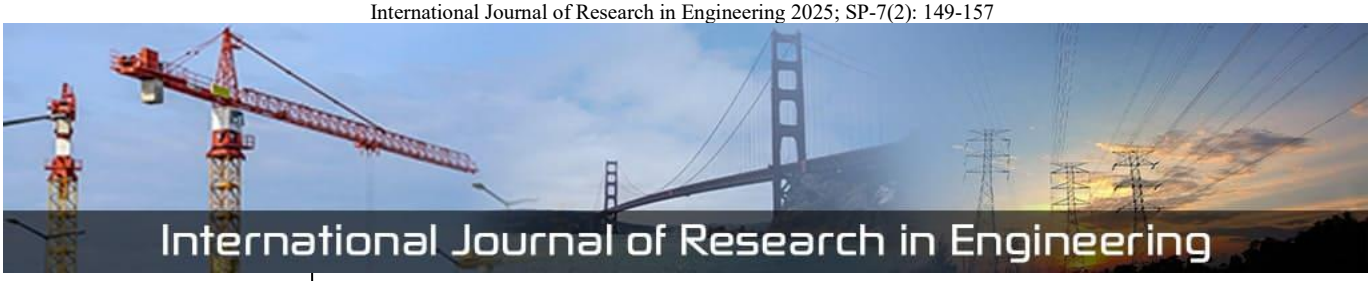

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Study the blockchain-based AI data security in 6G networks

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Abstract
It is anticipated that the introduction of 6G networks would bring about a revolution in the landscape of connection, making it possible to transmit data at rates and capacities that have never been seen before. It is of the highest priority to maintain strong data security in light of the growth of applications that use Artificial Intelligence (AI). Within the context of 6G networks, this research investigates the feasibility of combining Blockchain Technology (BT) with data security procedures that are driven by artificial intelligence. Specifically, the study studies the inherent weaknesses that are present in traditional data security protocols and investigates the potential of BT to strengthen security frameworks that are driven by artificial intelligence. The strategy that has been presented attempts to improve data integrity, confidentiality, and accessibility in 6G networks by using the immutable and decentralized properties of blockchain technology. This paper investigates several blockchain-based consensus mechanisms, smart contract features, and cryptographic methods to improve data security in 6G settings via a comprehensive examination.

Keywords: Blockchain technology, artificial intelligence, 6g network, security

1. Introduction
The technology known as blockchain includes the recording of information that makes it difficult to alter, cheat, or hack the system [1, 2]. An intriguing feature of BT is the implementation of authentication, which results in the creation of a system that incorporates many levels of security and authentication [3]. Authentication issues that arise with distributed ledger technology could be resolved with the use of blockchain-based procedures [4-6]. However, there is still a significant amount of work that has to be done to aid with machine learning models that can anticipate impending assaults or security concerns [7]. In the same way, the apps that run on 6G networks and cellular networks both have distinct vulnerabilities that need to be addressed by the implementation of multifactor authentication methods that are based on blockchain technology [8]. Because the former applications are mostly built on AI Visible Light Communication (VLC) technology, both of them are very susceptible when it comes to encryption, hostile behavior, and data transfer, which could represent an important cause of difficulty [9, 10].
Worldwide commercial deployment of fifth-generation (5G) wireless networks begins in 2020. Research and development of sixth-generation (6G) wireless communication technology is now underway in academia, business, and governments. This technology would be needed to satisfy the needs of future networks in 2030 and beyond [11]. Superior network speed, very low communication latency, and deeper coverage are the primary characteristics of 6G networks as compared with 5G networks. 6G networks would make full use of the millimeter wave, terahertz, and light wave portions of the ultra-high frequency wireless spectrum. 6G networks would combine technologies like terrestrial mobile communications, satellite Internet, and microwave networks to create a green network that can sense data intelligently, assess security in real-time, cover space and earth in coordination, and facilitate group collaboration of all things [12-14]. As the network enters the 6G era, it will face increased performance demands and application situations. In the 6G era, a fully covered and versatile network would be developed using an integrated air-space-

ground. Communication technology [15]. However, owing to diverse applications and communication scenarios, very heterogeneous network connections, and service requirements for exceptional performance, 6G networks encounter heightened requirements for bandwidth, latency, security, connection density, and flexibility [16-18]. Fig. 1 depicts several concerns that the least futuristic 6G implementation should address.

