or share data effectively.

The cost and resource requirements associated with Blockchain implementation can also be a barrier. Developing, deploying, and maintaining Blockchain systems require significant investment in infrastructure and skilled professionals.

Finally, user adoption and awareness remain key challenges. Blockchain technology is still relatively new and complex for many users. Governance in decentralized networks can also be problematic, as decision-making processes are often slow and require consensus among multiple stakeholders.

VII. FUTURE SCOPE

Blockchain technology is expected to play a transformative role in the future of digital systems, with its applications expanding far beyond cryptocurrencies. As industries continue to digitize and demand more secure, transparent, and efficient systems, Blockchain is likely to become a foundational technology in the global digital infrastructure.

One of the most significant future directions of Blockchain is its role in the development of Web3, which represents the next generation of the internet. Unlike the current web, which is largely controlled by centralized platforms, Web3 aims to create a decentralized ecosystem where users have greater control over their data and digital identities. Blockchain will serve as the backbone of this ecosystem by enabling trustless interactions, decentralized applications (DApps), and peer-to-peer transactions without intermediaries.

Another important area of future development is the adoption of Central Bank Digital Currencies. Many governments and central banks are exploring or already piloting digital currencies based on Blockchain or distributed ledger technologies. These digital currencies are expected to improve financial inclusion, reduce transaction costs, and enhance the efficiency of monetary systems. At the same time, they will allow governments to maintain regulatory oversight while benefiting from Blockchain's transparency and security.

Blockchain is also expected to significantly impact financial services through Decentralized Finance (DeFi). DeFi platforms aim to replace traditional banking services such as lending, borrowing, and trading with decentralized alternatives that operate on Blockchain networks. In the future, DeFi could provide more accessible financial services to people who are currently unbanked, especially in developing regions.

The integration of Blockchain with emerging technologies such as Artificial Intelligence (AI) and the Internet of Things (IoT) is another promising area. Blockchain can provide secure and tamper-proof data for AI systems, improving the reliability of

machine learning models. In IoT ecosystems, Blockchain can ensure secure communication between devices, enable automated transactions, and maintain data integrity. This combination is expected to drive innovation in areas such as smart cities, autonomous vehicles, and industrial automation.

In addition, Blockchain is likely to play a key role in enhancing supply chain management systems. Future supply chains will rely on Blockchain for real-time tracking, transparency, and traceability of goods from origin to destination. This will help reduce fraud, ensure product authenticity, and improve efficiency across global logistics networks. Industries such as food, pharmaceuticals, and manufacturing are expected to benefit significantly from these advancements.

The concept of digital identity is also expected to evolve with Blockchain technology. In the future, individuals may have self-sovereign digital identities stored on Blockchain, giving them full control over their personal information. This can reduce identity theft, simplify verification processes, and enhance privacy in online interactions.

Another emerging area is the use of Blockchain in the metaverse and Non-Fungible Tokens (NFTs). Blockchain enables the ownership and transfer of digital assets in virtual environments. As the metaverse continues to grow, Blockchain will provide the infrastructure for secure digital ownership, virtual economies, and decentralized marketplaces.

Environmental concerns surrounding Blockchain are also driving innovation toward green and sustainable Blockchain solutions. Future developments will focus on energy-efficient consensus mechanisms such as Proof of Stake and other low-energy alternatives. This will help reduce the carbon footprint of Blockchain networks and make them more environmentally sustainable.

Furthermore, Blockchain is expected to revolutionize governance and public services. Governments may adopt Blockchain for transparent voting systems, secure record-keeping and efficient public service delivery. This can enhance trust between citizens and authorities while reducing corruption and administrative inefficiencies.

Finally, continuous research and innovation are likely to address current limitations such as scalability, interoperability, and usability. Technologies like sharding, cross-chain communication, and layer-2 solutions will improve Blockchain performance and enable seamless interaction between different networks. As these challenges are resolved, Blockchain adoption is expected to accelerate across various sectors.

