6G Wireless Communication Networks:
Challenges and Potential Solution

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ABSTRACT

This paper presents a comprehensive survey of security needs, applications, and current challenges and threats for 6G wireless communication networks. 6G technology has brought much attention to business entities and academia recently. The development of a relevant 6G wireless technology to meet the security issues and technical challenges of 5G networks as well as major system upgrades over previous wireless technologies are discussed. The importance of the comparative study is estimated for security issues and communication of devices like wireless devices and focuses on creative innovations that would offer the progression changes required for empowering 6G. First, the authors present the evolution and security threats landscape of wireless communication networks. Then they explore the potential applications of 6G networking technologies. Finally, this paper concludes with a detailed discussion of security issues, research challenges, and possible solutions in 6G that enable critical technologies.

KEYWORDS

5G, 6G, Artificial Intelligence, Blockchain, Massive Connectivity, Security Issues

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INTRODUCTION

The fifth-generation networks (5G) are under construction commercially soon launched in most countries worldwide. It is predicted that 4G may arrive at the bottleneck before 2020, and 5G might be 2030. However, the upcoming wireless network system is being evolved based on recent advances in wireless and networking systems such as software-defined networking and virtualization in 5G and Artificial Intelligence (AI), Internet of Thing (IoT), Internet of Everything (IoE) and Virtual Reality need high reliability, low latency and ultra-high-speed for the uploading and downloading in 6G(Ahmad & Afzal, 2020)(Almrezeq et al., 2022). 5G has higher bit rates with more than 10 gigabits per second than previous technologies, more capacity, and low latency. This is a strong point for the one thousand million attached devices regarding the Internet of Things. Moreover, there are exceptional services available in the age of 5G like blockchain-based facilities, Unmanned Aerial Vehicle (UAV), data networking, fog computing, vehicle–to–vehicle communication, smart grid and smart parking etc. The up-gradation work of 5G networks has been finished and is now ready for deployment worldwide with its full features for commercialization.

The significant drawbacks of 5G wireless communication are less able to deliver a fully cybernetic and expert system that provides all kinds of service with an altogether fascinating experience (Nawaz et al., 2019). Even though the 5G mobile technology will be started coming week with new facilities over the established systems, but cannot resist completing the needs of the next-generation system after ten years (Md. Alimul Haque, Anil Kumar Sinha, 2017). The 5G technology will provide significant advancement and give high quality of service (QoS) compared to previous technologies (Shafi et al., 2017). However, the rapid development of automatic and data-centric systems can transcend 5G wireless communication's properties. Some technologies, like the virtual reality (VR) system, needed to go beyond 5G (B5G) because it requires a minimum rate of 10 Gbps data rate (Mumtaz et al., 2017). So, in 2030 5G has no scope to sustain itself in the technology sector due to limitations. Drawbacks and limitations of 5G and the emerging revolutionary technologies drive the development of next-generation called 6G networks (Zong et al., 2019).

To overcome constraints of 5G, the transition from radio to sub terahertz (sub-THz) and optical spectra supporting explosive 6G applications with new features that are attractive(Whig et al., 2022). The significant attributes of 6G will be the convergence of all the prior attributes, such as excellent connectivity and reliability, low power intake, network densification and higher throughput using security. Even the 6G wireless network would likewise continue the rate of these past generations, which contained services, which included new services with new technologies. Sensible wearables devices, Artificial Intelligence, autonomous automobiles, computing reality devices, enhancements, sensor and 3D mapping (Elsayed & Erol-Kantarci, 2019) will undoubtedly be popular and new services in 6G. Managing a huge volume of data and fast connectivity of each device would be the primary and vital challenges in 6G wireless networks. Even though the 5G arrange time has not yet wholly shown up, the obstacles of 5G innovation mean we should start researching the 6G network now.

Be that as it may, what is a 6G network? Also, by what method will it be different from 5G systems? Up until now, the 6G network has no standard capacities or particulars, just numerous prospects. A few expert users fight that 6G systems should be something other than a quicker form of a 5G technology; actually, the advancement in 5G connectivity in different ways. For instance, inclusion will not be constrained to the bottom level, like the 5G system. Instead, it would have complete undersea surface region inclusion.

Furthermore, the Six Generation system should have a lot of higher Artificial Intelligence (AI) capacity. In perspective on numerous specialists, the 6G network ought to be a "simulated intelligence-enabled" organize, which means AI is the two its driver and most conspicuous element(M. A. Haque et al., 2023). It uses AI in technologies as the 5G network would. Therefore, the 6G network will firmly integrate the capacity to operate AI instruments and systems. Besides, as issues on the security and protection of systems have become progressively significant as of late, the hazard should be a necessary part of the design (T. Zhu et al., 2020). Therefore, we imagine the effect of 6G networking technology in different fields in this article focuses on the security issue and their potential solutions.

The primary purpose of this paper is to provide expert opinion on innovative future research that will have the potential to transform the 6G communication network. The rest of this paper is classified as follows. Section 2 deals with a detailed survey on the literature review. In section 3, the aim of the study and significant contribution by the authors is presented. The research methodology for writing this paper is discussed in section 4. Section 5 elaborates the technological evolution and security landscape from first-generation (1G) to sixth-generation (6G) networks. In section 6, several driving applications of 6G Wireless Communications are described along with key communication technologies of the 6G and security issues of 6G enable technologies. In section 7, open challenges and guidelines about 6G technologies are discussed. Section 8 focuses on future research direction in the field of wireless communication. Last but not least, a summary of the paper is concluded in section 9.

LITERATURE REVIEW

6G is expected to be rapidly developed in the future, and more in-depth studies are being conducted for the same. This literature review summarises some studies on the 6G communication network.

