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Next-Generation Urban Intelligence: Integrating 6G Communication and Blockchain Technology for Smart City Advancements

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Abstract: ***The process of modern urbanization necessitates significant advancements in social, environmental, and economic aspects to enhance the overall quality of life in cities. This evolution has given rise to the concept of "Smart Cities." The incorporation of cutting-edge technologies such as blockchain, the Internet of Things (IoT), and other innovative communication systems has accelerated the progress towards the establishment of the sixth-generation communication intelligence, commonly known as 6G.Connected to the blockchain in smart cities is a crucial key, and researchers conducted an in-depth analysis of prior research to elucidate the pivotal contributions, ensuring a clear understanding of the state-of-the-art in sixth generation blockchain for smart cities. This study aims to pave the way for future research by examining key technologies, scenarios, challenges, and associated issues. Exploring the obstacles in deployment that require resolution before the implementation of block intelligence in 6G networks, this study aims to establish a foundational understanding for forthcoming advancements in blockchain technology within this generation. The paper outlines prospective research areas critical for the evolution of blockchain in the 6G era. Additionally, it addresses the challenges associated with integrating blockchain amidst the advancements in computing and mobile communication technologies, offering insights into the complexities that need to be navigated for a successful efficiency.***

Keywords— Urban Intelligence, 6G, Blockchain, Communication Technologies, Security

I. INTRODUCTION

In the span of every decade, mobile communication technology undergoes significant transformations. Over the past ten years, there has been a notable shift necessitating a revision of existing regulations to accommodate service-aware models that promote competitiveness. This adaptation is crucial for supporting operations of exceptionally high speed and ultra-low latency networks, laying the foundation for the emergence of a hyper-connected, artificially intelligent society. The evolving landscape prompts a revaluation of regulatory frameworks to align with the dynamic demands of advanced mobile communication technologies [1].

To meet the demands of the evolving technological landscape, existing regulations must undergo revisions to accommodate competitive service-aware models. This adaptation is essential for supporting extremely high-speed and ultra-low delay network operations. The potential use cases, empowered by faster speeds, enhanced

dependability, and seamless connectivity, collectively contribute to advancing the capabilities of the current network infrastructure [2].

However, the enhanced flexibility of 6G networks may introduce vulnerabilities related to resource management, spectrum efficiency, security, privacy, traceability, and interoperability. Blockchain, as a distributed ledger, is characterized by transparency, documentation, and decentralization, free from control by any single individual or group. The unfolding landscape of future changes will play a crucial role in determining the innovative applications that can be derived from 6G network technologies, with blockchain emerging as a particularly significant element in addressing pertinent issues in this domain [3].

The advent of new applications made possible by 6G technology necessitates the evolution of cities on social, environmental, and economic fronts to enhance the quality of life and work. This holistic transformation is essential for the successful integration and optimization of the innovative services and applications offered by 6G networks [4].

The primary objective is to maximize the utilization of available tools and technological intelligence to develop smart cities that significantly enhance the quality of life. The introduction of the "Smart City" concept underscores the overarching goal of optimizing existing technology to create intelligent urban environments [5].

The emerging technology known as blockchain addresses privacy and security issues effectively due to several characteristics, including transparency, decentralization, and immutability. It provides high-quality services by recording transactions and enabling thrustless interactions among participants on a distributed ledger.

In parallel, the 6G network system tackles latency and reliability issues within the smart city. With distinctive features designed to address concerns related to latency and dependability. The combination of blockchain and 6G technologies showcases a synergistic approach to fortifying security, reliability, and efficiency in the evolving landscape of smart city development [6].

A. Contribution of the Research:

The literature on security challenges in 6G-envisioned smart cities is substantial, with a limited number of publications addressing the integration of blockchain-based solutions and 6G in applications for smart cities. The primary objectives of this review paper are as follows:

•To offer high-level review aims to provide a comprehensive understanding of blockchain, its relationship with 6G trends, and its potential applications in shaping the future of intelligent and secure communication networks.