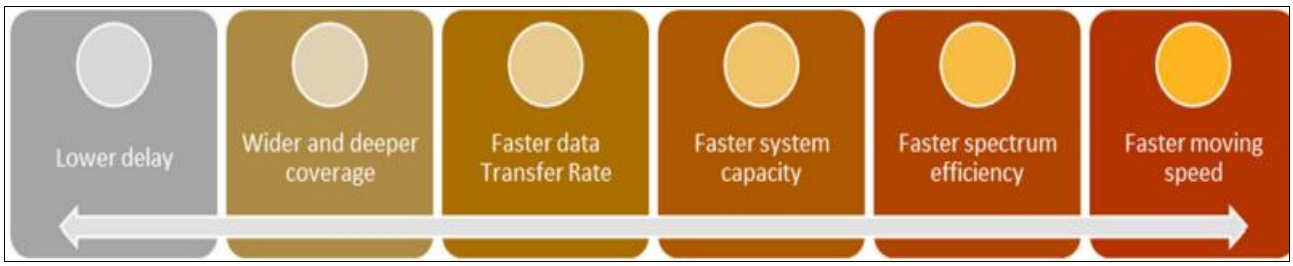

Fig 1: Different aspects that are covered by 6G [19].

AI is gaining more and further significance in this age of 6G technology [20]. The foundation of artificial intelligence is the mining of huge data for training and learning purposes, the constant improvement of processing power to handle increasing transmission rates, and the acquisition of more flexibility via continuous learning. Massive device connections and exponentially increasing data traffic will be challenges for 6G networks in the future. The complexity and latency overhead associated with managing and controlling these enormous data sets in real time is going to be significant. A key difficulty for 6G networks is how to dynamically assign wireless resources, precisely monitor and regulate network resources, and effectively perceive service characteristics. 6G networks would be able to handle and govern enormous amounts of wireless big data because AI is used at both the application and network layers, making the network smarter and more automated [21, 22].

The remainder of the paper is laid out as follows. Section 2 gives an overview of the 6G cellular network. In addition, Sections 3 and 4 of this study is an overview of BT and AI. Section 5 gives a comparison of previous work and section 6 gives an addition of blockchain and AI for wireless communications. The paper is concluded in Section 7.

2. 6G Cellular Network

Most nations in the globe are still stuck in the implementation of 5G technology with the scientific community debating the possibilities and opportunities that can arise with the materialization of 6G technology. The majority of academics, however, believe that the Internet of Everything (IoE) would be able to take off after 5G and Beyond 5G (B5G) technologies are completely implemented, which would justify the large demands for 6G [23,24]. Communication between linked devices, or thing-to-thing connection, would take center stage in the next generation of wireless technology (6G), as opposed to people-to-people connectivity, which was the focus of 1G-4G and 5G, respectively (Fig. 2) [25, 26].

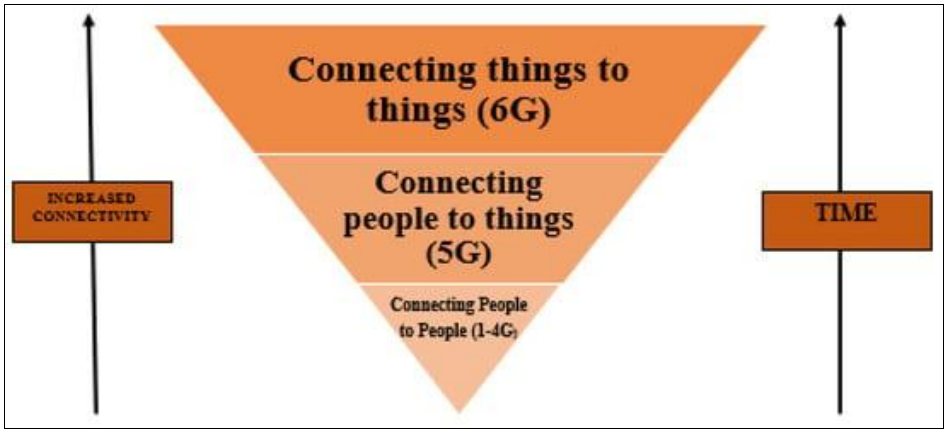

Fig 2: Evolution of the Internet

Research on the internet is going to face significant shifts and problems shortly as a result of the growing number of people who are connecting to the Internet and the enormous several devices that are linked to the Web. To address the issues that are brought about by 5G mobile communication, the research groups are actively exploring possibilities to find solutions. By the time 6G becomes a reality, it is anticipated that a significant number of these difficulties will have been resolved [27, 28].

