THE FUTURE OF SECURE AND OBLIGATORY COMMUNICATION: BLOCKCHAIN APPLICATIONS FOR SECURE 6G COMMUNICATIONS

Abstract

Research on sixth-generation (6G) wireless communications has been formally started globally in order to construct future mobile communication networks. 6G networks must overcome a number of issues, such as resource-demanding mobile devices, difficult wireless resource control, and highly complex network architectures, quickly rising processing and storage requirements, and security and privacy risks. To solve these problems, the implementation of blockchain technology and artificial intelligence (AI) in 6G networks may provide up-to-the-minute insights into how to enhance network quality of services in terms of competency, safety, integrity, expenses, and rife. Distributed ledger technology, often known as blockchain, is one of the most ground-breaking technological developments that can enable the operable standards of the Sixth Generation while also resolving the majority of the persistent limitations. In this paper, we examine potential research areas, upcoming application prospects, and how blockchain might be utilized to address the unresolved issues related to 6G.

Keywords: "Blockchain", "SixthGeneration", "Conversation", "ArtificialIntelligence", "Computing

Authors

Rajat Kumar
MMICTBM
Maharishi Markandeshwar
(Deemed to be University)
Mullana,(Ambala) Haryana 133207, India

Shivansh Mittal
MMICTBM
Maharishi Markandeshwar
(Deemed to be University)
Mullana,(Ambala) Haryana 133207, India

Chetna Thakur
MMICTBM
Maharishi Markandeshwar
(Deemed to be University)
Mullana,(Ambala) Haryana 133207, India

Tejinder Pal Singh Brar
MMICTBM,
Maharishi Markandeshwar
(Deemed to be University)
Mullana,(Ambala) Haryana 133207, India

THE FUTURE OF SECURE AND OBLIGATORY
COMMUNICATION: BLOCKCHAIN APPLICATIONS FOR SECURE 6G COMMUNICATION

I. INTRODUCTION

Fifth-generation (5G) cordless networks have been extensively implemented globally since 2020. In order to meet the demands of future networks projected in 2030 and beyond, researchers from the government, business, and educational sectors are currently actively working on the development of sixth-generation (6G) wireless communication technology. Sixth-generation networks are anticipated to provide significantly faster data transmission rates, fewer communication delays, and improved coverage capabilities in comparison to 5G networks. The development of a fully automated, data-driven intelligent society that is distinguished by the smooth integration of many wireless networks functioning in terrestrial, aquatic, aerial, and extraterrestrial environments is part of the vision for 6G mobile networks. Ultra-high frequency cordless spectrum resources, including as millimeter waves, terahertz, as well as light waves, will be completely utilized by 6G networks. In order to create an integrated green network with collaborative connectivity among devices, real-time security assessments, intelligent data perception, and interrelated coverage across both space and terrestrial environments, these networks will also integrate a variety of technologies, besides satellite Internet, microwave communication networks, and terrestrial mobile communication. With the introduction of 6G, a comprehensive air-space-ground integrated communication system will be easier to construct and provide ubiquitous network connectivity in all situations. However, 6G networks have higher demands for security, bandwidth, latency, flexibility, and connection density due to the wide variety of applications and communication situations, ultra-diverse network connections, and the need for exceptional performance. As a result, strict data security measures will be required for the effective deployment of 6G applications. In this regard, blockchain technology appears to be a very promising remedy. It is a technical framework that combines a number of technologies, such as distributed storage, encryption techniques, consensus processes, chain data structures, and unicasting transmission. The system is exposed to a number threats and challenges regarding security, data privacy, sustainability, and scalability because to the performance requirements for 6G networks, which include ultra-high peak rates, ultra-low energy consumption, ultra-high dependability, ultra-low latency, and seamless connectivity. Blockchain technology is a crucial instrument to tackle these difficulties, especially because of its intelligent node consensus, distributed network design, and intelligent contract features. A safe, intelligent, and effective fundamental basis for realizing the Six Generation networks' vision is provided by the synergistic application of blockchain and Six Generation networks. Notably, the 6G white paper highlights how important it is for the 6G framework to include an endogenous trust network.