Various surveys exist on 6G wireless communication networks(Nawaz et al., 2019). S. J. Nawaz et al. studied Machine Learning (ML) and Quantum Machine Learning and suggested an aided framework for Quantum Computing for the 6G network. (Giordani et al., 2019) M. Giordani et al. try to estimate 6G requirements. (Saad et al., 2019) W. Saad et al . discussed the primary drivers of 6G applications and proposed a set of standard classes to meet the requirement for 6G performance. (Tariq et al., 2019) F. Tariq et al. present an extended vision of 5G for required changes in 6G. (Li et al., 2019) B. Li et al. are conducting a detailed survey on 5G / B5G UAV communications. (Letaief et al., 2019) K. B. Letaief et discussed AI-based 6G network architecture approaches. (Stoica & de Abreu, 2019) R.-A. Stoica et al. discussed the AI revolution for 6G networks. (Lovén et al., 2019) L. Loven et al. concerned the potential AI Edge in 6G wireless communication prospects. (Clazzer et al., 2019) F. Clazzer et al. provided random access for IoT applications in 6G.(Mahmood et al., 2019) N. H. Mahmood et al. discussed various machine communication in 6G and presented appropriate efficiency metrics and technologies. (J. Zhao, 2019) J. Zhao has presented intelligent reflecting surfaces for 6G networks. (Salehi & Hossain, 2019) M. Salehi et al. analyzed the number of intrusion tools for UAV networks. (Basar et al., 2019) E. Basar et al. presented the theoretical efficiency limitations of the reconfigurable artificial surface-assisted 6G network system. (Xia & Jornet, 2019) Q. Xia et al. proposed a communication networks protocol, especially for the THz band. (Al-Eryani & Hossain, 2019) Y. Al-Eryani et al. proposed delta-Multiple orthogonal access for excellent 6G communication. (Ankarali et al., 2017) Z. E. Ankarali et al. proposed Z. E. Ankarali et al. proposed a system for design techniques, developing flexible waveform and numerology. (X. Huang et al., 2019) X. Huang et al. discussed terrestrial network capacity and reviewed backbone links supporting the family of wireless networks. (P. Yang et al., 2019) P. Yang et al. discussed the potential and latest research techniques for 6G.(Rappaport et al., 2019) T. S. Rappaport et al. presented technological issues and problems for wireless and sensor applications beyond 100 GHz. (Katz et al., 2019).

In 2019 M.Katz et al. showed a detailed chart of technical issues related to B5G. (Elliott et al., 2019) D. Elliott et al. discussed the advantages of a 6G enabled data centre in assuring flexibility and adaptability. (M. Wang et al., 2020) In 2019 M.Katz et al. presented a detailed chart of technical issues related to B5 G. M. wang et al discussed the latest security challenges related to a 6G communications in 2020. (Viswanathan & Mogensen, 2020b) Harish Viswanathan et al. addressed significant technology changes likely to characterize 6 G (spectrum access approaches and new spectrum bands; incorporation of localization and sensing technologies into device design, fulfilling extreme latency or consistency performance requirements; latest network design concepts including subnetworks and advanced security policies). (S. Zhang et al., 2020) S. Zhang et al. demonstrated 6G's promise of connecting everything from the point of view of non-technical consumers in a very well-organized way at 1000 times lower price. (Alsharif, Kelechi, Albreem, et al., 2020) Alsharif et al. provided a series of trade-offs, with the main obstacles and future 6G networks connectivity approaches. (Nayak & Patgiri, 2020) Sabuzima Nayak et al. discussed all potential applications and identified the potential of the 6G system in a variety of areas, such as city transportation. (Y. Zhao, Zhao, et al., 2020) Zhao has discussed the promising technologies that enable the paradigm shift in the 6G wireless networks such as AI, active/passive intelligent surfaces, terahertz communications, and visible light communications in detail and presented other promising technologies in short.

Table 1 outlines available research activity assessing advancements in many 6G sectors. This demonstrates that the existing studies have only explored a few specific topics, but no article has explored the entire evolution of 6G yet(Lu & Zheng, 2020)(Saad et al., 2019)(Letaief et al., 2019)(Giordani et al., 2020)(Zhou et al., 2020)(Khan et al., 2020)(M. Z. Chowdhury, M. Shahjalal, S. Ahmed, 2019)(T. Huang et al., 2019)(Dogra et al., 2020)(Dogra et al., 2020)(Zong et al., 2019)(Akyildiz et al., 2020)(S. Chen et al., 2020). As a result, this survey paper provides a comprehensive overview of 6G advancements, concentrating on a variety of topics such as applications, requirements, innovative solutions, effective approaches, observations, important points, and future problems and driving trends and vision(Viswanathan & Mogensen, 2020b)(P. Yang et al., 2019)(Z. Zhang et al., 2019)(Viswanathan & Mogensen, 2020a)(Tariq et al., 2020)(Y. Zhao, Zhai, et al., 2020)(De Lima et al., 2021)(Mucchi et al., 2020).

AIM OF THE STUDY AND CONTRIBUTIONS

This paper will provide readers and researchers with a detailed idea and general understanding of 6G security issues.

The contributions of our paper are listed below:

1. We discuss the existing surveys for 6G networks that deal with communications, applications, standardization and security issues.
2. Identify and present the security issues in the 6G promising vital technologies.
3. The challenges and future research direction of the 6G network are finally summarized.

RESEARCH METHODOLOGY

The comparative study's methodology is based on a scientific analysis of existing literature survey on security issues and and challenges of 6G enabling technologies and applications. We have selected empirical review methodology to obtain the most relevant standards on the practical implication of security in the 6G technologies instead of acquiring knowledge from theories and credence. The fundamental goal of this imperial study is to analyse 6G technologies and recognize the most frequently encountered security issues. To achieve the objective of this study, the paper on 6G enable technologies security issues related to components and its application technology from 2014 to 2021 were reviewed. Furthermore, keywords of "Security issues in 6G enable technologies" were searched in the electronic databases in the Nature Electronics, Nature Photonics, Scopus and IEEE Explore search engines. Based on the comparative study, we find that some key applications of 6G will play

Table 1. 6G Survey

Ref.	6G Driving Trends	Applications	Requirements/Vision	Technical Challenges	Enabling Technologies	Ongoing activities	Research Direction	Remarks
13	L	M	L	M	H	L	L	Developments, core technologies, scenarios and challenges of 6G.
41	L	M	L	M	H	L	M	6G taxonomy, key enabling technologies, use cases, emerging technologies, research challenges, and future directions.
2	L	H	M	M	H	L	M	6G vision, network architecture, emerging technologies, applications, communication requirements and possible technologies.
38	M	M	M	L	M	L	H	6G vision, drivers, applications, technological trends, service classes, performance requirements, enabling technologies and research directions.
42	L	M	M	L	H	L	L	Wireless evolution towards green 6G. 6G architectural changes, pervasive AI, enhanced network protocol stack and potential technologies.
43	L	M	M	M	H	M	M	5G NR, next-generation wireless communication architecture for 5G/6G networks, technologies and applications of 6G networks, ongoing projects on 6G.
16	L	H	M	H	M	L	L	6G architecture, AI technologies, AI Applications and hardware-aware communication.
39	L	H	L	L	H	L	L	Different 6G use cases and enabling technologies.
7	L	M	L	M	H	L	L	6G applications, enablers, AI and technologies.
44	M	L	H	L	M	L	L	Drivers, 6G requirements, system architecture and technologies.
45	L	H	L	M	H	L	H	6G use cases, communication technologies, and future research directions.
28	M	L	H	M	H	L	L	6G vision, requirements, technologies and challenges.
46	L	L	L	H	H	L	L	6G technologies and challenges.
47	L	L	M	L	H	L	L	6G vision, use cases, requirements, AI and technologies.
33	M	M	M	L	H	L	L	6G use cases, requirements, KPIs, design, key technologies and solutions.
49	L	M	M	M	M	L	L	6G vision, use cases, challenges and technologies
50	L	M	M	M	H	L	L	6G communication technologies, security and privacy, AI and applications
40	L	H	M	M	H	L	L	6G vision, features, applications, requirements, enabling technologies and envisaged issues. 6G communication technologies, security and privacy, AI, and applications.
51	L	M	L	H	H	L	L	Technologies, opportunities, challenges and application in 6G convergent communication, sensing and localization.
My Paper	H	H	H	H	H	H	H	A detailed survey of 6G driving trend, applications, requirements, vision, technical challenges, security issues and future reserach direction.