The applications and communication technologies that can be available with 6G network are revolutionary and powerful; nonetheless, there can be a great deal of special vulnerabilities. These applications would provide challenges in the areas of communication, access control, malicious behavior, authentication, and encryption (for an illustration of these challenges, see Fig. 3 below).

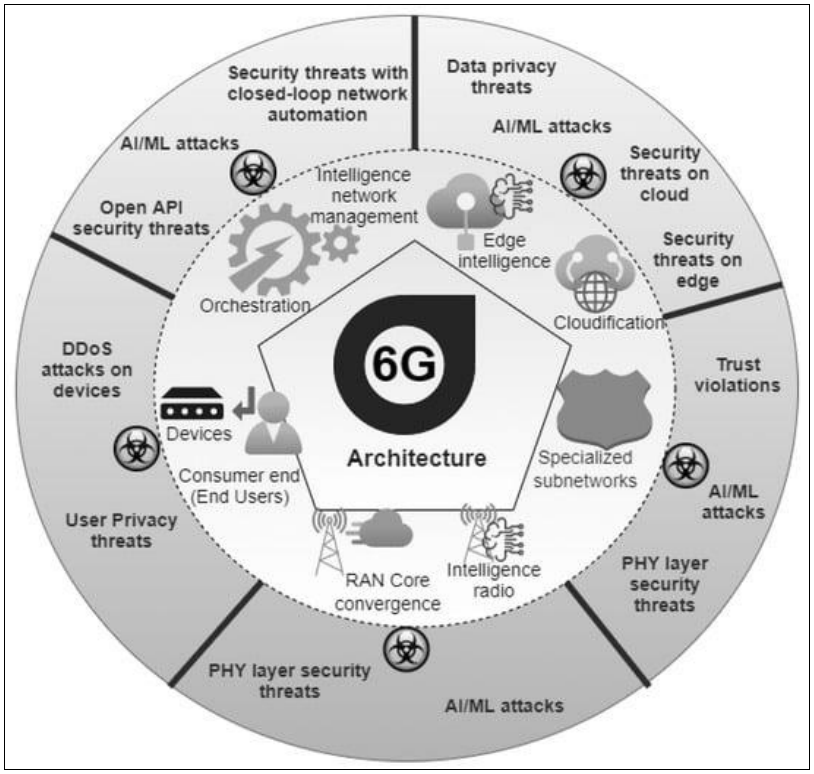

Fig 3: Privacy and security concerns with 6G networks

The figure shows that 6G would enable AI and ML-powered autonomous systems, as well as applications built on technologies like molecular communication, THz, quantum communication, distributed ledger technologies primarily based on blockchains, etc. Blockchains and DLT are currently using multistep or multifactor authentication, so they can be pretty secure. AI applications, on the other hand, might have problems with malevolent behavior, communication, and encryption owing to the large amounts of data sent.

3. Overview of Blockchain Technology

Block chains are distributed ledgers in which data is recorded, stored, and controlled over a peer-to-peer network of individual computers. It is a string of blocks that cannot be changed, have their timestamps verified, and are connected to one another using cryptographic hashes. Each new block that is added at the end of the chain includes a special code or a hash value that refers to the data that was previously contributed to a block. The one-way encrypted hash algorithm yields this corresponding hash result [29].

Each network node has two keys: a public key that is used to encrypt data before it is transferred, and a private key that is used to decrypt messages and read them. It's the kind of cutting-edge innovation that might have a profound effect on the modern digital world. It implies that transactions can be conducted in an open, efficient, and safe manner, without the need for any third party to function as an intermediary.

Blockchain is a consensus-based system that needs the consent of more than half of the participants or nodes before carrying out any transaction [30]. However, all blockchain transactions are public, if the information involved is very sensitive, only certain parties are allowed to see the details of the transaction. BT now has many potentials uses in many different fields, including finance, cryptocurrency, smart contracts, voting, and more.

Classification of BT

Fig. 4 illustrates the difference between public, private, and consortium blockchains based on several parameters [31].