•To facilitate the comprehension of blockchain technology and the concept of a smart city among readers and scholars.

•The proposed solutions incorporate 6G communication technologies with the aim of mitigating network-related challenges such as latency, reliability, accessibility, bit rate, and capacity.

The order of the paper is as follows: Section 2 explains the related research work in this field. Section 3 describes a detailed explanation of the background of blockchain and 6g for intelligent cities. Section 4 presents the challenges and future developments in the research areas outlined. In section 5, the conclusion is given. Document is a template. An electronic copy can be downloaded from the conference website. For questions on paper guidelines, please contact the conference publications committee as indicated on the conference website. Information about final paper submission is available from the conference website.

II. BACKGROUND OF BLOCKCHAIN AND 6G FOR SMART CITIES

This section delves into the historical trajectory of blockchain, 6G, and smart cities, providing a comprehensive exploration of the evolution and development of these technologies over time. The subsequent content offers an in-depth explanation of each of these technological domains.

A. 6G Communication Network

According to the International Telecommunications Union's (ITU) IMT-2030 Standard released in May 2019, the objective of 6G is to offer a novel range of sensory data and experiences, together with a transformative user interface. 6G enables the development of many data-intensive, real-time applications, including haptic communication and the establishment of smart cities through the Internet of Things (IoT). 6G will explore innovative communication strategies, unconstrained by existing network principles or technology. The following are a few prospective attributes that may be observed in 6G technology include [7].

•**Faster Speeds**: It is anticipated that 6G will provide data transfer rates that surpass those of its predecessor, 5G. The precise velocity has not yet been determined, but it is anticipated to fall within the terabits per second (Tbps) spectrum.

•**Low Latency**: the duration it takes for a signal to travel between two devices, is a critical factor in communication. Anticipated to exhibit minimal latency, 6G technology is poised to enable near-instantaneous communication between devices and applications. This advancement promises swift and responsive interactions in the digital realm.

•**High Connectivity**: The potential for achieving a seamless integration between devices, networks, and satellites is anticipated with the advent of 6G technology. The provision of ubiquitous connectivity, including in remote areas, is expected.

Energy Efficiency: In contrast to preceding wireless technologies such as 5G, it is anticipated that 6G will exhibit reduced energy consumption. This will result in an extended lifespan of gadget batteries and a reduction in their energy consumption.

AI Integration: The integration of artificial intelligence (AI) technologies within the framework of 6G is anticipated to provide substantial assistance for the advancement of highly complex applications such as autonomous vehicles, smart urban environments, and healthcare systems.

Security: It is anticipated that 6G will incorporate advanced security measures to safeguard against potential cyber threats and attacks. Additionally, as depicted in Figure 1, this will encompass sophisticated encryption and authentication mechanisms.

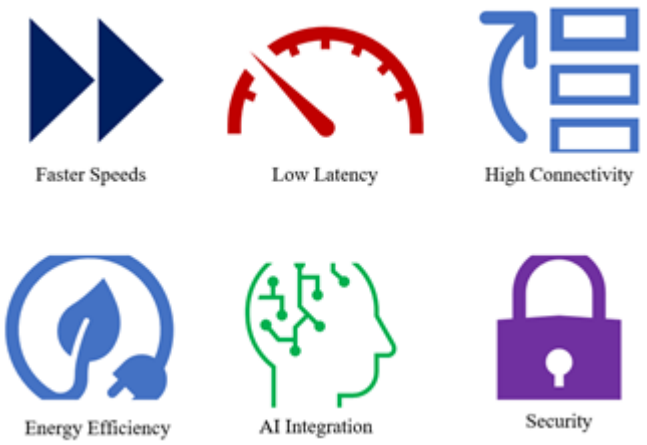

Fig1: Characteristics of the 6G Technology.

B. BLOCKCHAIN

The core principle underlying distributed ledger technology (DLT) involves the decentralization of data storage, thereby preventing any single party from altering or exerting control over the data. While the mechanics of blockchain may be intricate, the fundamental notion of DLT remains quite simple [9].