II. LITERATUREREVIEW

AuthorName	Methodology	Input	Summary
HemalathaS etal.,2024	Hilbert transform for demising vibration signals	Vibration signals collected from spinning machinery for bearing fault detection.	6G integrates AI/ML for security and network automation.
	PCA,SFFS,SVM and ANN for Data analysis and classification	Data set analyzed using PCA and SFFS for feature selection	Challenges and solutions for AI/ML-based security enforcement in 6G.
AnudharshiniCet al.,2024	Block chain-based trust management methodology	Block chain-based trust management methodology	Block chain-based trust management enhances VANET security and privacy.
	Creation of anonymous shrouding zones for vehicle privacy	Creation of anonymous shrouding zones	Innovative solution for secure communication in Intelligent Traffic Systems.
KokkondaShivaK umaretal.,2023	Decentralized procedure using block chain technology	Big data	Blockchain technology for secure communication system with decentralized tasks.
	Smart contract for validating user's certificate and data security	Industrial IoT	Focus on improving communication security through block chain-based messaging.
A.V.R.Mayurietal .,2023	New security techniques for 6G networks include authentication and encryption.	Post-quantum cryptography , AI, block-chain, THz, VLC, edge computing, ML.	6G networks focus on enhanced security and connectivity features.
	6G security design supports the Zero Trust principle for networks.	New security techniques for trust worthiness and privacy in future networks.	Technologies like AI, block-chain, and quantum cryptography shape 6G networks.
SobanaSikkanane tal.,2023	Machine learning applied to wireless communication	6G enables pervasive, reliable, near instant wireless connectivity.	ML applied in massive MIMO,NOMA, OWC, polar codes, security.

	Application of ML in massive MIMO,OWC,NOMA, security and polar codes	Cutting-edge technologies like machine learning, block-chain, tera-Hertz communication is utilized.	Research works on ML in wireless communication systems.
Syed etal., 2023	Categorization of threat-countering techniques into three types: Intrusion Detection System (IDS) entity attributes and cryptographic methods,	Threat model taxonomy, authentication techniques, future research directions	Survey on emerging 6G security concepts and authentication techniques.
	Categorization of authentication techniques into eight types, including mutual authentication, handover authentication etc.	Message append, alteration, tampering threats; session hijack, data diddling threats	Future research directions and threat counter measures in 6G communication.
PriyaKohlietal.,2023	The paper discusses popular algorithms and strategies for unauthorized intrusion detection.	Real-time data about registered drivers and cars.	6G security and privacy challenges due to wireless nature.
	The paper conducts a comparative examination of previously offered methodologies.	Unauthorized intrusion into anode over a connected network.	Unauthorized intrusion can compromise network reliability and data privacy.
Dr.G.Nanthakumar2023	Enhanced user key management and authentication scheme proposed	Enhanced user authentication and key management scheme for Six Generation.	User authentication and key management system for 6G industrial applications.
	Modified and upgrade diversion of UAKMS-NIB suggested	Out performs other schemes in security and performance for industrial applications.	Enhanced security scheme for 6G enabled (NIB)Networking Box.
Saikant Samanta etal.,2022	Incorporation of blockchain for resource consumption and sharing in 6G.	Big data	6G technology expected to revolutionize telecommunications sector.
	Examination of privacy and security issues in	Industrial IoT	Blockchain integration for efficient resource

