iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 **Issue:** V **Month of publication:** May 2023

DOI: https://doi.org/10.22214/ijraset.2023.52051

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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 V May 2023- Available at www.ijraset.com

Blockchain-Enabled IoT: Enabling Trust and Security in a Connected World

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Abstract: ***Blockchain technology has gained significant attention for its potential applications in the Internet of Things (IoT) realm. By combining blockchain with IoT, a new paradigm emerges that offers enhanced security, transparency, and trustin IoT networks. In the context of IoT, a blockchain serves as a decentralised and immutable ledger that records all transactions and interactions among connected devices. This decentralisednature eliminates the need for a central authority, ensuring that data exchanges and smart contract executions occur in a transparent and tamper-proof manner. Blockchain enables the creation of trusted ecosystems and facilitates direct peer-to-peer interactions between IoT devices. Through the use of smart contracts, devices can autonomously execute predefined actions based on predetermined conditions, eliminating the need for intermediaries and central control. This decentralised approach enhances efficiency, reduces costs, and improves scalability in IoT networks. Blockchain enhances privacy in IoT networks through cryptographic techniques. Individuals can maintain ownership and control over their personal data, selectively granting access for specific purposes while preserving privacy. However, integrating blockchain and IoT also presents challenges; issues such as scalability, interoperability, and the computational requirements of blockchain consensus algorithms require further research and development to ensure widespread adoption. The paper suggests various approaches to opportunities and challenges.***
Keywords: Blockchain, Security, Communication, Internet of Things (IoT), Cryptography.

I. INTRODUCTION

Blockchain technology has emerged as a transformativesolution with the potential to revolutionise various indus- tries, including the Internet of Things (IoT). By combining blockchain and IoT, a new paradigm emerges, offering en hanced security, transparency, and trust in IoT networks. This research paper aims to explore the integration of blockchain technology in IoT, its potential applications, benefits, and challenges, in order to shed light on its transformative impact. The Internet of Things (IoT) is a network of interconnected devices that communicate and share data seamlessly. However,the widespread adoption of IoT faces several challenges, particularly regarding security, privacy, and trust.

Traditional centralised systems lack the necessary resilience to ensure data integrity and protect against unauthorised access and cyber threats. Blockchain technology, originally introduced as the underlying infrastructure for cryptocurrencies like Bitcoin, has gained attention as a potential solution for these challenges. Blockchain serves as a decentralised and immutable ledgerthat records all transactions and interactions among connected devices. By incorporating blockchain into IoT, a trustless and transparent environment can be created, empowering IoT networks with enhanced security and privacy features. The objectives of BC and IoT integration can be summarised as follows:

A. Security

The BC secures transactions between nodes. It's a completely new approach to secure communication. BC enables IoT devices to communicate securely with one another.

B. Framework for Decentralisation

This strategy is used in IoT and BC. It abolishes the centralised system in favour of a decentralised system. It improves the overall failure probability and performanceof the system.

C. Autonomous

All IoT nodes in BC are free to communicate with any other node in the network because there is no centralisedsystem in place.

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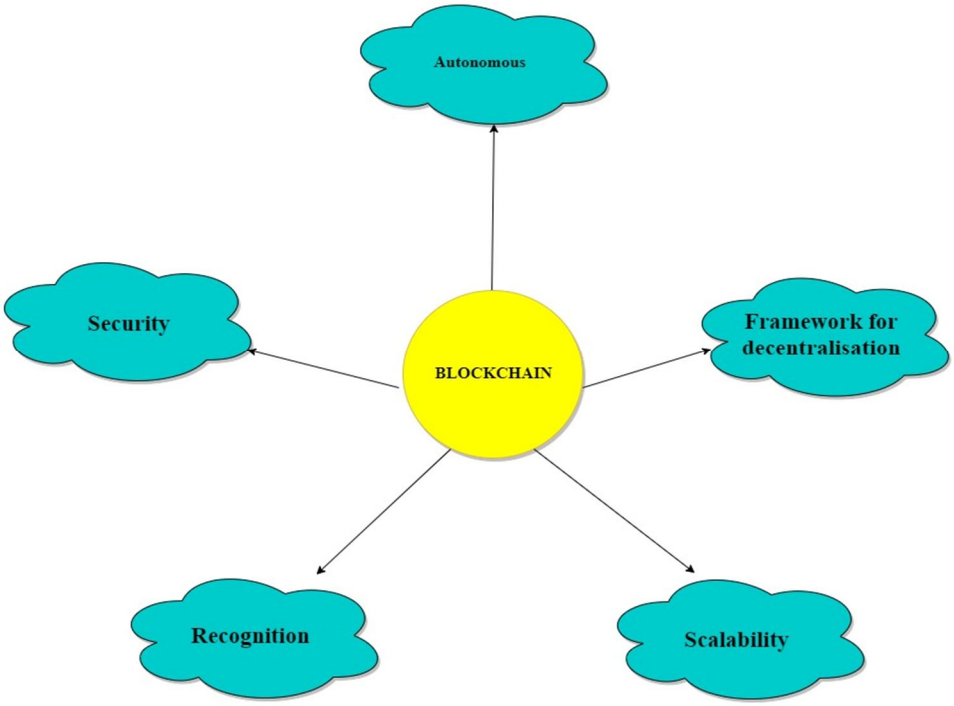


