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Blockchain Based Secure Edge Computing

Balasurendran M,

Ph.D Research Scholar,

Department of Computer Applications

Madurai Kamaraj University,

Madurai

Tamilnadu, India

ırscholar@gmail.com 8838530415

Dr. M. Ramakrishnan

Professor & Head

Department of Computer Applications

Madurai Kamaraj University,

Madurai

Tamilnadu, India

ramkrishod@mkuniversity.ac.in

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Abstract

This study examines the intersection of edge computing and blockchain, two revolutionary innovations that offer improved speed, efficiency, and privacy in handling data and management. Blockchain, a decentralized record-keeping system, links transaction blocks cryptographically to

guarantee openness and data integrity, whilst edge computing decentralized the processing of data by putting computing power within reach of data sources, lowering latency, and improving real-time capabilities. Combining the two technologies takes advantage of both their mutual dependence on decentralized networks. Although edge computing uses GPUs and local processors to speed up

blockchain activities, blockchain improves edge computing by protecting data integrity and facilitating reliable transactions. Additionally, the article presents the DEAN protocol, a collaborative system that exhibits up to 25x higher capacity and
18 x resistances to manipulation of data in edge situations. Technologies like Hedera's Hashgraph consensus, which offers high throughput, cost-effectiveness, and strong privacy, solve issues like interconnection, data privacy, and sustainability. Working together, providers such as Hut 8, Solana, and Lumen show how blockchain-edge integration can be used practically to create decentralized, that is outstanding performance computing platforms that serve Web 3.0, AI, and IoT applications that are the future.

Keywords: Blockchain, Edge Computing, DEAN Protocol, Consensus Algorithms, Decentralized Transactions, High-Throughput Computing

Introduction

Edge computing has impacted every level and facet of our life, enhancing the way we live and work as a result of the growth and widespread use of cloud services and smart devices. The privacy and security features of edge computing, when coupled with blockchain technology, focus our interest to novel areas for further investigation. Medical institutions, smart grids, smart home systems, automobiles, highway unit networks, and other smart devices are all connected to servers in both residential and commercial settings absent the need for human involvement. The enormous volumes of information produced by such devices and, in some situations, the need for quick responses are beyond the efficiency of cloud computing. Thus, low-latency, heterogeneous edge computing is the emerging trend for remote data services.

The efficiency may increase and access latency could fall when service providers are deployed

near end devices. An edge computing network can also help you eliminate the possible security and privacy hazards associated with a centralized system. The potential threat of data leakage could be reduced, for instance, by handling information locally rather than centrally. Nevertheless, Edge computing has flaws in terms of security and privacy, and its architecture is not flawless. Many devices and servers on networks are difficult to handle due to its scattered and varied structure. These types of servers are additionally difficult to manage demanding system workloads due to insufficient hardware resources. Incorporating blockchain technology into edge computing is important. Distributed software installed on each server is called a smart contract in a blockchain environment [8], which uses a distributed database architecture supported by consensus protocols. Considering the assumption that the computational service will be more efficient and available, a design like this can improve the security and confidentiality of the system.While edge computing, when integrated with blockchain technology, has a promising future vision, there are many problems that need to be resolved. Edge devices' inadequate computing and storage capabilities make it difficult to guarantee the reliability and confidentiality of blockchain data. Furthermore, because edge computing has a diverse organizational framework, possible security problems could occur, like local network authentication and the need for encryption for local user data. We should have a thorough conversation and investigate these issues.

1. Bridging Edge Computing and Blockchain

We examine each of these technologies in more detail before looking at the potential for symbiotic partnerships.

1.1. What is blockchain?

The core element of blockchain technology is a distributed database that securely and immutably records transactions over computer networks. Every transaction is compiled into an initial "block," and each one is thereafter cryptographically connected to the data contained in the block that comes before it. As a result, a collection of blocks is created, therefore the term "blockchain." The entire chain is dispersed over several computers (nodes) on the network, guaranteeing confidentiality and openness while guarding against data manipulation.

1.1.1. How Blockchain Technology Works

Blockchain technology, the backbone of cryptocurrencies like Bitcoin, is a distributed ledger system that enables secure and transparent transactions. At its core, a blockchain is a chain of blocks, each containing a list of transactions. These blocks are linked together using cryptographic hashes, creating an immutable record of all transactions [9]. Unlike traditional databases stored on centralized servers, a blockchain is decentralized, meaning that no single entity has control over the entire network as shown in figure1.

Instead, multiple participants, known as nodes, validate and store copies of the blockchain, ensuring its integrity.Consensus methods like Proof of Work (PoW) and Proof of Stake (PoS) are essential to blockchain security. PoW pits miners against one another for completing challenging mathematical puzzles; the first person to do so adds new blocks to the chain. Since this procedure uses a lot of processing power, it is hard for a bad actor to change previous transactions. PoS lower the energy usage of PoW by choosing validators according to the quantity of tokens they possess. Together with encryption

methods, these consensus algorithms give blockchain a high degree of resistance to fraud and manipulation.

