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Blockchain-Enabled Wireless Communication: Revolutionizing Data Integrity and Privacy in Network Systems

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Abstract

The integration of blockchain technology into wireless communication systems represents a transformative advancement in ensuring data integrity and privacy. Traditional wireless networks often face significant challenges related to security vulnerabilities, data breaches, and centralized control, which can compromise the confidentiality and reliability of transmitted information. Blockchain-enabled wireless communication offers a decentralized and tamper-proof solution by leveraging blockchain's inherent properties of transparency, immutability, and distributed consensus. This approach enhances data integrity by ensuring that all communication records are securely encrypted and recorded in an immutable ledger, making unauthorized alterations virtually impossible. Furthermore, the decentralized nature of blockchain reduces the risk of single points of failure and mitigates potential attacks on network infrastructure. By employing smart contracts, blockchain can automate and enforce security protocols, streamline network management, and enable more robust authentication mechanisms. Privacy is significantly improved as blockchain enables more granular control over data access and sharing. Users can retain ownership of their personal data and selectively disclose information based on predefined criteria, minimizing exposure to potential breaches. Additionally, blockchain's decentralized verification process ensures that sensitive data is not stored in a central repository, thus reducing the risk of large-scale data leaks. Despite these benefits, the integration of blockchain into wireless communication systems presents challenges such as scalability issues, increased computational overhead, and the need for standardized protocols. This abstract explores how blockchain technology can revolutionize wireless communication by addressing these issues and enhancing both data integrity and privacy. It also discusses the current state of research, practical implementations, and future directions for integrating blockchain with wireless communication networks.

Keywords: Blockchain Technology, Wireless Communication, Data Integrity, Privacy Enhancement, Decentralized Networks

Introduction

The number and time of interactive devices connected over the wireless network have enhanced in modern times. This has created stress on the existing wireless network, and thus the demand was felt for adopting new and innovative technology in wireless communication.The traditional wireless network presents various issues communication. One of the major issues is network privacy, wherein the information being communicated does not achieve the best level of network privacy in traditional wireless communication [1]. Other issues include network complexity, vulnerabilities, and decentralization. Apart from that, it is also very important and the need of the hour to assure security and protection against the new emerging threats and attack vectors. Wireless communication technologies have also become incredibly common in our everyday lives. They may be used to facilitate information management, wireless communication, and computing in various public settings, including hospitals, universities, and airports, among other locations. Wireless communication allows mobile devices such as smartphones to access calendars, mail, contacts, and the internet more

conveniently than ever before. Due to the fast expansion of the Internet of Things (IoT), many IoT devices may be linked to one another over a wireless network, becoming more common [2].

Blockchain technology can be applied in wireless communication to secure the network in closed transactions. In recent time blockchain technology has become the most research area because of the potential benefits that the technology can provide to various sectors and industries. Blockchain technology offers the benefits of improved security, transparency, transaction speed, and enhanced efficiency. Every block in the blockchain directly depends on the data that is stored in the consecutive blocks. Together the blocks result in meaningful data, and thus it becomes challenging to alter the data stored in blockchain. Thus, blockchain helps in providing security in the transactions, and the communication of the information is carried out in a more protected and secured fashion [1]. The information communicated on social networking networks, bank networks, and other networks needs to be protected with regard to the maintenance of confidentiality, integrity, and privacy of the information. But the traditional wireless communication in fails to provide the desired level of security in modern times. The nature and type of threats in recent times have advanced, which has become beyond the scope of the traditional wireless networks to protect. Blockchain-enabled wireless communication can be used to address the issues and challenges that are faced by traditional wireless communication. The major advantage of blockchain-enabled wireless communication is decentralization. It helps in ensuring secure and robust operation across the given network involved in wireless communication. The future of wireless networks and wireless communication is getting inclined towards blockchain technology because of the benefits that blockchain provides to wireless communication. The first and the most basic benefit that blockchain will provide to wireless communication is the improvement of network security. This will help in ensuring that the information being transferred across the wireless network is secured and protected from hackers and alterations [3].