Fig1: Blockchain features.

D. Recognition

Every connected IoT device has a distinct ID that enables identification. Every block in BC has a unique identification. Consequently, BC is a dependable tech- nology that offers.

E. Scalability

In BC, IoT devices will communicate with one another through a highly available intelligent distributed networkwhich links to the target device in real-time.

The above section described above the introduction with integration of blockchain and IoT , while the rest of the paper is summarized as follows: section 2 represents the literature survey, section 3 represents the blockchain's role in IoT, section 4 introduces the role of BC in IoT, section 5 represents the opportunities of the integrated approach, section 6 represents the challenges and section 7 represents the conclusion.

II. LITERATURE SURVEY

In this [1], the authors provide a broad overview of the way blockchain technology might enhance the security and privacyof IoT systems. and highlight the importance of decentralised consensus, control over access, and data trustworthiness in maintaining secure and private IoT networks. In addition to strengthening data integrity and reducing weaknesses in smart grid IoT systems, the authors in [2] recommend using blockchain technology to enhance safety and confidentiality. In [3] discusses on how blockchain can be used to demonstratingthe potential to address security and privacy issues in the setting of a smart home environment. For industrial IoT sys-tems, the authors suggest [4] a secure data-sharing framework that combines blockchain and attribute-based encryption. Theyemphasise how successful this strategy is. In IoT environments,they discuss in [5] how blockchain can provide transparentand immutable data storage, enabling reliable auditing and fostering trust among various stakeholders.

III. THE BLOCKCHAIN'S ROLE IN IOT

The Internet of Things (IoT) makes it possible for physicallyconnected objects to send and receive information via a diversenetwork. The subsequent categories could potentially be used to categorise the IoT.

1) *Physical Things: Each* linked device in the chain hasan individual identification number due to the Internet of Things. The physical objects can communicate via other IoT nodes and share information.

2) *Gateways:* These are the components that join the cloud and physical world in order to guarantee internet connectivity and privacy.
3) *Networking:* This helps to determine the quickest path between nodes in the Internet of Things and manage the flow of information.
4) *Cloud:* Information is stored and computed in the cloud. The block chain (BC) is a series of authenticated, encrypted blocks of transactions maintained by a net-worked device. The openly available and shared digital record contains the block information. In a network of IoT devices, the BC offers encrypted interaction. Thefeatures of the blockchain vary depending on whetherit is private, public, or a consortium.