1.2. What is edge computing?

Edge computing introduces data computation as near to data collecting as feasible. Centralised data centers which may utilize enormous computer processing power and access and save vast volumes of data are essential to cloud computing. Although it is an effective tool, issues with internet access, confidentiality, independence, and computation speed arise because of its centralized design. By allocating computation power to periphery networks, edge computing lessens the strain on core cloud servers [7]. Real-time or near-real-time computation of information is made possible by this close accessibility, which also increase performance.

In the age of artificial intelligence (AI) applications and the Internet of Things (IoT), when real-time data processing is essential, this is especially important. For instance, medical monitoring devices are excellent choices for edge computing due of their rapid expansion, which enables

concerns to be identified and remedies to be initiated more rapidly. Devices may handle data remotely via edge computing, which allows for quicker reaction times as well as improved utilization of network resources. Edge computing has the potential to influence the development of online services and stimulate invention as the need for AI applications increases.

1.3. How do edge computing and blockchain interact?

The primary advantage of integrating blockchain technology with edge computing is the potential to handle data and communicate securely without depending on centrally managed servers or outside services. However, exactly do these innovations interact? Because both blockchain and edge computing rely on decentralized platforms and distributed networking, they are related. Data integrity and safe, decentralized transactions are offered by blockchain. Edge computing moves processing power far from centralized servers and closer to data sources. Edge computing is a cutting-edge computing technique that, by dividing the data processing burden within adjacent edge devices (also known as edge nodes) and executing fewer processes on the cloud, might improve the effectiveness of machine learning along with various computational techniques. For numerous purposes, this kind of technology has shown great promise, especially in helping companies optimize their entire information technology performance and efficiency in operations.

Implementing a blockchain protocol might prevent hackers from taking control of edge nodes and gaining exposure or altering private data.In order prevent hacking of data and enable equitable sharing of information with speedy recovery in the face of inadequate storage, processing, and network capacity, this

research suggests a cooperative protocol, called DEAN, across edge nodes [5]. This group of researchers developed a cooperative protocol that is built on a parallel method with three distinct fundamental components: nodes, blocks, and transactions. The network's nodes are separated into two groups: sensors and edge nodes. The sensors are limited to submitting requests to the edge nodes for validation; the edge nodes distribute, validate (i.e., mine), and preserve blocks in the blockchain.

Every node is capable of authenticating itself using its private and public keys. A node's distinct hash ID aids in its identification by others. A node's public key can be used by any other node in

the network to confirm its identity (i.e., hash). Each time a node produces a block in the DEAN protocol, it receives a reward known as a "coin." Similar in various traditional conventional blockchains, blocks contain a variety of necessary components as well as extras [10]. The last essential element of DEAN's underlying mechanism consists of transactions that sensors post to the blockchain. Another essential component of this partnership is the use of powerful graphical processing units (GPUs) often found in edge computing devices as illustrated in Figure 2. These GPUs can speed up the execution of blockchain transactions and improve the efficiency and timeliness of data validation and verification.

By harnessing the computational power of GPUs to handle transactions quickly and efficiently, edge computing devices can significantly accelerate blockchain operations. Furthermore, integrating IoT devices into the Edge layer will enhance collaboration between edge computing and blockchain. With IoT devices, these requirements can be moved to the edge layer, where they may not be able to perform blockchain operations effectively. By distributing processing workloads across the network, this decentralized approach improves efficiency and scalability [8]. Blockchain's distributed database technology provides a transferable and transparent platform for processing and storing data, while edge computing increases performance and reduces latency.

In essence, the two together provide businesses with the ability to optimize the processing of data and come up with a complete solution. In its initial tests, the prototyping system outperformed all other systems and showed an impressive tolerance for random failures. Results show that DEAN-based blockchain implementation performs better than other sophisticated blockchain systems with 25 times more efficiency and 1,000 times fewer holdubs across 18 nodes. The novel protocol described in a previous study can provide exceptional data reliability and efficiency in edge computing. In the future, the emulator could be refined and used in real-world scenarios, improving the security and reliability of edge computing techniques [1].

1.4. Combining edge computing and blockchain presents challenges.

Blockchain and edge computing have a lot of possibilities together, but there are also drawbacks:

- **Interoperability:** One of the biggest challenges is working with various blockchain specifications and protocols with edge computing infrastructure. As blockchain

technology develops further, unique protocols and standards with unique demands and specifications will appear daily. Incompatibilities can arise when combining multiple of these protocols using edge computing design, making it more difficult for devices and networks to communicate seamlessly. To enable smooth integration and interoperability between various blockchain platforms and edge computing environments, companies need to spend on interoperable technologies and standards