Another advantage of blockchain-enabled wireless communication is improvement in the effective utilization of the resources as well as the facility of efficiently monitoring the network. The integration of blockchain with cognitive wireless communication helps in taking advantage of the available network infrastructure of wireless communication. This understanding of blockchain was gained by the various research that was conducted in the area of blockchain. The efficiency of monitoring the network of wireless communication is one strategy to keep an eye on the possible source of threat in wireless communication. The paper highlights the various points related to the history of blockchain technology and the use of the same in wireless communication [1]. Further, the advancements and failures of blockchain-enabled wireless communication are also mentioned.

History

In 1991, research scientists Stuart Haber and W. Scott Stornetta introduced bitcoin technology to the world. A time-stamping digital solution was to be developed by the scientists so that they do not miss the document dates. This led to the system of cryptography with the help of which secured block of chains can be developed. Further, in 1992, such secured block of chains was used in the form of Merkel Trees that is used to store a series of data and records. Further, in 2004, scientists Hal Finney introduced a system of Reusable Proof of Work (RPoW) in the form of digital cash. Later in 2008, Satoshi Nakamoto conceptualized the secured block of chains in the theory of distributed blockchains that we today know as blockchain technology in the world of cryptocurrency.

Bitcoin was the first decentralized virtual currency that was introduced in 2009 by Nakamoto. It was based on cryptographic proof. In the bitcoin transaction, the data involved in the transaction is broadcasted anonymously to the participants present in the network, wherein the responsibility of the participants is to validate the transactions. The validation is done through solving cryptographic puzzles termed mining [3]. The participant in the network that comes up with the solution of the cryptographic puzzles gets awarded with a few bitcoins. In 2009, 50 bitcoins were awarded to the participants for solving the cryptographic puzzle. Bitcoin is the most popular cryptocurrency that derives a multimillion-dollar market involving anonymous transactions on a global scale without the involvement of any third party in the transaction. As per Accenture's execution of the dispersion of developments hypothesis, Blockchain had a 13.5 percent acknowledgment rate in monetary administrations in 2016, which has entered the early adopter's stage [4].

In recent few years, blockchain has largely impacted the financial sector and has made a place for itself in various other industries. Blockchain holds the potential to establish faith with regard to transactions among peer entities. This is possible because of the decentralized platform that blockchain technology provides, wherein the traditional issues of security and vulnerability are overcome. The centralized ledger host that was found in the traditional transaction faced the major issues of security, privacy, and access.

Blockchain technology also holds the potential to be used in designing self-managed scalable decentralized networks.

Decentralized Control Mechanism

The potential benefits provided by blockchain technology in the transaction of bitcoin and in the financial sector resulted in deep research for the integration of blockchain in network access and wireless communication. The first major benefit that blockchain-enabled wireless communication has is a fully decentralized control mechanism [1]. It means that the control and decision-making power is transferred from a centralized entity like an individual or organization to a distributed network. In the decentralized network in wireless communication, the participants don't require to place

a huge trust in each other since each member gets the opportunity to copy the same data in distributed ledger form. In case the ledger gets corrupted by any means, then it gets rejected by most of the members present in the wireless communication network. Thus, the control is distributed amongst all the participants of the network.
Another benefit that blockchain provides to wireless communication is the opportunity provided to independent operators to integrate their individually developed systems in order to provide the authorization settings required across the network [1]. This facility not just gives independence to the individual operators but also improves the overall security and authentication system of the entire network. The data from the sender's end reaches the receiver's end in an exact manner without any alteration, and then it is said that the confidentiality of the data in the transaction was maintained.

5G Network

Different type of algorithms have been developed in the past to prevent the disclosure of private information and avoid the destruction of wireless lines. Examples of such algorithms and techniques include AES encryption and beamforming in 5G networks. But they have failed to be much effective in the various application which people use in different sectors and industries. Vulnerability scanning revealed various types of weakness that were present in the different layers of the wireless networks. All such weakness adds up to the issue of security and privacy of communication in the wireless network. The integration of blockchain technology in the wireless network is thus said to be important since it overcomes the mentioned issues of the previous techniques.

Sixth Generation Network

The recent few years past witnessed an increase in the number of wireless devices, including smartphones. This resulted in a tremendous increase in wireless traffic which became very difficult to manage and secure. The saturation of the fourth-generation communication system resulted in the demand for the fifth-generation wireless networks with enhanced capabilities and potentials. The deployment of 5G networks and research on 6G has resulted in the interest in blockchain-enabled wireless networks and communication. In 2018 the Federal Communications Commission of the United States presented the vision of using blockchain technology in the sixth-generation network of wireless communication [2].