H High M Medium L Low

a vital role in the new digital world, such as smart healthcare and medical system, smart grid, fog computing, biometric and smart banking, smart home etc.

EVOLUTION AND SECURITY THREATS LANDSCAPE OF WIRELESS COMMUNICATION NETWORKS

This section provides the basic idea about the evolution of mobile networks with security and threats, as shown in Figure 1. The mobile networks have evolved through four generations and are just at the corner of experiencing the latest 5G networks, and researchers show the vision of fabulous 6G. However, the 1st technology was introduced in the preliminary 1980s with a data rate of 2. 4kbps without security because initial telecommunication was not encrypted. Due to this entire network and users' vulnerability, unwanted eavesdropping is easily possible by a third party (Santhi et al., 2003)(A. Haque et al., 2014). In addition, the first-generation system has significant security issues like cloning and illegal access.

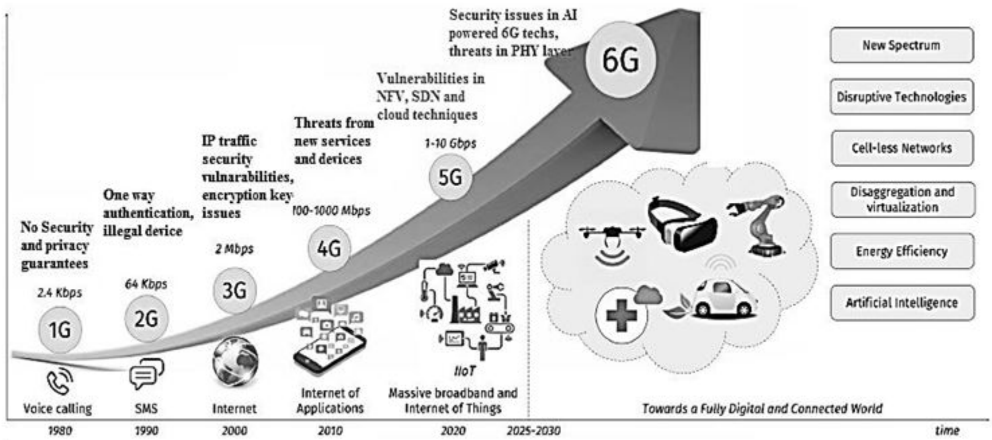
In Finland, the 2G mobile networks were launched in 1991, using the GSM standard. Ultimately, the chats might be encrypted, enhancing security and opening up dozens of new modern communication choices for many businesses. However, conversations were transmitted with significantly improved clarity, minimising static and other ambient disturbances. It's important to mention that 2G represented more than just a step forward in telecommunications. It laid the groundwork for the next century of human contact. Customers may now receive and send text, images, and audio/video files by pressing buttons on their cellphones in addition to phoning. Such digital exchanges looked to provide an infinite number of possibilities. 2G transmission rates were initially limited to 9.6 Kbps. 64Kbps is now an actuality by the end of the 2G period. EDGE technologies allowed for download speeds of up to 1Mbps. Even if the speed were lesser in comparison to what we have now, 2G transformed telecommunication services in the 1990s (T. Halonen, J. Romero, and J. Melero, 2003)(Brookson, 1994). Notwithstanding, despite the extraordinary improvements in security and privacy over 1G, 2G still experiences numerous shortcomings. One significant security issue is that authentication is a single direction; the system verifies the user, yet the user cannot authenticate, creating security gaps(Cattaneo et al., 2013).

3G was launched in late 2000 with a high-speed data transmission rate of up to 2Mbps and high-speed mobile access to services based on Internet Protocol (IP). However, 3G networks are extra highly-priced than 1G and 2G because it includes Wideband Code Division Multiple Access (WCDMA), Universal Mobile Telecommunications System (UMTS) and CDMA 2000 technologies (T. Halonen, J. Romero, and J. Melero, 2003). 3G presents the power of excessive-pace offerings like on-call for video, peer to peer file sharing and composite Web services and offers better coverage with improved performance for less cost (Andrews et al., 2007). 3G security is much better than 2G due to two–way Authentication. 3G provides a complete security system to protect users and wireless transmitted signals. However, some threats are still associated with the IP traffic and encryption keys in 3G networks, such as unauthorized access to data, threats to integrity, Denial of Service (DOS), unauthorized access to services (Chuah, 2010).

4G is generally called the successor of the 3G and 2G standards. It provides Multimedia Messaging Service (MMS), DVB, video chat, mobile and High-definition television content with the data rate of up to 1 Gbit/s on the downloading and up to 500 Mbit/s on the uploading. 4G networks have more security threats than past networks due to unsecured wireless architecture and defects in key management protocols. The 4G networks are unsecured against Denial of Service (DoS) attacks and data integrity attacks (Seddigh et al., 2010).

5G is relied upon to give new an incentive as an essential innovation supporting future industry and society, along with AI and IoT, just as further upgrading its technical features such as high speed, rapid, high limit, low idleness, and enormous availability. However, due to the new architecture, technologies, and broadcast nature of 5G wireless systems, it is possible but difficult to provide security features such as authentication, integrity and confidentiality and bring newly vulnerable to security and privacy protection (Huawei Technologies Co., 2015). In addition, the media access control layer (MAC) and Physical layer are top security issues in 5G networks (Vij & Jain, 2016). Due to these security issues, various attacks are very common in 5G networks such as DoS and DDoS, MITM, eavesdropping and traffic analysis, jamming.