- **Data security and privacy:** Due to the unique features of edge computing and blockchain, these issues may present difficulties when combining the two technologies. Edge computing is the management of information nearer than its source, which includes personal information collected, manipulated, and transmitted by Internet of Things devices. All transactions are documented in an irrevocable ledger when blockchain is activated in this system, which may expose personal information to manipulation or unlawful access. Also, since data is always available as soon as it appears on the blockchain, the inviolability of blockchain transactions may cause problems for data privacy. Strong encryption, anonymity, and access control procedures may be required to protect the confidentiality of the data on the blockchain and protect sensitive data.
- **Scalability:** Inherent constraints on the rate and computational speed of transactions of blockchain networks are the root cause of scalability problems. Blockchain networks find it difficult to effectively manage a large number of transactions, especially public. Long confirmation times, high transaction costs, and network congestion can result in this. When Edge is paired with computing, especially when it often involves the large number of IoT devices that generate data and transactions, scalability issues become clearer. The network's capacity may be exceeded by the large number of transactions that edge devices generate and require processing on the blockchain [4]. It takes creative ways for maximizing resource allocation, boost transaction throughput, while enhancing network scalability in order to handle this surge of transactions whilst preserving responsiveness and speed.

1.5. Blockchain and Edge Computing's potential

These issues can be resolved by Hedera, only one publicly accessible ledger which utilizes Hashgraph Consensus, a more secure and faster substitute for blockchain consensus techniques.

- Being able to communicate with one another. Hedera's native tokenization and consensus service APIs, in addition to its Ethereum Virtual Machine (EVM) smart contracts, allow users to build ecosystems and applications that seamlessly interface via other systems.
- Security and privacy of data. To offer the maximum level of security, Hedera employs the asynchronous Byzantine Fault Tolerance (aBFT) Hashgraph Consensus algorithm.
- The ability to scale. Hedera transactions typically cost $0.001, but Hashgraph now reaches high-throughput with over 10,000 transactions per second. The enormous volume of data involved in edge computing can be managed using Hedera. Its stable codebase offers dependable and highly scalable network architecture.
- Businesses may achieve unprecedented degrees of privacy, scalability, and efficacy by utilizing the beneficial relationship between edge computing and blockchain. Businesses and sectors that use edge computing and blockchain can spur innovation and beat the competition as these innovations advance.

2. Collaborations between edge computing and blockchain

Additionally, providers are entering the blockchain-edge computing space. A few instances of these service providers are Lumen, Solana, and Hut 8.

- **Hut 8:** A pioneer in digital assets, Hut 8 is hopeful about blockchain and Bitcoin. It was among the initial companies to be eligible for an offering on an important stock market and is among the

  leading miners of digital assets in North America. Web 3.0, which is still under development, is going to be used by Hut 8, and it will be an essential component of this system. Web 3.0 is a perfect fit for Edge since it primarily depends on decentralization, whereas blockchain focuses significantly on distributed computing. In order to enhance traffic filtering and speed up critical data for apps, Web 3.0 will heavily rely on edge computing concepts and a decentralized architecture.

- **Solana and Lumen:** According to Lumen's vice president of sales, Lumen Edge Computing Solutions offers the improved network safety, efficiency, and control those new technologies like blockchain demand. He asserts that blockchain technology and edge computing are compatible partner technologies. Lumen and Solana have been collaborating to introduce their Edge Bare Metal technology to Solana's blockchain developers. Solana was capable of to prevent hardware expenses as a result, which might have caused delays in developing of applications and their release to the market. Additionally, this approach allows for "pay-as-you-go" resource use by turning on and off bare metal servers as required.

Another benefit of this partnership is the fact that it closes supply chain gaps, and this hinder decentralized networks' ability to grow by gaining access to resources, which was how the Solana network was extended and decentralized [3]. The overall latency of the Lumen environment is just 5 milliseconds or less, resulting in exceptional performance. The latter in consequence results in an increase in the rapidity and efficacy of decentralized migrations across the network.

3. Conclusion

A revolutionary advancement in safe, effective, and accessible data handling and administration is represented by the combination of edge computing and blockchain technology. Organizations may bypass the conventional constraints of centralization and latency by utilizing the decentralized and unchangeable nature of blockchain technology in conjunction with the real-time, localized possibilities of edge computing. Novel protocols such DEAN and sophisticated consensus techniques like Hedera's Hashgraph, which provide previously unheard-of speeds, safety, and seamless integration, further improve the integration. Excellent performance computing environments which enable IoT, AI, and Web 3.0 applications are made possible by partnerships amongst industry giants such as Hut 8, Solana, and Lumen, which demonstrate the real-world use of these technologies. Even while issues like interoperability, adaptability, and data privacy still exist, strong answers are offered by ongoing technological breakthroughs and teamwork. This collaboration has tremendous promise, enabling sectors to open up new avenues, spur inventiveness, and create robust systems that can be not only effective but also safe and

future-proof. As edge computing and blockchain develop, their combination will serve as a fundamental component of next-generation digital infrastructure, influencing the direction of ecosystems driven by technology.

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