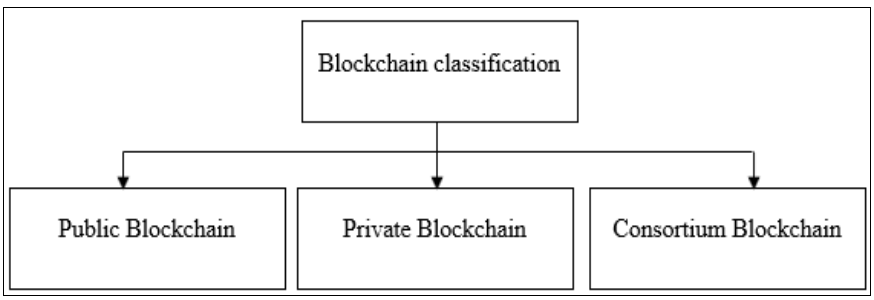

Fig 4: Classification of Blockchain

- **Public Blockchain**

A public blockchain is a platform that allows individuals from all organizations and professions to join, transact, and generate. There are no constraints on any of these variables. As a consequence, these blockchains are often known as 'permission-less' blockchains. Each user has unrestricted access to the whole blockchain and can inspect any transaction, conduct any audit, or look at any section at any moment. There are no central authorities or validator nodes

in a blockchain system. Anyone can join the network, gather transactions, and start the mining process to get mining rewards.

- **Private Blockchain**

It is a blockchain system designed to allow for the secure and confidential transfer of information inside a single organization or between numerous organizations, with mining power vested in a central authority or a small number of trusted users. It is also known as a permission blockchain because no one can join without first being invited. Controlling access is determined by a set of rules or the network in charge, depending on the kind of node.

- **Consortium Blockchain**

Consortium blockchains can be thought of as a kind of permissioned or semi-private blockchain in which consensus and block validation are handled not by a central authority but by a network of trusted nodes selected in advance. These hubs are in charge of vetting potential miners and network participants. A multi-signature approach is utilized for block validation, where a block is only regarded as legitimate if it has been signed by these nodes. In contrast to the fully centralized private blockchain and the fully decentralized public blockchain, this system is only partly decentralized since it is controlled by a subset of validator nodes [32]. Their distinctions and peculiarities are listed in Table I.

Table 1: Classification of Blockchain and their characteristics

	Public	Consortium	Private
Participants	Without permission • Anonymous • Could be malicious	Permissioned • Identified • Trusted	Permissioned • Identified • Trusted
Consensus mechanisms	Proof of work, proof of stake, etc. • Large energy consumption • No finality • 51% attack	Voting or multi-party consensus algorithm • Lighter • Faster • Low energy consumption • Enable finality	Voting or multi-party consensus algorithm • Lighter • Faster • Low energy consumption • Enable finality
Transaction approval frequency	Long Bitcoin: 10 minutes or more	Short 100 ms	Short 100 ms

4. Overview of AI Technology

In today's world, AI has evolved into a discipline that is thriving, with a multitude of practical applications and current research issues [33]. The field of AI is an all-encompassing field that incorporates a wide range of fields, including computer science, logic, biology, psychology, philosophy, and many more. In applications such as voice recognition, image processing, natural language processing, autonomous theorem proving, and intelligent robotics, AI has achieved extraordinary successes by achieving exceptional outcomes [34,35].

During the early stages of artificial intelligence, issues that were very challenging for human intellect but relatively easy for computers to solve in a short amount of time. For artificial intelligence, the main problem is in completing activities that are simple for humans to carry out but difficult to explain formally. For example, identifying words spoken by people or faces in photos is a job that falls into this category. In most cases, people have innate solutions for these types of challenges. Most of the big advances in AI in the last few years have been reduced to ML technology or its implementation. Fig. 5 is an outline of some of the most important methods and areas of study in AI and machine learning.