Blockchain technology has the potential to offer significant advantages in the advancement of smart cities driven by 6G technology. The anticipated transformative impact of technology on the domain of smart cities encompasses enhanced connectivity speed and reliability, alongside expanded compatibility with a greater array of devices and applications.

A block encompasses various data components such as the block header, activities, hash values, and more. The utilization of cryptographic primitives ensures data confidentiality, data immutability, and secure participant identification within the blockchain. Each user engaging with the blockchain is required to apply their digital signature, thereby contributing to the completion of a transaction with enhanced security measures [10].

SMART CITIES

Smart cities leverage digital and data infrastructures to enhance the lives of residents, promote environmental responsibility, and streamline municipal operations. The integration of 6G technology stands out as a transformative element, offering substantial improvements to the capabilities of smart cities in various dimensions.

Cutting-edge technologies are at the forefront of innovative city programs aimed at addressing urban challenges such as traffic congestion, pollution, and energy consumption. These initiatives strive to leverage innovation to create effective solutions and improve the overall quality of urban life.

Smart cities harness a range of technologies, including sensors, cameras, and other Internet of Things (IoT) devices, for data collection and analysis. The integration of these technologies allows for informed decision-making and the optimization of various aspects of urban living.

In general, the use of 6G technology within smart cities has the potential to greatly enhance the well-being of residents, promote sustainability, and optimize the delivery of urban services. Smart cities have the potential to

derive substantial advantages from the utilization of blockchain technology, a decentralized, secure, and transparent system designed for the storage and dissemination of data [11].

III. RELATED WORK

This section aims to navigate through the extensive landscape of existing related work in 6G, blockchain and smart cities.

In [12] Proposes a resilient, autonomous, secure, and transparent infrastructure powered by the synergy of 6G technology, blockchain, and artificial intelligence. Incorporating unmanned aerial vehicles (UAVs). The research reveals that this novel approach surpasses traditional methods in terms of predictive precision, operational efficiency during increased user demands, and optimal utilization of bandwidth.

The authors in [13] Recognizes the key challenges in amalgamating Blockchain and IoT methodologies to realize sophisticated solutions, with a focus on addressing their inherent limitations and constraints. The goal is to alleviate deficiencies by exploring the integration of blockchain technology with IoT in the context of 6G infrastructure, ultimately aiming to decrease computational costs associated with these technologies.

In [14] In the domain of Cooperative Spectrum Sensing (CSS) within 6G networks, the authors have proposed an innovative system that prioritizes blockchain technology to safeguard location privacy. Addressing a substantial concern in this context, where the sensor encounters various malicious attempts, the system focuses on enhancing privacy and security for 6G wireless networks, particularly when the secondary user (SU) is actively engaged.

In [15] Scientists propose a decentralized deep learning architecture underpinned by blockchain and 6G technology, ensuring the reliability of model training. The suggested architecture is evaluated against Cloud-based and P2P-based decentralized deep learning systems, with results indicating superior performance in terms of accuracy and latency.

The authors in [16] Uses distributed ledger technology's permission-type properties to ensure accountability and transparency while sharing infrastructure among providers. Testing on a low-resource device shows that BEAT adds only a few seconds to processing.

In [17] The authors introduce an innovative 6G Multi-Layered Blockchain Assisted Network of Drones ecosystem that elevates the network through robust control and compliance mechanisms. This ecosystem exhibits exceptional resilience against cryptographic and authentication threats, ensuring a high level of security. Simulation results highlight the efficacy of the location-compliance-based path planning module, revealing a notable reduction in the average flying duration for Unmanned Aerial Vehicles (UAVs).

in [18] researchers seamlessly integrate digital twins with wireless networks, shifting real-time data processing and computing to the edge layer through the introduction of a novel concept known as a digital twin wireless network (DTWN). Within the DTWN framework, the researchers implement a blockchain-enabled federated learning system for collaborative computing. This integration not only enhances the dependability and security of the system but also significantly improves data privacy.