	6G networks.		management in smart cities.
Khurram Shahzad etal.,2022	Cryptographic algorithms : ZK-SNARKS,SHA-256,SHA-512	Decentralized blockchain data blocks with hash codes fors ecurity.	Blockchain-enabled authentication mechanisms for the enhancement of security within 6Gcommunicationnetworks.
	Data security methods: Hashing function, add-onDP, built-inDP	Blockchain ensures integrity,availability, security,privacy,and accesscontrol.	Utilizes smart contracts and digital signatures for data security.
Gowtham Ramkumar etal.,2022	Secondary data analysis method	Secondary data analysis method used.	Transition to cognitive digital world with blockchain for 6G.
	Collect role of Blockchain technology in 6G network	Vital Role of Block-chain technology in Six Generation network discussed.	Blockchain networks crucial for overcoming digital restrictions in 6G.
MulumbaBanzaGracia et al.,2022	Systematic literature review technique	Systematic literature review on 6G security, privacy, and trust.	6G is successor to 5G with faster data rates.
	Search with precise keywords in research databases	Extracted security issues: visible light communication and artificial intelligence.	Security challenges in 6G include AI and visible light communication.
SahilGargetal.,2021	Blockchain based privacy-aware distributed collection strategy	Blockchain based security-aware distributed collection strategy for data gathering.	6G network integrated with NIB for industrial applications.
	Better blockchain with new blockheader structure and block generation rules	Improved blockchain with new block header structure and two block generation rules.	Proposed BPDC strategy for secure data aggregation in industrial applications.
RiponPatgirietal.,2021	Envisioning potential applications of 6G communication technology in future.	Hugeamountofdatap roducedbyintelligent driving.	6G communication technology revolutionizes various applications with Artificial intelligence driven operations.

	Discussing impact of 6G communication technology in diverse applications.	Real-time data upload on the Internet facilitated by 6G.	Enables Internet of everything, impacting UAVs, holographic communication, and more.
Volkeretal.,2021	AIML-based automation for network configuration and operation	Security and trust technology enablers for 6G era.	Synthetic data for privacy and analysis tasks.
	Data synthesis for artificial data generation and model transformation.	Focus on cyber-resilience, privacy, trust, and AI/ML importance.	Data synthesis mimics real data characteristics for model simplification.
WeiweiLi etal.,2020	A data security frame work utilizing blockchain technology for applications in Artificial Intelligence.	A blockchain-enabled data protection framework for Artificial Intelligence applications within sixth-generation Telecommunications networks.	6Gnetworksintegrate AI forintelligent services with blockchain data security.
	Integration of AI and blockchain for evaluating and optimizing intelligent service quality	Integration of AI and blockchain for intelligent service quality optimization.	Block-chain enhances data privacy and security in AI applications for 6G networks.
WangYujueetal., 2019	Distributed secure communication method based on block chain	System public parameters, public keys, private keys, session key-related parameters.	Distributed secure communication method based on block chain technology.
	Encryption, decryption, session key processing, distribution, and restoration techniques	Data encryption, decryption, privacy of session keys and user data.	Ensures privacy of session keys and user data during transmission.

III. GENERAL COMPLAINT IN 6G [4]
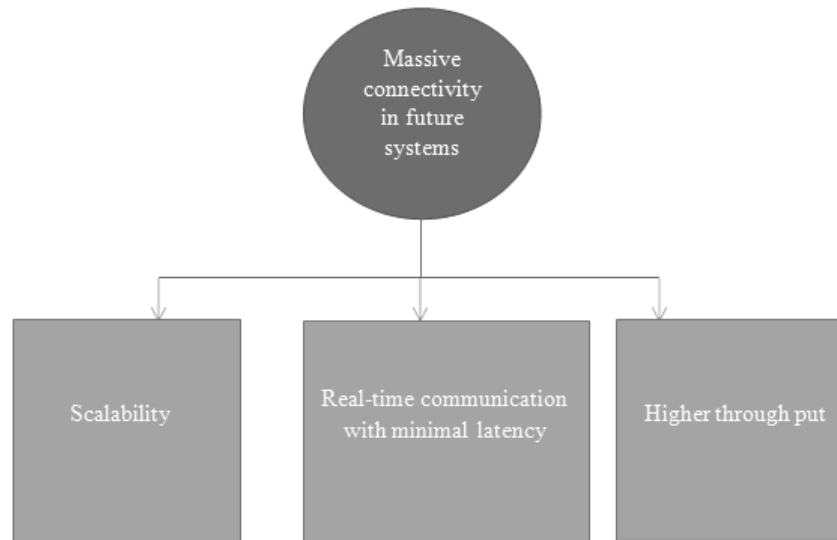
Several of the discernible Obstacles in the realm of 6G are: A. Massive connectivity in future systems [4].