Figure 1. A detailed comparison of 6G with the previous wireless mobile networks and security landscape



Specifications	1G	2G	3G	4G	5G	6G
Data rate	2.4 kbps	64 kbps	2 Mbps	100-1000 Mbps	≈ 20 GBPS	≈ 1 TBPS
End-to-end latency	20- 200 sec	10-100 sec	1 Sec	100 ms	10 ms	1 ms
Highest spectral efficiency	1 bps/ HZ	0.5 bps/ HZ	2.5 bps/Hz	15 bps/Hz	30 bps/Hz	100 bps/Hz
Network mobility support	Up to 15m/hour	Up to 50km/hour	Up to 150km/hour	Up to 350km/hour	Up to 500km/hour	Up to 1000km/hour
fmax	-	-	-	5 GHz	90 GHz	10 THz
XR	-	-	-	NO	Partial	Full
THZ communication	-	-	-	NO	Very Limited	Wide
Services	-	-	-	Video	VR, AR	Tactile
System Architecture	-	-	-	MIMO	Massive MIMO	Intelligent surface
AI	NO	NO	NO	NO	Partial	Full
Autonomous vehicle	NO	NO	NO	NO	Partial	Full
ER (Extreme Reality)	NO	NO	NO	NO	Partial	Full
Haptic Communication	NO	NO	NO	NO	Partial	Full
SI (Satellite integration)	NO	NO	NO	NO	NO	Full

6G VISION, DRIVING APPLICATIONS AND KEY TECHNOLOGIES

Driving Applications of 6G Wireless Communication Network

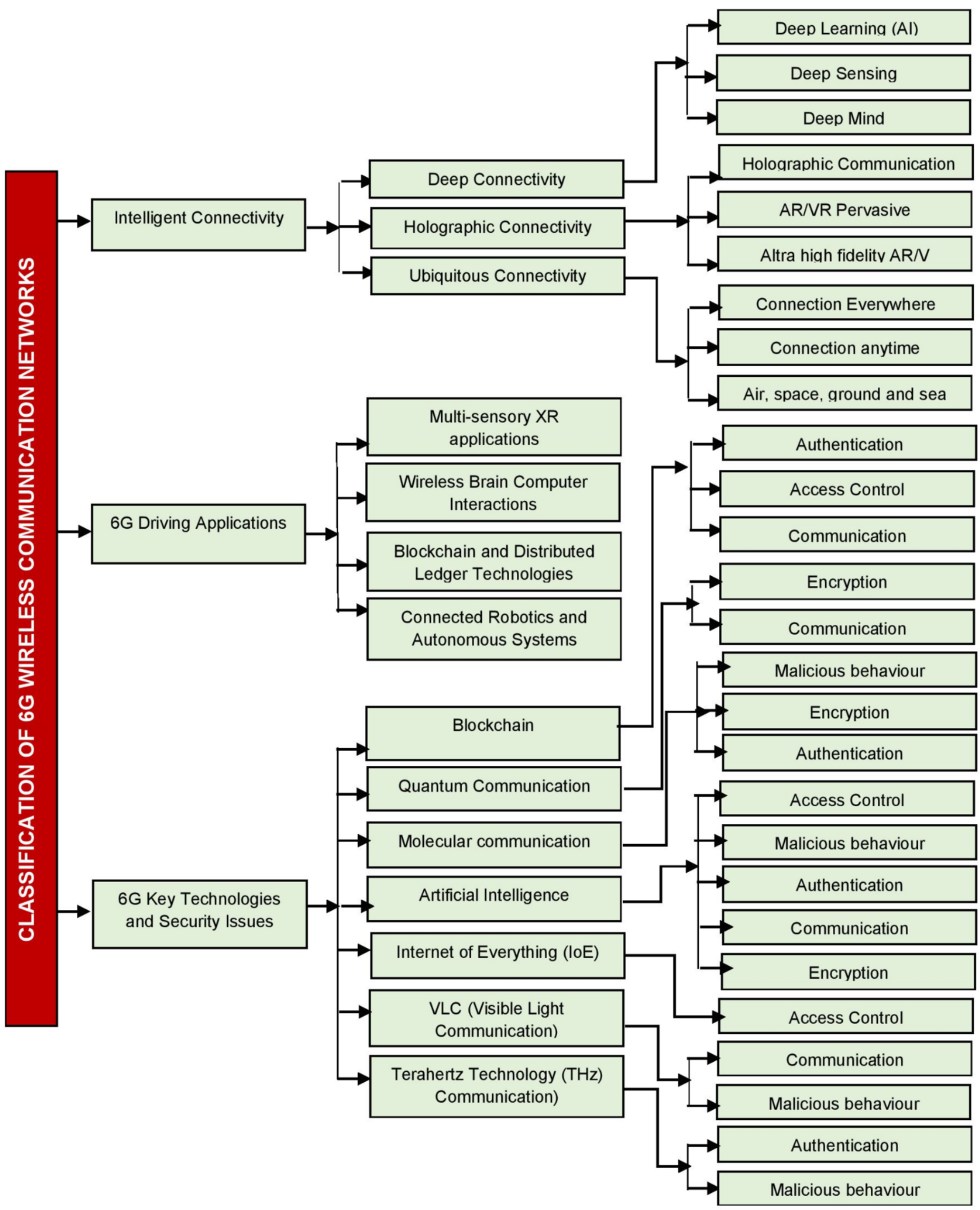
Multi-sensory Extended Reality (XR) Applications

XR will introduce several apps for deadly 6G on virtual reality, mixed reality and augmented reality spectrum. The resulting 5G network is quickly becoming a whole interactive XR environment delivering all sensory feedback owing to its failure to provide extreme, minimal delays for high data rate Multi-sensory applications. Impressive experience with XR applications requires a basic architecture not just for the technologies specifications but also perception demands that they integrate cognition of human senses and Physiology. Minimum and maximum perceptual parameters and limitations for design should be considered (compute and scan, etc.). Implementing VR/AR via cloud networks makes it much more compact and easy to reach. The profound experience with VR/AR would be enhanced in the 6G network(Gui et al., 2020) as shown in Figure 2.

Wireless Brain-Computer Interactions (BCI)

Generally, BCI applications have been limited to healthcare scenarios that can control people using brain implants or prostheses adjacent to computing devices. However, the recent arrival of brain-computer wireless interfaces and implants will transform this area and bring new usage to possible cases involving 6G access. These possibilities vary from film enabling brain-controlled feedback to a multi-brain-controlled video (Zioga et al., 2018). BCI creates a connection between the brain and a machine. The computer placed on the inside of the body (like the sensory cortex) or the outside (like the artificial limb) of the signal processing, retrieval of features, transmission of features and feedback is various processes involved for wireless BCI. Now BCI applications are used as auxiliary equipment to control disabled people. Chen et al. (X. Chen et al., 2015) Proposed a new concept of speeding up spelling through brain signals in wireless BCI. With the 6G network launch, the wireless BCI was predicted to see further applications. While similar to XR applications, wireless BCI requires fast speed, ultra-low latency and reliability. In addition, BCI wireless is typically more sensitive than XR to sensory perceptions and the need to promise 'quality-of-physical-experience.'