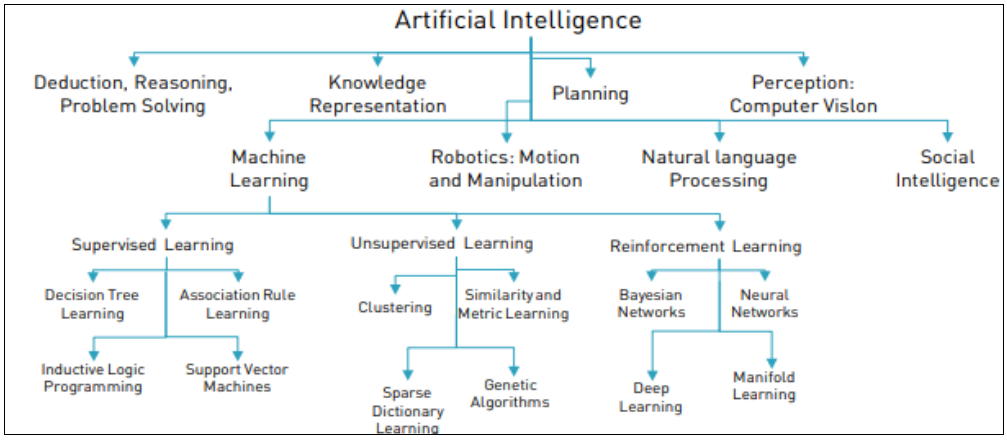

Fig 5: Significant AI and machine learning methods and fields [36].

a) Characteristics of AI

- In this section, they will talk about some of the most significant aspects of artificial intelligence, such as data driving, uncertainty, environmental perception, and scalability
- **Data Driving:** AI is now in the process of completing the technological leap from AI-driven knowledge expression to AI-driven knowledge learning powered by big data. AI can readily benefit from the increase in the quantity of data and processing as it rarely requires human engineering [37]. For example, a data-driven ML network simulates the function-to-be-implemented by seeing it as an opaque black box, replacing it with an ML network, and finally, connecting the input and output using a mountain of training data.

- **Uncertainty:** There is a great deal of mystery around AI because, like any other field, it has certain commonalities and has some unique characteristics when compared to fields like cognitive psychology, physics, mathematics, and physics. Most branches of AI do not progress in a way that is consistent with standard mathematical practices or with broad physical theories. The mathematics and technical foundations of AI will forever be dominated by the necessary connections to cognitive and behavioral psychology. The AI framework is still in its early stages, according to predictions.

- **Environmental Perception:** The capacity for understanding the external world should be generated by the AI system with the aid of sensors and other devices. Like humans, AI can take in data from its surroundings via sight, sound, smell, and touch, and it can also respond appropriately to external input in the form of words, faces, and body language. These responses have an impact on human and environmental decision-making as well. An ideal AI system would be able to learn and exhibit certain adaptive traits. In other words, AI can adapt to new data, tasks, or environments by adjusting parameters or updating optimization models.

- **Scalability:** The AI software and hardware infrastructure has evolved, allowing for larger and more complex AI models. AI has been becoming better and better at tackling problems with ever-increasing complexity. New learning algorithms and architectures designed for Deep Neural Networks (DNNs) would undoubtedly open up more possibilities for AI's potential uses.

5. Comparison of Previous work in related Studies

It offers a detailed analysis and viewpoint on the present research development of BT and AI for 6G wireless communications (Table 2).

Table 2: Comparison of existing related research

Research work	Year	Blockchain for 5G/6G	Ai for 5G/6G	Blockchain and AI for 5G/6G	Key Technologies
Wang *at al*.,[38]	2021	Yes	No	No	Blockchain, RAN
Nguyen *at al*.,[39]	2020	Yes	No	Limited	Blockchain, IoT, SDN, NFV
Yue *at al*.,[40]	2021	Yes	No	No	Blockchain, D-Apps
Tahir *at al*.,[41]	2020	Yes	No	No	Blockchain, RAN, D2D, SDN
Bhat *at al*.,[42]	2020	Yes	No	Limited	Blockchain, IoT, MEC
Sharma *at al*.,[43]	2021	Limited	Ye	No	ML, DL, IoT, Blockchain
Sun *at al*.,[44]	2020	Limited	Yes	no	ML, FL, Blockchain
Rekkas *at al*.,[45]	2021	No	Yes	No	ML
Liu *at al*.,[46]	2020	No	Yes	No	ML, FL
Shafay *at al*.,[47]	2022	No	No	No	Blockchain, DL, ML, FL
Wang *at al*.,[48]	2021	No	No	No	Blockchain, AI
Yang *at al*.,[49]	2022	No	No	No	Blockchain, AI
Dhar *at al*.,[50]	2021	Limited	No	Limited	Blockchain, AI
Dibaei *at al*.,[51]	2022	Limited	Limited	Limited	Blockchain, ML, DL