Recent Contributions

Back in 2015, Alibaba launched the Ant Chain project in China with the aim of providing blockchain services for the purpose of data storage, communication, and computation.

Followed by that, in 2016 the Tencent released the first white paper on blockchain that highlighted the use of blockchain as a service platform Tencent Blockchain as-a-service (TBaaS). TBaaS is the white paper released to provide the one-stop blockchain solution for users. The next significant step was seen in 2018 when AT&T launched the edge-to-edge blockchain solution with the aim of helping corporations digitally track their business process through the entire supply chain [2]. In the same year, the China Academy of Information Communication Technology and trusted blockchain initiatives proposed the integration of blockchain technology in the future telecommunication industry. Blockchain holds the potential to change the entire scenario of wireless communication in the coming years. Various research has been conducted in the area wherein one very interesting concept is of blockchain radio access network (B-RAN). This concept refers to wireless communications having the functionalities of blockchain, which can be applied in network access as well as resource management.

Advancements

The various potential benefits that blockchain technology provides have resulted in the advancement of the technology in various industries, including finance and communication. Increase in the interest of researchers in this area that has accounted for new findings of blockchain technology and its use in various fields.

Blockchain Radio Access Network

One such advancement is the Blockchain radio access network (B-RAN). The introduction of blockchain in the network can result in economic incentives as well as help in avoiding overhead cost that is usually associated with centralized schemes. The participants in the B-RAN network can function as access users as well as access providers and also indulge in organizing a powerful network [1]. This can also result in the removal of intermediate third parties and security risks.

Integration of blockchain in the network can help in roaming data exchange across various parties and networks involved in wireless communication. The identification of the visiting subscribers can also be made effectively and at a faster pace. The virtual public network of B-RAN provides the required level of security and self-organization that presents leads to an open market. Further, the cooperation, as well as competition amongst the participants of the network, can result in lowering the cost of the data access services without having the need for any additional radio infrastructure deployment [1].

Blockchain for CWCN

Bitcoin transaction between two communicating entities is broadcast to the participants who are there in the network. Those are the participants who validate the network and ensure that the cryptographic puzzle (PoW) is mined. When

used with the sensor devices, the validity of the Cognitive Wireless Communication Network (CWCN) blockchains is considered as not feasible. The blockchain implementation requires energy for CWCN so that it takes less computation time. This is a simple process that is energy-consuming. It is energy efficient in computation time that requires energy consumption only for the mining process, and is known as the computation time factor [3].

CWCN is internet-operated and requires wearable sensors for the same. It can be applied in the healthcare organization, in the process of intelligent farming, smart packing, and others. This is considered a robust method of blockchains and can be backed by the cloud to ensure security in a verified manner. User authentication in CWCN can be crucial, but permission blockchain makes it possible to strengthen the certified-based authentication along with the hash function substitution [3].

5G/6G Network Advancement

Another major advancement is in regard to the fifth and sixth-generation network. The 5G network is all set to improve the network and communication in modern times. The 5G network has three main features, the ability to support enhanced mobile broadband, massive machine-type communication, and ultra-reliable low latency communication services [4]. 5G can open a new arena for innovation in business and other sectors. The rapid expansion in the 5G network has also opened the doors to new issues like security issues, data immutability, and privacy concerns [4]. Various security tools and solutions have been effective in the era of 2G, 3G, and 4G networks. Such security solutions included the hybrid automatic repeat request techniques, automatic repeat request, and forward error correction channel codes. But these techniques don't possess the ability to provide the required security in the 5G network that demands new and advanced security technologies [4].

In the modern era of the 5G/6G network, the major security features that are required to be possessed by a security tool are transparency, immutability, and decentralization. With regard to all the existing and the most recent developments in the field of technology, blockchain technology appears to be the most promising to provide the security that the 5G network requires. Blockchain technology makes use of peer-to-peer network architecture wherein the network architecture is taken care of by the participants present in the network. The integration of blockchain technology with the 5G network will result in the emergence of new mobile services that will further enhance wireless communication across the globe. 5G network takes into account the heterogeneous devices and networks wherein the aim is to interconnect more than 500 million mobile devices by the end of the year 2030. In such a situation, the need for a transparent, secured, and decentralized security technique is very crucial, and thus the wireless communication turns towards blockchain technology for all these requirements.