Figure 1: Issues of Different 6G in Networks[1]

1. **Scalability:** Proponents of industrial IOT anticipate that future industrial ecosystems will see the connection and operation of billions of devices, driven by the advent of concepts like massive Machine-Type Communications (MMTC). Consequently, it will be a significant challenge to adapt the design of 6G systems to accommodate this extraordinary demand for traffic.

   - Real-time communication characterized by minimal latency is an essential necessity in the computing ecosystems of the future. Effective device-to-device and machine-to-machine interactions demand a high level of accuracy with virtually no delays to ensure precise functionality. Applications such as autonomous driving and augmented reality-assisted medical-care systems will necessitate reliable communication with consistently minimal delays, particularly in the context of extensive data exchanges.

   - **Enhanced throughput:** Mission critical systems that leverage the forthcoming 5G and advanced communication ecosystems necessitate the simultaneous connectivity of billions of devices. The network infrastructure, including base stations, must be capable of managing a vast capacity of transactions in real time.

   - **Synchronization:** Synchronization is a needful requirement for time-sensitive industrial applications. The essential spinal column systems of a nation, such as power distribution networks and transportation systems, must achieve real-time synchronization to ensure precise functionality.

2. Security Requirements in Forth Coming Computing Ecosystems

- **Confidentiality:** The forthcoming computing infrastructure, particularly   the Internet of Things (IOT), presents significant vulnerabilities due to its reliance on wireless connectivity. Encryption methods, such as symmetric key algorithms, must be lightweight to accommodate the limited power of IOT devices. Nevertheless, these lightweight cryptographic approaches may inadvertently compromise data privacy due to their computational limitations.

- **Integrity:** The substantial amount of data generated by future system necessitates that authorized users can access and modify this data while it is in transit. Any unauthorized eavesdropping or alteration of data during transmission can lead to deviations from the system's intended functionality.

- **Virtualization Security Solution:** Addressing virtualization security issues requires a system equipped with a secure virtualization layer that incorporates technologies capable of detecting hidden malicious software, including rootkits. Moreover, the hypervisor must facilitate complete segregation of storage, computing, and network services through secure protocols such as VPN, SSH, and TLS. Virtual machine introspection (VMI)is a hypervisor feature that assesses and identifies security threats by analysing CPU register data, file input/output, and communication packets of each virtual machine(VM)to thwart potential breaches. In the context of containerization, it is essential for the operating system to properly configure the privileges of various containers and restrict access to critical system directories and the host device's file container.

3. Technology Constraints: The creation of the requisite hardware and infrastructure to facilitate the sophisticated features of 6G presents a considerable obstacle. This encompasses the development of efficient antennas, advanced signal processing capabilities, and network components that can accommodate ultra-high data- rates and ultra- low latency.

4. Network Design and Integration: The task of crafting a resilient and scalable network architecture that can effectively incorporate diverse technologies, such as satellite communications, edge computing, and heterogeneous networks, poses a significant challenge. It is imperative to ensure smooth interoperation among various network elements while optimizing overall network performance.

5. Energy Sustainability: Given that 6G   networks are anticipated to manage extensive data traffic and support a multitude of connected devices, achieving energy efficiency is a critical challenge. The development of energy- efficient hardware, effective power management strategies, and sustainable network designs is vital to reduce environmental impact and operational expenses.

6. Privacy and Security Concerns: As the complexity of 6G networks increases alongside the proliferation of connected devices, the establishment of robust security and privacy measures becomes essential. The development of authentication protocols, sophisticated

encryption techniques, and intrusion detection systems is necessary to defend against cyber risks and protect user data. Given the diverse applications of 6G, including critical design, medical-care, and finance, ensuring the privacy and security of these networks is predominant.