In [19] The article introduces a secure Unmanned Aerial Vehicle (UAV) strategy over the 6G network, combining Interplanetary File System (IPFS) and Blockchain (BC) technologies. This innovative approach aims to safeguard data security and privacy, reduce data storage costs, and enhance network speed. The proposal suggests leveraging a game-theoretic method to manage resources efficiently and impartially, providing a strategic framework for optimizing the utilization of resources in the context of secure UAV operations over the 6G network.

The author's in [20] presented is an Intelligent Self-Driving Transportation System integrated with blockchain technology. The argument posits that current centralized logistics information systems could gain advantages from the distributed nature of 6G networks, addressing concerns related to low confidence and concentrated rights. The utilization of blockchain adds an additional layer of security and decentralization to improve overall system reliability.

In [21] the study explains dynamic spectrum accessibility and its challenges. The basics of 6G networks' future uses. Highlighting blockchains' network slicing and DSA capabilities, their challenges, trade-offs, gaps, and research opportunities. Also, in [22] Create a crisis response system using blockchain-driven federated learning and wireless mobile miners at drones in 6G networks. Energy usage and blockchain latency are also considered in the drone network architecture. Wireless connectivity between drones must be fast to avoid forking blockchains when executing blockchain activity.

In [23] The authors developed a blockchain-based spectrum sharing framework. The trust levels of all UAVs participating in decentralized spectrum sharing are assessed using a trust management technique that emphasizes lawful spectrum use and truthful spectrum sensing reporting. Through the dense placement of uncrewed aerial vehicles (UAVs) as mobile cellular base stations, sixth generation (6G) wireless communications are expected to be ultra-high-speed, ultra-reliable, and ultra-low-latency.

In [24] Secure blockchain-based UAV communication (BC-UAV), a revolutionary) framework, provides network services, including processing, caching, and information. The purpose of the blockchain was to use hashing to increase cloud security. Core clouds rely on edge clouds to help them react to user queries rapidly.

The authors in [25] This research proposes a group-based switching authentication technique for 6G heterogeneous networks. They use aggregated signature and blockchain technology to account for the changeover of group customers in real-world circumstances. To improve the authentication process's effectiveness and ensure its security. The recommended protocol was formally examined and subjected to additional security analysis using the AVISPA tool. The results show that the methodology is secure. Table 1 below describes relevant work.

TABLE I
RELATED WORK DESCRIPTION

Ref No, Year	Methodology Application	Result
[12]2020	which self-manageability, security, transparency, and trustworthiness.	Attains predictive precision and exhibits elevated throughput.
[13]2020	Blockchain and 6G communication network research problems	Due to higher energy, execution, and communication overhead,
[14]2023	Privacy preserving for the Cooperative Spectrum Sensing	improves network speed
[15]2022	Integrated Deep Learning in 6G networking	outcomes improve accuracy and delay
[16]2022	Infrastructure Sharing architecture	just takes a few seconds to process overhead.
[17]2023	the 6G network to facilitate the Internet of Drones.	a high level of security against attacks and diminish the average flight time for drones
[18]2021	A framework for collaborative computing to enable federated learning.	improved cost-effectiveness
[19]2020	UAV communication scheme	decreases data storage costs and improves network speed.
[20]2022	Intelligent Autonomous Transport System	Excellent security performance and prediction accuracy,
[21]2023	Dynamic spectrum access and network slicing	showing the latest blockchain-enabled DSA and network slicing,
[22]2020	network of drones	minimizing drone wireless communication delays
[23]2022	a trust management scheme with UAV	demonstrate its efficiency against malicious UAVs
[24]2022	blockchain‐ based UAV communication	improve the security in the cloud
[25]2023	handover authentication strategy	accomplished global switching authentication

IV. CHALLENGES AND FUTURE DIRECTION

The potential of the integration of blockchain technology into 6G networks for the purpose of facilitating creative city applications presents several obstacles. The following are several challenges that need to be addressed:

•**Scalability**: The blockchain technology is renowned for its limited transaction speed, and this concern is further exacerbated when applied to an intelligent city system that involves a high volume of real-time transactions. The issue of scalability in blockchain networks is a significant obstacle that must be resolved prior to the successful integration of blockchain technology into smart city applications.