Failures and Challenges

The integration of blockchain technology in wireless communication has attracted researchers, and various research work has been conducted in this area. Despite the mentioned advances and benefits that blockchain-enabled wireless communication provides, there are certain challenges and failures which needs to be addressed well before making the amalgamation of blockchain and wireless network like 5G network.

Issues Related to Scalability and Performance

The scalability and performance are the major issues in blockchain-enabled wireless network communication. The perspective of throughput, storage, and networking is taken into account to better understand the issue of scalability. In comparison to non-blockchain wireless communication and application, blockchain-enabled wireless communication has less throughput. An example of this issue is Bitcoin processing only 4 transactions per second, whereas visa can process 1667 transactions per second [4]. It tells the seriousness of the problem of scalability on the integration of blockchain technology in wireless networks. Apart from that, blockchain-enabled wireless networks also face the issue of storage burden because of the copy of data stored at the nodes, which adds to the storage burden. Blockchain is expensive and requires significant bandwidth, which presents the issue of networking.

Issues Related to Security and Privacy

The major reason behind the integration of blockchain technology in wireless network communication is to provide the required level of security that the traditional techniques fail to provide. But recent incidents and research work have revealed that the blockchain contains certain issues with regard to security and privacy [6]. The basic reason behind this issue is the lack of awareness about the technology. Since the mass does not possess the exact knowledge of the blockchain technology and the way it can be implemented in wireless network communication so proper security step is not taken with regard to the same.

The failure of blockchain technology to secure the information that is transacted in wireless communication is one of the major concerns behind the integration of blockchain in the wireless network. The privacy of the data is the major priority in the current time when a wide range of information is communicated over the wireless network. Some of the information is very sensitive and confidential, and thus it cannot be afforded to comprise with the privacy of such information. Because of the gravity of the issue, researchers continue to study the factors that contribute to the issue of security and privacy in blockchain-enabled wireless communication. The advanced and innovative security tools and strategies can, however, help in addressing the issue [4].

Conclusion

The wireless network has become all the more complex in recent times because of the increase in the devices being connected to the network. It has also resulted in diversity in the types of information that is communicated in the wireless network. In order to address the security and other issues that traditional wireless network has the blockchain technology can get integrated with wireless network communication. It is recommended that blockchain can be used as collective security to secure the applications in the systems. Further, the current work on the blockchain can be cost-effective and help in building mature blockchain solutions. Implementation of energy-efficient blockchain-related systems can consume 16% less energy in terms of computation at different difficulty levels [3]. It can be concluded that CWCN devices in CWCN applications cannot be run by blockchain technology. In the computation world, the level of difficulty is regularly increased, and it has to be taken care of in an efficient manner. CWCN seems to be a dazzling future in the world of energy-efficient computation with its scalable, secure, and cryptographic development. Though blockchain can be a good solution for its applications, it consumes energy. Blockchain can be used as a good possibility in reducing hardware and software vulnerabilities in the physical CWCN.

Blockchain can set up communitarian trust among independent organization substances and speed up, for instance, proficient asset sharing, confided in information interconnection, secure access control, individual protection, and following affirmation, and management functionalities for remote organizations, on account of its decentralization, straightforwardness, secrecy, changelessness, discernibility, and strength. Following a short prologue to the establishments of Blockchain, a careful assessment of the latest drives to join Blockchain into remote innovation according to a few viewpoints was finished. In the era of 5G and 6G, the need is to have a technology that will provide security, decentralization, and transparency to the network. Blockchain technology possesses the ability to provide all these features to the wireless network, and thus it is being looked at as the possible solution to all the concerns in the 5G and 6G networks. The integration of blockchain in the 5G network will open room for new advances and development in the field of wireless communication. Because of the potential of both blockchain and the 5G/6G network, this is the major topic of interest of researchers in modern times.

Blockchain-enabled wireless communications can be made more transparent and thus help in winning over the trust of all the participants involved in the process of the communication. It can be concluded that the integration of blockchain in wireless communication results in the decentralization that makes it easier to manage, access, and control the wireless communication by the participants of the network. However, this integration requires to be done only after carefully studying the blockchain technology in-depth so that the issues related to scalability, performance, and security can be efficiently addressed.

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