IV. WHAT BLOCKCHAIN CAN BRING TO SIXTH GENERATION [16]

Block chain technology stands out as a key enabler for realizing the full potential of 6G systems. This section examines how the capabilities and advantages of block chain can address the potential challenges outlined in Section II [17].

1. **Intelligent Resource Management:** Managing network resources poses significant challenges in light of the anticipated massive connectivity requirements within future telecommunications ecosystems. Operations related to resource management, including spectrum sharing, orchestration, and decentralized computation, must be aligned with the demands of an extensive infrastructure

2. **Enhanced Security Features**

   - **Privacy:** Privacy is a crucial aspect when considering security. The implementation of data privacy varies significantly within the intricate security demands of the forthcoming 6G network ecosystem.
   - **Availability:** Ensuring service availability is a critical requirement for future communication ecosystems. Particularly, the expanded threat landscape and extensive connectivity in the 5G environment increase the vulnerability to Distributed Denial - of- Service attacks.
   - **Authentication and Access Control:** Centralized systems face scalability challenges regarding access control. Consequently, the centralization of access control presents a notable obstacle in the development of future networks.

3. **Scalability:** Scalability represents a critical requirement for 5G and future -. The constraints associated with centralized systems can be addressed through the implementation of blockchain technology and smart contracts, thereby accommodating the anticipated demand for extensive connectivity in the future. The decentralized architecture, along with these ease of integration of edge, fog computing nodes and will enhance the service capabilities within these networks.

V. 6G APPLICATIONS [20]

1. **Multi-Sensory Extended Reality Applications:** By integrating data from humans gestures, senses, the surrounding environment, and various data sources, XR applications can deliver fully immersive experiences for users. Ensuring data integrity is essential for these applications, as any malicious data manipulation could significantly alter the user experience.

2. **Human Bond Communication:** This application focuses on utilizing data from all five human senses to facilitate a more expressive, realistic and comprehensive exchange of

information between machines and humans. Given the sensitive nature of the data involved, stringent security measures are necessary to protect the intimate information being transmitted. Enhanced Support for Vertical Domains: In industries where similar products or services are developed, produced, and delivered—such as manufacturing, energy, healthcare,andautomation—the3GPPhasestablished multiple key performance indicators (KPIs) for various core and secondary quality of service (QOS) parameters. The capabilities of 5G massive machine-type communication (MMTC) may struggle to keep pace with the growing number of connected devices in these vertical sectors.

3. **Futuristic Applications of Wearable Technology:** Another significant area of focus is wearable technology, which includes implantable sensors, smart clothing, and brain-computer interfaces (BCI). This domain necessitates ultra-advanced capabilities to meet the demands of future applications.

4. Intelligent Healthcare The evolution of intelligent healthcare in 6G must address the persistent challenges faced by 5G networks. A more profound and widespread incorporation of block chain technology in future networks has the potential to enhance existing healthcare systems, leading to improved decentralization, security, and privacy. A significant technical challenge that lies ahead is the issue of privacy. Additionally, the integrity of healthcare data can be ensured through the immutable nature of block chain technology.

VI. BLOCKCHAIN AND 6G

1. Blockchain: 17]

Block chain represents a convergence of various technologies focused on network management, consensus mechanisms, and automation. It functions as a distributed ledger, where data is organized into a sequential chain of blocks. The integration and selection of these block chain technologies must be executed with precision to achieve the necessary security attributes per tinenttothe specific application context. As the range of block chain use cases continues to grow, so too does the variety of options available for constructing a block chain. In terms of governance, block chain can be categorized as either public, consortium, or private. In a public block chain, any node has the ability to join, exit, read, or write, thereby ensuring complete decentralization. Conversely, consortium and private block chains restrict write access to a designated group of organizations or a single organization, respectively. The careful combination and selection of these technologies are essential to meet the security requirements of the intended application scenario.