VIII. CONCLUSION

Blockchain technology is a transformative innovation that has the potential to revolutionize multiple industries. Its decentralized nature, combined with transparency and security, makes it a powerful tool for modern digital systems. While challenges remain, continuous advancements in Blockchain platforms and consensus mechanisms are likely to enhance its scalability and usability in the future.

REFERENCES

[1] G. Habib *et al.*, "Blockchain technology: Benefits, challenges, applications," *Future Internet*, 2022.

[2] Singh *et al.*, "Blockchain technology, structure, and applications: A survey," *Procedia Computer Science*, 2024.

[3] Z. Zheng *et al.*, "Blockchain technology and application: An overview," *PMC*, 2023.

[4] D. Jadhav and P. Adkar, "A review on blockchain technology," *International Engineering Research Journal (IERJ)*, 2019.

[5] P. Paul *et al.*, "Blockchain technology and its types," *International Journal of Advances in Science and Engineering (IJASE)*, 2021.

[6] F. Casino, T. K. Dasaklis, and C. Patsakis, "A systematic literature review of blockchain-based applications," *Telematics and Informatics*, vol. 36, pp. 55–81, 2018.

[7] S. Saberi *et al.*, "Blockchain applications in supply chain," *Computers & Industrial Engineering*, 2021.

[8] P. Arora and R. Nagpal, "Blockchain technology and its applications," in *Proc. Int. Conf. Innovative Computing and Communication (ICICC)*, 2022.

[9] M. A. Khan *et al.*, "Blockchain technology: Applications and challenges," *IEEE Internet of Things Journal*, 2019.

[10] S. Nakamoto, “Bitcoin: A peer-to-peer electronic cash system,” 2008. [Online]. Available: https://bitcoin.org/bitcoin.pdf

[11] G. Wood, “Ethereum: A secure decentralised generalised transaction ledger,” Ethereum White Paper, 2014.

[12] Z. Zheng, S. Xie, H. Dai, X. Chen, and H. Wang, “Blockchain challenges and opportunities: A survey,” *International Journal of Web and Grid Services*, vol. 14, no. 4, pp. 352–375, 2018.

[13] M. Crosby, P. Pattanayak, S. Verma, and V. Kalyanaraman, “Blockchain technology: Beyond Bitcoin,” *Applied Innovation Review*, 2016.

[14] E. Androulaki *et al.*, “Hyperledger Fabric: A distributed operating system for permissioned blockchains,” in *Proc. EuroSys Conf.*, 2018.

[15] S. Saberi, M. Kouhizadeh, J. Sarkis, and L. Shen, “Blockchain technology and its relationships to sustainable supply chain management,” *International Journal of Production Research*, 2019.

[16] K. Christidis and M. Devetsikiotis, “Blockchains and smart contracts for the Internet of Things,” *IEEE Access*, vol. 4, pp. 2292–2303, 2016.

[17] X. Xu, I. Weber, and M. Staples, *Architecture for Blockchain Applications*. Cham, Switzerland: Springer, 2019.

[18] M. Swan, *Blockchain: Blueprint for a New Economy*. Sebastopol, CA, USA: O’Reilly Media, 2015.

[19] D. Drescher, *Blockchain Basics: A Non-Technical Introduction in 25 Steps*. Berkeley, CA, USA: Apress, 2017.

[20] A. Narayanan, J. Bonneau, E. Felten, A. Miller, and S. Goldfeder, *Bitcoin and Cryptocurrency Technologies*. Princeton, NJ, USA: Princeton University Press, 2016.

[21] S. King and S. Nadal, “PPCoin: Peer-to-peer crypto-currency with proof-of-stake,” 2012.

[22] Hyperledger Foundation, “Hyperledger Fabric documentation,” 2023. [Online]. Available: https://hyperledger.org

[23] V. Buterin, “Ethereum white paper: A next-generation smart contract and decentralized application platform,” 2013.