Figure 2. Classification of 6G wireless communications



Blockchain and Distributed Ledger Technologies (DLT)

In 2017 and 2018, hundreds of companies, including world-famous companies and leaders in their countries or regions in different sectors, have joined major blockchain and DLT respective initiatives. DLT ranged encoded, and a dispensed database serves as a ledger wherein information of the transaction is stored. At the core, DLT is an innovative approach to the database with the data model in which cryptography is used in each update transaction and verification to be possible in specific blockchain the entire network, depending on the purpose and stakeholders (*Smart Networks in the Context of NGI*, 2020).

Connected Robotics and Autonomous Systems (CRAS)

CRAS is the most comprehensive and autonomous driving application of the 6G network. Recently, researchers have been investigating automated 6G wireless vehicle technology, which has dramatically changed our daily lifestyle, i.e. drone – delivery UAV system. Unmanned aircraft is the most popular UAV system. Nowadays, this system is used in various fields such as s such as monitoring, aerial imaging, emergency relief and drone training, leisure, law, food distribution, safety, education, research, agriculture defence, commerce, science, agriculture. UAV also facilitates aerial and high-speed communications while the network base station (BS) is down. Autonomous networks will have a multi-dimensional network. This device would insert intelligence around the system and logical AI into the networking system (T. Huang et al., 2019). Like introducing automated cars, drone delivery services, autonomous drone swarms and autonomous robots, CRAS is an essential factor behind 6G networks.

To summarise, 6G networks must have increased network capabilities above 5G technology to implement new applications. Table 2 shows several 6G requirements of the application.

Essential Communication Technologies of 6G

6G technologies can transform the nature of our experience of culture, environment, community and industry. 6G connectivity is more about the sixth sense of communication. Here we discuss some

Table 2. Requirement in 6G applications

FeMBB	umMTC	eRLLC	ELPC	LDHMC	High Spectrum Efficiency	High Area Traffic Capacity	MBBLL	mLLMT	AEC	6G APPLICATIONS
H	L	H	L	H	L	H	M	M	L	UAV based Mobility
H	H	L	H	H	L	H	L	H	H	Holographic Telepresence
H	H	M	H	L	L	L	H	M	L	Super-Fast Hot Spot
L	M	M	H	H	L	M	M	H	L	IoT Manufacturing
L	H	L	H	M	M	L	L	M	L	IoT Supply Chain
H	H	H	M	M	L	L	H	H	H	IoT Healthcare
M	H	H	H	M	L	L	H	M	L	Drone based System
L	L	L	M	L	M	M	L	L	M	IoE
H	M	M	H	L	M	M	L	H	L	Industrial Iota
H	M	L	H	L	M	H	L	L	M	Ultra dense cellular IoT networks
			H	High	M	Medium	L	Low		

emerging technologies that could significantly allow 6G in the next ten years or more. They plan to be more innovative than pragmatic. There is a possibility that any of the proposals to be addressed in this segment will not be entirely available in the 6G process but may emerge as a 6G improvement.

Internet of Everything (IoE)

If 6G is operational, it would be the era of immense help in formulating practicable determinations dependent on data, such as raising the alarm clock. It must use the cache service, cognition, compute, and control of digital cognition information. These determinations produce the combined and improved mMTC and eMBB, the requirement to connect employees, actuators and the sensors in these machines. IIoT uses the central support of even low latency to ensure seamless convergence between them 6G communication follows 6Cs, specifically, capture, convey, data speeds and devices to encourage touch adventures combined and improved mMTC and URLLC. Tremendous capacity apparatus to restrain the actions taken by the devices (M. A. Haque et al., 2021)(Alimul Haque M., Haque S., Rahman M., Kumar K., 2022). Data 2.0 also requires a supercomputer to process and interpret data efficiently. Computed data are sent to smart IoE out of 6G is ability.

Artificial Intelligence

Along with AI and Deep Neural Networks (DNNs), machine learning (ML) explores technologies that compel new fields of quest opportunities, such as 6G communications and IoTs. 6G empowered with AI is predicted to widen attributes such as self-configuration, circumstance consciousness, an opportunistic set-up, and aggregation (Albreem et al., 2020). The possibility of wireless communication and the most intelligent radio connectivity can be perceived through AI-empowered 6G with the support of ML algorithms. Also, building the foundations of the component for wireless technologies is due by way of reconfigurable and innovative materials (Renzo et al., 2019); nevertheless, they indeed have been called the Multiple Input and Multiple Output (MIMO) 2.0 and researched in detail from (Nadeem et al., 2019a; Nadeem et al., 2019b). Descriptions of all ML Device-to-Device (D2D) Technologies Communicating, significant MIMP device architecture and optimization have been provided (Alsharif, Kelechi, Yahya, et al., 2020; Fang et al., 2019).

Figure 3. 6G-enabled key technologies

Furthermore, Han et al. (2017) presented a brand new network structure for analysing the information associated with big data, and also optimizations can be facilitated by investigation in the physical layer. Basar (2020) indicated an indicator modulation that may help boost 6G system efficiency's incorporation. Significantly, ML techniques and higher intelligence might increase overall effectiveness, but that may also improve the architecture and functionality of all 6G wireless systems. The Benefits of works in communicating solutions along with wireless are comprehensive from the following three categories:

Operational Intelligence (OI)

This technology allocates resources efficiently to reach proper network operations rather than involving procedures, allowing the use of multi-objective optimizations that can operate in the extraordinarily nuanced and competitive nature of 6G due to its complexity, scalability and scale. Optimization techniques that quantify multiple objectives that are implanting operation are complicated NP difficulties and, therefore, difficult to quantify (Shi et al., 2015). Now, advances in AI engineering and ML methods, for example, profound psychologist instruction (DRL), can assist your decision-maker and optimize their conclusions with the remarks generated by a loop. Such learning algorithms can be used by helping optimise resource allocation (Mao et al., 2018). Lately, Luong et al. (2019) dealt with device storage, unloading, and adaptive modulation problems.

Environmental Intelligence (EI)

Distributed and ubiquitous knowledge will become a possibility of technology, such as wireless networking conditions, through the advancement of radio technologies and spaces (Alsharif, Kelechi, Yahya, et al., 2020). Intelligence-based systems may hit a wide variety of deployment settings, including data centres, IoT hardware such as bridges, aerial vehicles and auto-robots (Yaqoob et al., 2020), although growing, self-organizing and self-curing possesses the durability of D2D communication for a 6G network utilizing structures. In (Alsharif, Kelechi, Yahya, et al., 2020), a number of the advancements described demand ways to sense your air tide transformations utilizing intelligent reconfigurable surfaces. These advancements place the base for gear that's useable for EI. To get DNNs, the extracted attributes are handed in to the cloud or edge apparatus; however, it is an ambitious task because of this communication and computation capacities and heterogeneity of those apparatus.