•**Security**: Although blockchain is considered a safe technology, it is not impervious to cyber-attacks. Intelligent cities generate substantial volumes of data, necessitating robust security measures to safeguard against potential cyber threats. To safeguard the confidentiality and integrity of the sensitive information kept within the network, it is imperative to incorporate rigorous security measures into the design of blockchain technology.

•**Complexity**: The incorporation of blockchain technology into 6G networks for the purpose of implementing innovative applications in urban settings necessitates the collaboration of a proficient team comprising specialists in the domains of blockchain, networking, and security.

•**Cost:** The utilization of 6G and Blockchain technologies in the context of large-scale intelligent city applications can incur significant costs. To ascertain the feasibility of investment, it is imperative to carefully consider the expenses associated with the establishment and upkeep of blockchain networks in relation to the potential advantages they offer.

The following are possible future direction paths for integrating blockchain technology with 6G in the context of smart cities.

•**Decentralized Data Management**: Smart cities are expected to produce substantial volumes of data that necessitate real-time processing and analysis. Blockchain technology offers a safe and decentralized method for handling data, thereby guaranteeing its integrity and transparency.

•**Secure and Private Transactions**: The utilization of blockchain technology has the potential to facilitate secure and confidential transactions within intelligent cities, safeguarding sensitive data, including personal information and financial transactions, from unauthorized access by hackers and harmful entities.

•**Energy Administration**: The integration of 6G technology and Blockchain can facilitate the effective management of energy consumption inside smart cities, hence promoting optimal energy utilization and minimizing wastage. This intervention has the potential to mitigate energy expenditures and enhance the city's sustainability.

•**Identity Management**: The integration of blockchain technology and 6G has the potential to effectively oversee identity management within smart cities, thereby enabling individuals to securely and efficiently access various services and information.

In general, the integration of blockchain technology with 6G in smart cities has the potential to enhance the efficiency, sustainability, and security of urban environments for people, as depicted in Figure 2.

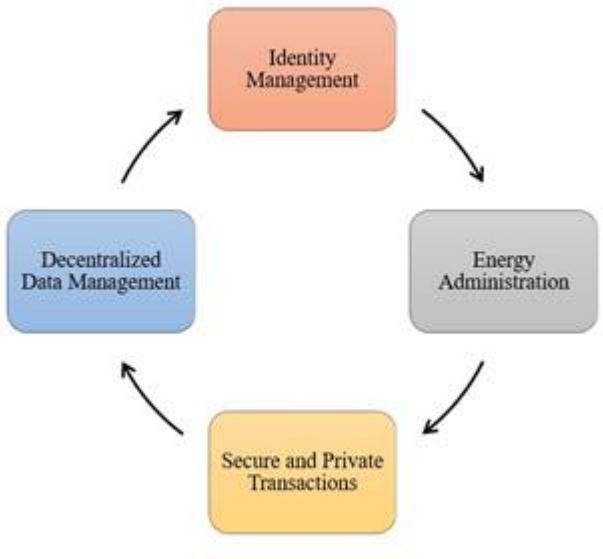

Fig2, Future Direction Which Blockchain Integrated With 6G In Urban Intelligence.

V. CONCLUSION

Blockchain technology has the potential to contribute to the advancement of smart cities driven by 6g technology. the challenges related to the use of blockchain-based architecture have been previously acknowledged. in this context, we present a concise compilation of future research paths pertaining to the development of sustainable and intelligent cities. In the realm of smart cities, the advent of 6G technology is expected to bring about significant transformations, characterized by enhanced connectivity speed, increased reliability, and a wider range of interconnected devices and applications. In summary, the integration of blockchain technology into 6G networks for the purpose of facilitating novel urban applications presents notable obstacles. These obstacles encompass scalability, security, interoperability, complexity, cost, and regulatory concerns. The resolution of these difficulties is of utmost importance to fully harness the capabilities of blockchain technology in intelligent urban environments.

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