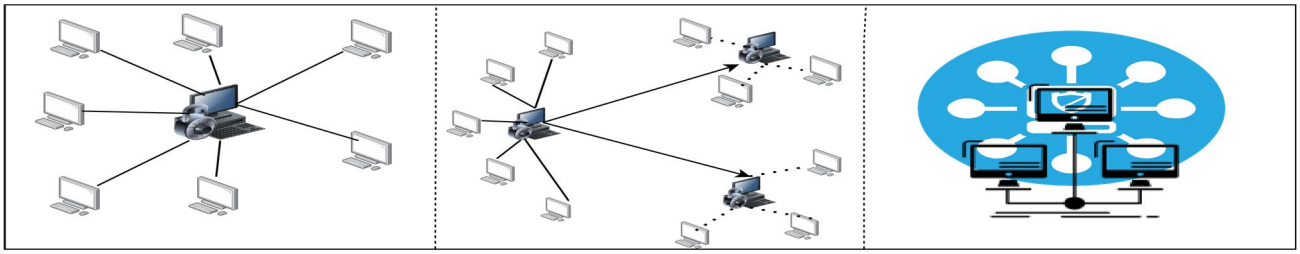


Fig 2: Types Of Blockchain

Blockchain databases feature decentralised trust models, high levels of security as well as accessibility to everyone, confidentiality ranging from low to high, and transferable identities as well, whereas centralised databases feature centralised trust models, low levels of protection and open access, high levels of confidentiality, and non-transferable identities. The blockchain is more sophisticated than centralised storage based on the aforementioned characteristics. Blockchain technology is utilised to create applications for the Internet of Things on the IOTA, IOTIFY, iExec, Xage, and SONM platforms.

IV. BENEFITS

1) *Confidence Among Parties:* Due to its safety characteristics, the BC-IoT solution will increase confidence across the many linked pieces of equipment. Only validated equipment can interact on the internet, and each transaction block must be validated by miners before it can be entered into the BC.
2) *Reduce Money:* Since this method interacts directly without the involvement of another party, it saves money. It removes all nodes that connect between the person who sends the message and the recipient of the message. It allows for straightforward interaction.
3) *Minimise Time:* This strategy saves an enormous amount of time. It decreases transaction times from daysto seconds.
4) Safety and confidentiality: It secures and protects the equipment and data.
5) *Social Services:* This strategy unites devices that are connected with social and welfare services. Every devicethat is connected is able to communicate and share data with one another.
6) *Financial Services:* This method transfers assets in a safe manner, avoiding the involvement of another party. It offers a quick, safe, and confidential financial solution. It lowered both the expense and the duration of thetransaction.
7) *Management Of Risks:* This technique is critical in analysing and reducing the possibility of failed resourcesand transactions.

V. CHALLENGES

Numerous difficulties with Scalability, storage spaces. abilities, finding, and other factors may be encountered by the Internet of Things and BC. The integrating approach has to overcome the subsequent issues.

1) *Ability To Scale:* Scalability has emerged as one of the main difficulties facing BC-IoT. The blockchain system must manage an enormous amount of transactions as the quantity of connected devices rises while ensuring consensus among a sizable number of peers. [6] It is extremely difficult to scale the blockchain to handle the increasing volume of nodes and transactions while maintaining its efficient operation.
2) *Amount of Transactions:* The Internet of Things (IoT) creates a massive amount of information and transactions from a huge variety of portable devices. Blockchain networks have capacity and transaction speed constraints, particularly those that use proof-of-work as a consensus technique. The blockchain network may get crowded as the number of Internetof Things (IoT) gadgets expands, leading to latencies andrising transaction expenses.