Service Intelligence (SI)

Communication technologies, including e-health tracking (indoor and outdoor), multiple devices direction, knowledge discovery, and security, will be the key benefit systems for 6 G intelligence implementations in a human-centric network (Javaid et al., 2018; Dang et al., 2019). SI helps expand this sort of human-centric software and an intelligent Method to improve user gratification position precision, particularly for in-door events (Belmonte-Hernández et al., 2019). Likewise, information and the IoT set working with infrastructure may aid from personalizing (N. Zhu et al., 2015). The progress in SI could be accomplished throughout the systems that were centre beneath (Kishk et al., 2019).

Blockchain

Blockchains are unchangeable decentralized database solutions and are implemented in a centralized manner, i.e. (with no central repository) and usually without the fundamental authority. We enable a group of users to document transactions inside a ledger of that field such that no activity may be transformed. (Yaga et al., 2018). Block-chain will soon likely be a powerful technology to handle massive data in future communication systems. Blockchains are only one kind of ledger technology. In 2020 Dang et al. (Dang et al. 2020) detect that Decentralization depending on blockchain technology, can simplify Network direction and boost network operation. A ledger that is dispersed is distributed throughout computing devices or nodes. Just about every node retains and reproduces precisely the identical replica of the ledger. The peer-to-peer network is used for managing the blockchain. It may exist without no handled a host along with a centralized authority. The data on a blockchain is ordered in cubes and is accumulated. The cubes are fastened with cryptography and are all associated with one another. The blockchain technologies may have traceability of data centres, such as interoperability across apparatus interactions of IoT techniques and reliability to its connectivity of 6G communicating methods.

Quantum Communicating

Quantum communicating is just another communicating technology using application capacity in 6G networks. Indeed, one of its advantages is that this will boost data transfer efficiency and reliability. However, if an adverse event checks or reproduces any such thing from quantum communicating, the quantum state will be affected. It is perhaps not feasible for your receiver to be more oblivious of this hindrance (Z. Zhang et al., 2019). In principle, quantum communicating can offer absolute stability, and, as with all the breakthroughs, it needs to be acceptable for sharing. It provides new options and elevates communications that communications methods cannot attain (Gyongyosi et al., 2018). Thus, building the temptations of this technique might be appropriately used in advanced networking. Combining reinforcement learning with unsupervised learning makes it possible to utilize the system autonomously.

Terahertz Technology (THz)

Terahertz is the extraordinary possibility of higher frequencies connectivity, enabling data rates from the 100 Gbps sequence, in line with all the most vital 6G requirements. On the other side, the issues that hindered the use of Terahertz connections in business processes are so much-reaching decrease in transmission, molecular absorption and higher penetration, and antenna and radiofrequency (RF) circuitry technological challenges. Additional frequency bands may not maximize terahertz communicating functionality badly influenced by molecular absorption [86]. When limited to situations, it empowers new forms of too small-scale digital packaging solutions to your antenna and RF circuitry. An innovative way to build the terahertz frequency will be detected from Chevalier et al. (Chevalier et al., 2019). They create a streamlined device that may utilize the nitrous oxide or laughing gas to generate a Terahertz laser frequency trained over an extensive range at room temperature. Technology improvements in terahertz transceivers, such as electronics-based apparatus and photonics-based devices, conquer the terahertz gap and empower some possible utilize instances in 6G (Sarieddeen et al., 2020; Y. Yang et al., 2020). This discovery will give an unprecedented terabyte–per–second speed (10 to 100 times faster than 5G) to the next generation ‘6G’ in future. The critical potential application for THz technology will cover IoT devices, long-range communication, Wi-Fi, Computing chips and data centre.

Visible Light Communication (VLC)

Visual Light Communicating (VLC) is regarded as just one of all possible methods from the 6G. It is a kind of wireless communication for short-range, and it works by using data-modulated transmitters and photo-detectors (PDs) as recipients. VLC techniques apply observable gentle for communicating, which inhabit the range of 380 nm to 750 nm, comparable to a frequency range of 430 THz into 790 THz. The data rate of VLC is predicted to reach Tbps in the short-range environment in the entire year of 2027 (Strinati et al., 2019). The bandwidth issue in RF communicating is resolved because of the vast bandwidth access that is on account from VLC. Signals are just received by even the VLC receiver it has, and if they reside in an identical room, the transmitter will be unable to get the signals. So it conserves as a source of light that might be used both for communicating and lighting. Since of-its attributes of stations, higher bandwidth and shallow power consumption, VLC is among those candidates; uses of VLC comprise vehicle to vehicle communication, robots submerged communicating and information in hospitals. Chen et al. (C. Chen et al., 2018) invented a VLC technology called Li-Fi that might potentially support many connected users using services. There are also of all VLC technology. For instance, the use situations for all-natural lighting can impact; VLC should be inside transmissions.

Molecular Communication

Molecular communication is an Observed phenomenon among households organizations. Nanoscale and microscale systems are becoming feasible due to nanotechnology, bioengineering and artificial intelligence over the last decade. The molecular communicating technology can be just actually a 6G communications technology. It continues to be in its first phases plus a procedure. Biochemical signals can easily transmit information with the help of this molecular technology. Nakano et al. (Suda & Nakano, 2018) offered a portable molecular communicating procedure that helps the sender, both the recipient and the nodes, convey whenever they have been still moving.

3.1. Security Issues in 6G Enable Technologies

In the previous section, some key technologies have been discussed, which prove helpful in critical areas of the 6G network. High speed, low latency and secure transmitting are 6G main features. As stated in the previous section, most developments come at the expense of security issues. However, in Table 3, security issues about 6G technologies are presented.

Artificial Intelligence (AI)

6G is expected to act like an AI – a connectivity device that allows the machine to self-compute, self-indulge, and even self-decide. 6G will research spectral accessibility. 6G will depend on accountability to attract the computation to give future generation providers. In different ways, AI is often helpful, such as Large Data Processing, decentralized AI, resource management, and network optimisation techniques. AI technologies have some security issues. Loven et al.(Lovén et al., 2019) has presented that AI could boost edge protection by monitoring mechanisms and fine-grained controls. Dang et al. (Dang et al., 2020) proposed that AI might help identify network irregularities and include early warning mechanisms to improve the security of 6G networks. Sattiraju et al. (Sattiraju et al., 2019) presented an unmonitored learning approach that is helpful in the authorization process to increase the protection of the physical layer. Hong et al. (Hong et al., 2019) proposed a deep learning antenna architecture that could be applied to secure data in the physical layer communication. Nawaz et al. (Nawaz et al., 2019) discussed the ML and quantum encryption methods to secure the integrity of communication channels within 6G networks.

VLC

Low priced equipment, minimal disturbance, unlicensed bandwidth is the key advantage of VLC. However, it can mostly use indoors because of its limitation, i.e. low coverage area, requiring illumination source, and suffering from noise. Malicious behaviours and communication processes are the main security issue in VLC. Ucar et al. (Ucar et al., 2016) suggested a SecVLC protocol utilized within a car system to guard transmitting data. Moreover, Cho et al. (Cho et al., 2019) have discussed the collaboration of eavesdropping that could reduce security in VLC technologies.