2. Blockchainand 6G

- **AI Model Parameter Management Solutions:** The integration of artificial intelligence in 6G networks can facilitate operational and environmental intelligence. Given the complexities introduced by network densification, innovative RIS-based channel models, and the presence of numerous conflicting objectives and variables, optimization challenges in 6G networks are likely to become NP-hard. Rather than relying on traditional optimization methods, deep learning techniques are expected to be predominantly employed for the effective optimization of network resources in

dynamic operational and environmental contexts. Although training Artificial Intelligence models can be challenging, their application is highly efficient and yields significant results.

- The anticipated development of 6G technology involves a three-dimensional integration of infrastructure components, necessitating a sophisticated approach to managing these assets. The complexity of spectrum allocation, storage, and computational sharing models is expected to increase significantly. Artificial Intelligence will play a crucial role in optimizing resource utilization. Additionally, the management of trained models will present its own set of challenges. Block chain technology will be instrumental in establishing a trust less environment, ensuring the security essential for effective resource and Artificial Intelligence management.

- **Resource Management Solutions:** The applications of 6G will require substantial amounts of spectrum, computational resources, and other infrastructural elements.

VII. ADVANTAGE OF BLOCKCHAIN APPLICATIONS FOR SECURE 6G COMMUNICATION

Connected Robotics and Autonomous Systems (CRAS)

A key factor propelling the development of 6G systems is the forthcoming implementation of interconnected robotics and autonomous technologies, which encompass drone delivery systems, self-driving vehicles, autonomous drone swarms, vehicle platoons, and robotic systems. The integration of Connected Robotics and Autonomous Systems (CRAS) within the cellular framework transcends the notion of merely introducing another short packet uplink service for the Internet of Everything.

Blockchain and Distributed Ledger Technologies(DLT)

Block chain and DLT are poised to emerge as some of the most transformative technologies within the Internet of Everything landscape. These technologies can be regarded as the next evolution of distributed sensing services, necessitating harmonious combination of Ultra-Reliable Low-Latency Communication (URLLC) and massive machine-type communications (MMTC) to ensure low-latency, dependable connectivity, andscalability.

Integration of Communication, Computing, Control, Localization, and Sensing(3CLS)

The previous five generations of cellular technology were primarily focused on wireless communication. In contrast, 6G is set to revolutionize this concept by facilitating a convergence—offering a simultaneous integration—of multiple functions, including communications and computing.

Conclusion of the Smartphone Era

Smartphones played a pivotal role in the 4G and 5G eras. However, recent trends indicate a rise in wearable technology, which is increasingly taking over the functionalities traditionally

associated with smartphones. This shift is further accelerated by applications such as extended reality (XR) and brain-computer interfaces (BCI). The devices linked to the scope of applications encompasses intelligent wearable devices, integrated auditory headgear, and technologically advanced bodily implants capable of directly capturing sensory inputs from humans, signaling the decline of smartphones and potentially shaping a significant portion of 6G applications.

VIII. DISADVANTAGE OF BLOCKCHAIN APPLICATIONS FOR SECURE 6G COMMUNICATIONS [15]

One drawback associated with the utilization of block chain applications in ensuring secure communication for 6G networks pertains to the complexity of seamlessly achieving both optimal performance and security. The amalgamation of block chain technology with 6G networks presents challenges in terms of integration, necessitating the implementation of strong precautions to thwart potential malicious activities and safeguard data integrity. Furthermore, the incorporation of block chain into 6G networks could lead to increased network overhead and computational time issues, thereby impacting the overall efficacy of the communication system. Furthermore, the imperative for secure and confidential communication within 6G-supported Terrestrial and Non-Terrestrial Networks (TNTNs) underscores the significance of addressing security and privacy issues through innovative strategies for instance the integration of distributed AI with block chain technology. Given these complexities, forthcoming research endeavours should prioritize the enhancement of performance and security aspects of block chain applications within the realm of secure 6G communication networks [15]

IX. CONCLUSION

The configuration of Sixth Generation cellular networks, influenced by the substantial together with diverse requirements of the interconnected nature of all entities, is expected to generate novel opportunities for business. In this regard, the present study emphasizes the emerging challenges and underscores the significant contribution of block chain technology in addressing certain issues. Furthermore, potential avenues for future research are elaborated upon in this discourse.

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