6. Blockchain and AI Integration for Wireless Communication

Blockchain and AI can work together to solve current challenges, and their combination can make them even better. New use cases and performance standards would be met by the network as it enters the 6G era. Rising expectations on mobile communication networks result from a wide variety of factors, including but not limited to diverse applications, communication situations, very heterogeneous network connections, and needs for extremely high-performance services [52]. Combining BT with AI has the potential to optimize and improve several 6G network services and applications while also capitalizing on each technology's unique strengths [53-55]. Fig. 6 shows the 6G Internet of Things (IoT) smart apps and 6G secure services; this part will review these and other general uses of blockchain and AI in 6G networks.

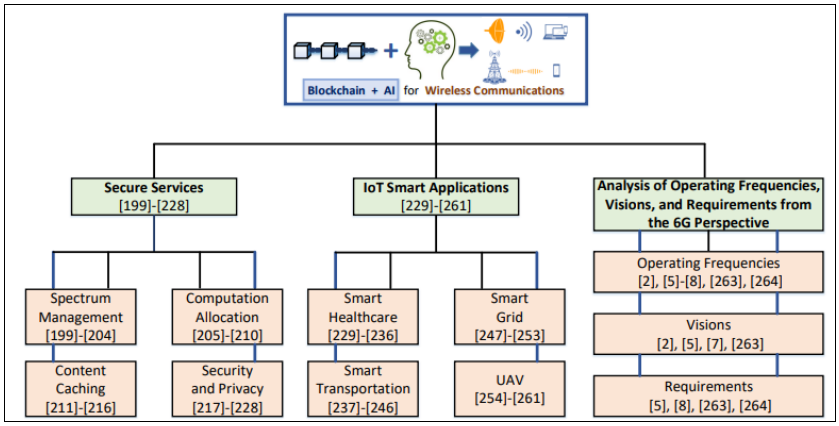

Fig 6: Taxonomy of blockchain-AI wireless communications integration

Fig. 7 shows how blockchain and AI are coming together for use in wireless communications. In addition, they go into detail on 6G's operating frequencies, visions, and needs. A study of how blockchain and AI could collaborate to provide safe services is shown in Table 3.