TeraHertz Technology (THz)

The transmission of THz plays a significant role in the uplink so that a line-of-sight link is not needed. THz up - link alternative provides secure network connectivity for VLC networks. A hybrid VLC / THz device is an efficient communications tool against ambient light that reduces the ratio of the VLC.

THz also has some security issues, like other 6G technologies. These are different protection and deceptive actions. Akyildiz et al. 2014 suggested electromagnetic THz frequency signature theories that can be efficiently used in physical layers for authenticating. Ma et al. (Ma et al., 2018) talk that an eavesdropper can intercept an indication if it has transmitted by way of narrow beams. They do but talk a solution.

Blockchain

With more than 50 billion UEs and IoT systems connecting to various capacities anywhere, 6G would need a comprehensive strategy to secure mobile data with strict security requirements. Because of the benefit of this ledger technology, blockchain technology is essential for authenticating and procuring foreseeable future communication systems. BlockChain security issues are associated with accessibility, authentication, and communications procedures. Kiyomoto et al. (Kiyomoto et al., 2018) address a modern computational framework for cell device authorization based on blockchain technologies. Kotobi et al. (Kotobi & Bilen, 2018) also proposed an approach to collaborating with the blockchain to enhance the security of media connectivity networks to achieve accessibility to this licensed network and include cognitive broadcasting. Ferraro et al. (Ferraro et al., 2018) point out that the hash capacity needed to verify transactions on a blockchain-based network may have a negative effect on reliability. Ling et al. (Le et al., 2019) present a blockchain radio-access architecture that could protect and efficiently manage access permissions and authentication for less trustworthy networked devices.

Quantum Communication

Quantum communicating is just an exciting tool that's very likely to bring towards just two fundamental standards of 6G, specifically exceptionally high data speed and security (Hosseinidehaj & Malaney, 2017). The security features of quantum without any repainting entanglement that cannot be cloned or obtained help it be a technological innovation for both 6G and outside approaches. Nawaz et al. (Nawaz et al., 2019) have proposed quantum technologies, which are used to protect fundamental security by using quantum key distribution models. Hu et al. (Hu et al., 2016) conjecture that numerous diverse manners of quantum encryption and other processes could be asked to ensure fully protected quantum communications.

IoE

The Internet of Everything (IoE) encircles information, people, the Internet of Things (IoT), and processes. IoE assembles around IoT's concept focused on linking network devices equipped through the internet with technical sensors. The sensors can discover and respond to changes within their environment, including light, temperature, sound, vibration etc. As the first security area, user authentication has been implemented to block unauthorized entry; it is also the primary line of protection. Cyber security incidents have been associated with IoE in industries and sectors, such as atomic facilities, metal electricity grids, mills, drinking water supplies, hospitals, etc.

Additionally, it is anticipated that the amount of damage will rise by 32%, or 17.7 trillion bucks, by 2020. However, traditional user mechanics are ineffective at dealing with this new circumstance. Therefore, Ding Wang et al. propose a simple short encryption scheme in line with the sliding window method, enhancing work efficiency and reducing storage and computational burden(Di. Wang et al., 2018).

Molecular Communication

Molecular communication security issues are associated with communication, authentication and encryption. Farsad et al. (Farsad et al., 2016) discussed that a few experiments had suggested the protection of molecular network communication because such a connection could be interrupted by an adversary. Lu et al. (2015) proposed a coding scheme that would improve the security of the transmitted data in 2015. Additionally, Loscri et al. (2014) implemented some critical directions for molecular communication, facilitating the development of new authentication mechanisms to protect data security. So it is time to build some workable molecular communication methods for 6G network security.

OPEN CHALLENGES OF 6G

This section introduces a wide range of challenging issues and future directions for 6G network security research. Comprehensive research attempts have been as discussed in the previous section; however, issues and challenges continue being open at the time of writing. Table 4 presents some novel challenges of 6G and their possible solutions.

Blockchain-Enabled Authentication and Security

With More than 50-billion IoT and UEs devices linked, 6G may require an approach to guarantee cellular data volume across a collection of programs that obey strict security and privacy conditions. Blockchain technical advancement will play a significant role in identifying and encrypting future communication systems. Some enjoyable implementation instances would involve dispersed safety direction for IoT in edge computing, content and NFV caches. Behnaam et al. in (B. Aazhang and et al, 2019) described some perceptible challenges in 6G such as massive connectivity in future systems, security requirements for potential cloud computation, higher data utilization for advanced applications, device resource restrictions.

Network Security

Security and privacy are the main challenges in the 6G network. Because these technologies are widely used not only for smartphones but also in the development of Artificial Intelligence wearable devices, smart home, city, hospital and satellite technologies, security methods employed in 5G would not be effective in 6G. Modern security techniques using advanced cryptographic technologies, such as physical layer encryption techniques and an adaptive network security system, must be addressed (Nayak & Patgiri, 2020) with low prices, lower complexity and excessive security.

TeraHertz Band

The THz band has fast data rates and high 6G frequencies, but this will become a significant challenge due to losing a high path. If data travel for long-distance communication, the propagation and atmospheric absorption losses are very high. It is a big challenge for future research and needs to resolve as early as possible. The challenge from the 6G communicating process would be the THz band. Ambient absorption and loss of transmission are very high in long-distance communication. That really can be an essential issue that needs to be dealt with.

Moreover, new multipath channel models are required to resolve this problem (Akyildiz et al., 2014). The modulation, along with also coding techniques, is not satisfactory for the THz band. Since the expansive data transfer capacity, the multipath channel resolves the issue of frequency dispersion. Present modulation and coding techniques are not successful in the THz band—the most significant obstacle for researchers to introduce modern modulation and coding techniques. New transmitter architecture should have high data transfer capacity, efficiency, and impact ability. Additionally, high power and frequency are significant challenges for the researcher because they directly affect the human body.