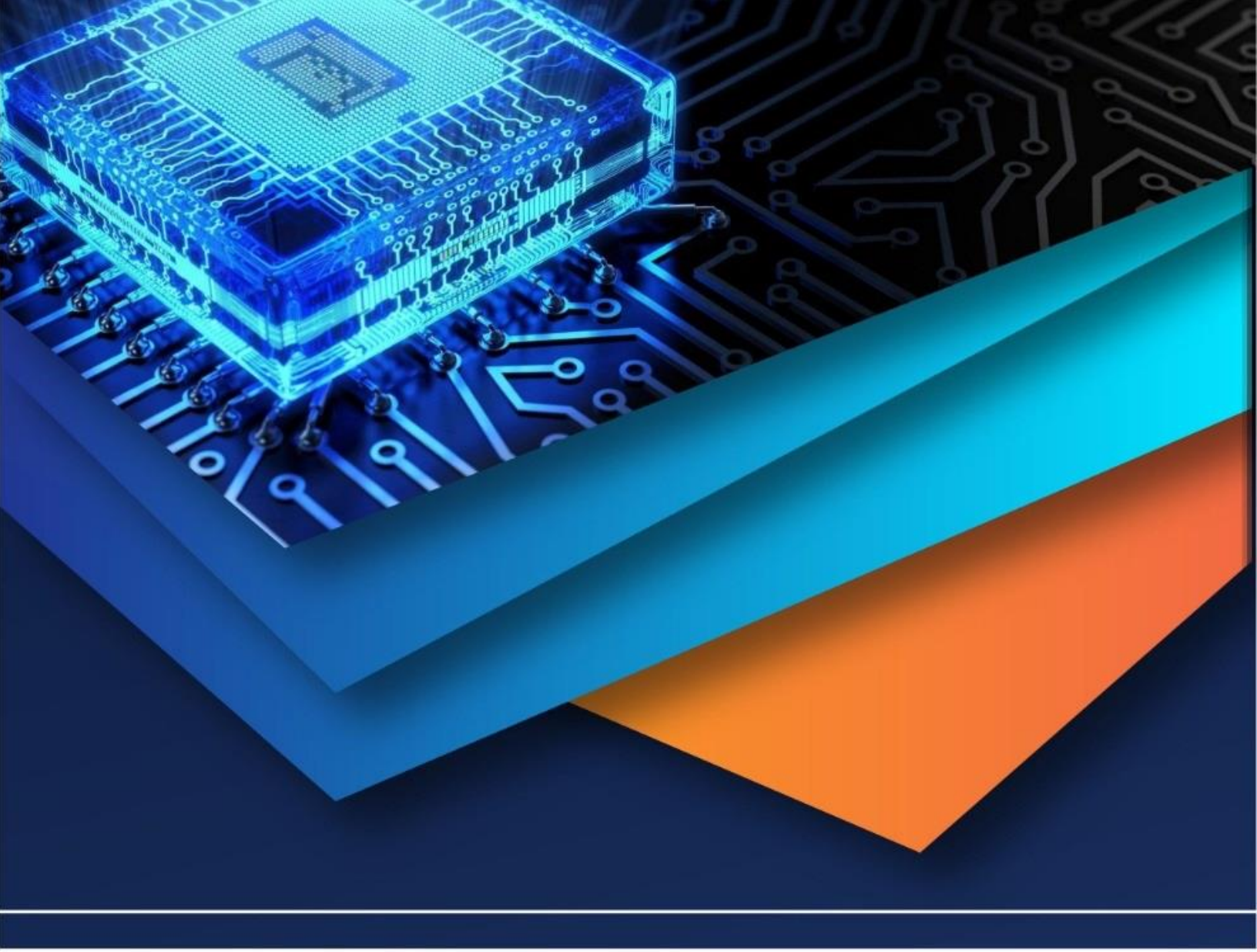
3) *The Bandwidth of a Network:* Internet of Things (IoT) equipment often uses low-power connections with a small amount of bandwidth for operations. Each interaction on the blockchain network requires sending an enormous amount of information, which may consume the capacity of the network and increase latencies. It's a major challenge to effectively use bandwidth on networks while preserving privacy and consistency.
4) *Specific requirements for Storage:* Due to the decentralised design of blockchain, each network user must keep an electronic copy of the complete blockchain [7].Internet of Things devices produce a lot of information, so it might not be possible to save all transactions on each device. A scaling difficulty is presented by coordinating the blockchain's storage needs with the constrained storage capabilities of internet of things devices.
5) *Trust and privacy:* In BC-IoT, security is of the utmost importance since it may result in major effects if Internet of Things (IoT) devices or blockchain networks are hacked [8]. Key challenges involve safeguarding IoT devices from assaults, safeguarding the security and privacy of information recorded on the blockchain, and protecting the privacy of users. It is crucial to provide adequate safety structures, encryption methods, and access control systems to protect both the blockchain technology and the Internet of Things (IoT) devices.

VI. CONCLUSION

The present paper examines a ground-breaking approach called the "BC" and "Internet of Things." There are numerous opportunities and difficulties mentioned. In the following section, the kinds of services that are offered are also outlined. Since it can replace the existing web infrastructure with an entirely novel system in which every smart device is linked to other gadgets using a network of peers in current circumstances, this strategy may represent the Internet's futuristic potential. It can speed up the process, save money, and instantly provide the appropriate data to the appropriate technology. Thus, it may be of significant assistance in the decades to come.

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