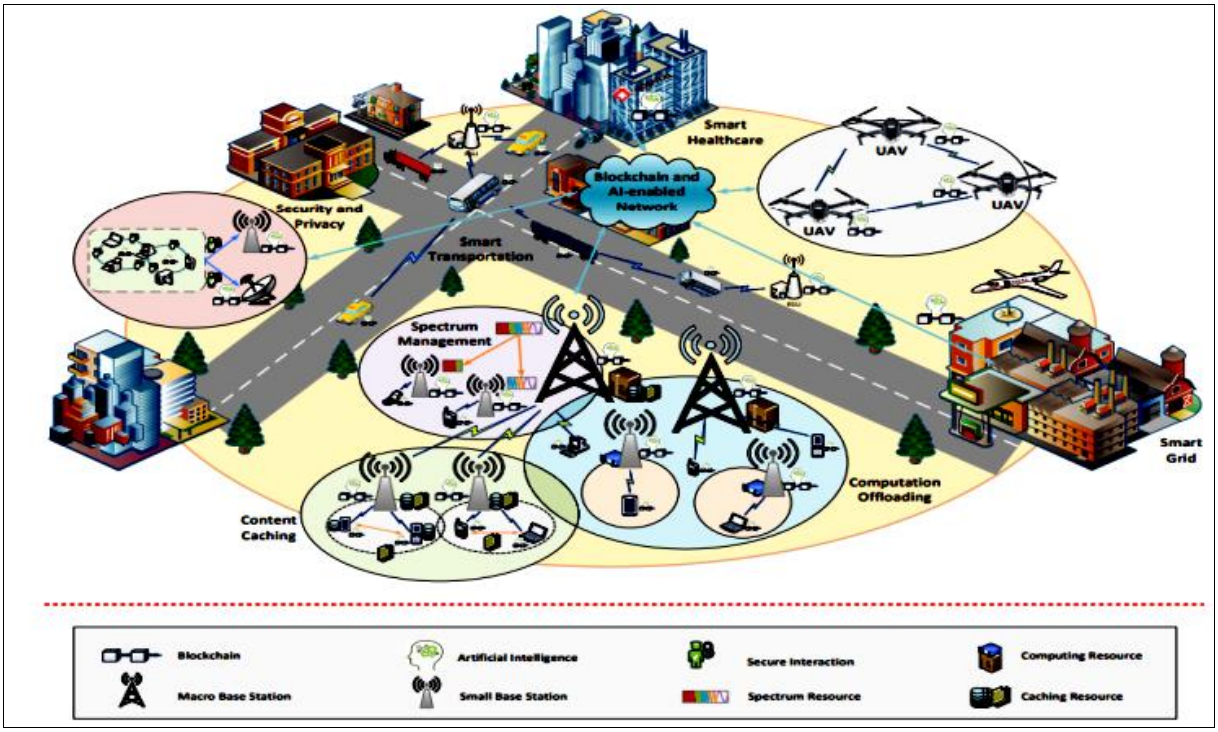

Fig 7: Blockchain-AI convergence for wireless communications

Table 3: Analysis of blockchain-AI Integration for secure services

Taxonomy	Reference	Year	Key Technologies	Main Contributions
Spectrum Management	[56]	2021	Hierarchic-al blockchain, DRL	In 6G and future networks, DRL proposes a dynamic resource-sharing architecture that is powered by BT and AI, allowing the user to optimize their profit margin.
	[57]	2022	Blockchain, AI, Deep RNN	The 6G network would allow for infrastructure and spectrum sharing among many cell carriers using a blockchain- and AI-based multi-plane architecture.
	[58]	2020	Permissioned blockchain, Digital twin, FL, DRL	Introducing a digital twin edge network architecture for user scheduling and spectrum resource allocation that is permissioned and blockchain-based.
	[59]	2020	Blockchain, MEC, DRL	Developing a multi-entity consent (MEC) framework on top of the blockchain to handle adaptive resource allocation; using DRL to solve the optimization issue of both spectrum resource allocation and block creation simultaneously.
Computation Allocation	[60]	2021	Private blockchain, RL, Edge computing	Offering a smart contract for the private blockchain network's computing resource allocation and a generic system architecture for blockchain-assisted edge computing.
	[61]	2021	Blockchain, Edge computing, naïve Bayes learning	A blockchain-guided offloading method for edge user distributed resource management was presented using Naive Bayes' linear identification of offloaded and non-offloaded instances.
	[62]	2021	Blockchain, DRL, Edge/cloud computing	The goal of this effort is to address the need for offloading and security in mobile edge-cloud IoT networks by creating a method that combines BT with distribution ledger technology.
Content Caching	[63]	2020	Blockchain, DL	The AI-Chain framework is being built using BT and deep learning to address the shared resource allocation issue in networking, edge computing, and content caching.
	[64]	2020	Permissioned blockchain, Edge computing	An intelligent and secure content caching strategy for vehicle edge computing networks that combines permissioned blockchain with distributed ledger technology.
Security and Privacy	[65]	2020	Permissioned blockchain, ML	Enhancing the security performance of distributed heterogeneous IoT networks with the integration of permissioned BT and artificial intelligence.
	[66]	2021	Hierarchical blockchain, Transfer learning	The ATLB system uses BT with transfer learning to provide a safe method of user identification.

7. Conclusion

The combination of AI and BT has emerged as a viable option to meet the growing difficulties of data security. This is because the development of wireless communication technologies is progressing towards the installation of 6G networks. To strengthen data security within the framework of 6G networks, this research analyzes the possible synergistic connection between Blockchain and AI.

The research begins by analyzing the unique characteristics and requirements of 6G networks, emphasizing the need for robust and efficient data security mechanisms. Subsequently, a comprehensive exploration of BT and its classification such as public, private, and consortium blockchains based on several parameters.

Furthermore, the study delves into the role of AI in augmenting security measures within 6G networks. By leveraging machine learning algorithms and intelligent threat detection systems, AI contributes to real-time monitoring and adaptive response mechanisms, ensuring a proactive approach to potential security breaches. Finally, a thorough investigation into the frequently used secure services that are backed by blockchain and AI was carried

out. The services that were highlighted in this investigation included spectrum management, compute allocation, content caching, and security and privacy services

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