Autonomous Wireless Systems

Only the 6G system can have complete assistance for development approaches such as Autonomous Vehicles, UAVs and AI-based Business 4.0. To build new technologies, people now want to own systems devices, interoperable processes, for example, autonomous computer systems, the program

Table 3. Security attacks and their impact on 6G key technologies and applications

SECURITY ATTACKS	COUNTERMEASURE TECHNIQUES	KEY 6G APPLICATIONS							
		UAV	Holographic Telepresence	Extended Reality	Connected autonomous vehicles	Smart Grid 2.0	Industry 5.0	Hyper-intelligence health	Digital Twin
AI/ML									
Poisonous attacks	Moving target defense/ Input validation	*			*		*	*	
Evasion attacks	Defensive distillation/ Adversarial training	*			*	*	*	*	
Infrastructure physical attacks & communication tampering	Use tamper-proof hardware	*			*	*	*	*	*
Compromise of AI frame-works	Security solutions for software, firmware and hardware.	*	*		*	*	*	*	*
ML API-based Attacks	Control information provided by ML APIs	*			*	*	*	*	
Model inversion attacks	Noise injection	*			*	*	*	*	
Model extraction attacks	Control information provided by ML APIs/ Noise injection	*			*	*	*	*	*
Adversarial attacks	Defensive distillation/ Adversarial training/ Input validation	*			*	*	*	*	
Privacy attacks	Differential privacy/ Homomorphic encryption.		*					*	*
BLOCKCHAIN									
Majority/ 51% attack	Select proper DLT architecture.	*			*	*	*	*	*
Double-spending attacks	Protect transactions.	*		*	*	*		*	
Re-entrancy attack	Use security check tools.	*			*	*	*	*	
Sybil attacks	Use strong authentication and access control mechanisms.	*	*	*	*	*	*	*	*
Authentication access control attacks	Use robust authentication and access control mechanisms.	*	*	*	*	*	*	*	*
Security misconfigurations	Identify semantic flaws.	*	*	*	*	*	*	*	*
Privacy attacks	Privacy by design approach.		*	*	*	*		*	*
QUANTUM COMPUTING									
Quantum cloning attack	Uncloneable encryption mechanisms		*						*
Quantum collision attack	Quantum resistant encryption solutions		*						*
VLC									
Authentication/ access control attacks	Location-based authentication				*		*		
Eavesdropping	Artificial noise-assisted visible light MIMO beamforming				*		*		
Jamming and data modification attacks	ML techniques to learn the environment in real time				*		*		
THz									
Authentication access control attacks	Electromagnetic signatures for physical layer authentication	*			*		*		
Eavesdropping	Characterization of the backscatter channel / Exploiting multipath.	*			*		*		
MOLECULAR COMMUNICATION									
Authentication access control attacks	Biochemical cryptography.							*	

of approaches, ML, autonomous clouds, the convergence of many heterogeneous subsystems, and heterogeneous wireless systems (Elliott et al., 2019). Thus, the system development gets challenging as well as increasingly complex. By way of example, developing an entirely autonomous technique because of the driverless motor automobile will likely soon be harder since 6G engineers need to design fully automated self-driving motor automobiles that work better than human-controlled cars.

Despite the Significant Potential of 6G, Several Challenges Must Be Addressed for Successful Adoption

Technological Limitations

Harnessing the Terahertz frequency band for communication in the context of 6G networks poses significant technological hurdles. These challenges primarily stem from the characteristics of the Terahertz spectrum, including high propagation loss, limited penetration capabilities, and substantial molecular absorption. Propagation loss refers to the attenuation of electromagnetic signals as they travel through a medium, and in the case of Terahertz frequencies, this loss is particularly high due to factors such as atmospheric absorption and scattering. As a result, transmitting signals over long distances becomes problematic, requiring innovative solutions to mitigate signal degradation. Moreover, Terahertz waves exhibit poor penetration capabilities, struggling to pass through obstacles such as walls, buildings, and even clothing. This limitation restricts the range and reliability of Terahertz-based communication systems, necessitating alternative strategies to ensure adequate coverage and connectivity. Addressing these technological challenges requires interdisciplinary research efforts encompassing areas such as antenna design, signal processing, materials science, and atmospheric physics. Innovative approaches, such as advanced signal modulation techniques, adaptive beamforming, and atmospheric modeling, may help overcome the limitations associated with Terahertz communication and pave the way for its integration into future 6G networks.

Table 4. 6G Key Challenges and their possible Guidelines

Technology	Key Challenges	Possible Solutions
Blockchain	➢ Additional computational, energy and financial overheads to operate the Blockchain. ➢ Lack of quantum resistance in computation oriented consensus algorithm.	➢ Design of quantum resistance lightweight consensus algorithm based on random processes in wireless communication. ➢ Develop AI based storage recycling and transactions prioritization mechanisms.
AI and FL	➢ New Security, privacy and ethical issues. ➢ Hardware Heterogeneity.	➢ Leveraging emerging technologies like Blockchain to design new security and privacy mechanism. ➢ Deploying edge AI to overcome the limitation and heterogeneity of IoT and mobile accessories.
Quantum Communication	➢ Long distance quantum communication. ➢ Secure Communication.	➢ 1st, 2nd, and 3rd generation quantum repeaters. ➢ Quantum key distribution protocols.
Non- Terrestrial Networks(NTN)/ 3D Networking	➢ Optimal placement of UAV ABS in 3D space. ➢ Real-time access to powerful computational resources.	➢ Efficient modelling of UAV integrated 6G networks. ➢ Extended processing to the edge 3D network.
Large Intelligent Surfaces	➢ Analysis and improvement of spectral efficiency is an aspect that requires more efforts.	➢ New channel models specific to LIS – controlled wireless environment are required.
ZSM	➢ Scalability, Security and Computational Complexity.	➢ Blockchain, AI, Smart Contracts and their integration.
Swarm UAVs	➢ Vulnerable for physical tempering and jamming.	➢ Computational offloading to edge networks and Global level standardization.

Energy Efficiency

As networks evolve to become more intricate and robust, the issue of energy consumption emerges as a critical concern. The exponential growth in data rates is placing unprecedented demands on network infrastructure, raising apprehensions about the sustainability of current energy consumption levels.

Security and Privacy

As we advance towards the era of 6G, the network's hyper-connectedness, coupled with the incorporation of AI and other cutting-edge technologies, substantially expands the potential attack vectors. Consequently, there arises a pressing need for the development of innovative security measures and privacy-enhancing techniques to safeguard against emerging threats and vulnerabilities. These measures must adapt to the evolving landscape of network architectures and communication protocols to ensure robust protection against cyberattacks and preserve user privacy in an increasingly interconnected digital ecosystem.

Regulatory and Standardization Issues

The anticipated arrival of 6G heralds a transformative era characterized by a plethora of groundbreaking technologies, services, and applications. However, with these advancements come inevitable regulatory and standardization challenges that demand prompt attention and resolution. As 6G networks promise to revolutionize communication capabilities, regulatory frameworks must evolve to ensure seamless integration and compliance with evolving technological standards. Additionally, standardization efforts must keep pace with the rapid innovation in 6G technology to facilitate interoperability, compatibility, and global adoption. Addressing these challenges effectively is paramount to unlocking the full potential of 6G and realizing its benefits across diverse industries and societal domains.

FUTURE RESEARCH DIRECTIONS

Adaptive MI-Enabled 6G

Adaptive machine learning-enabled 6G uses dataset at a centralized location and sends model parameters to end devices that update global learning models using their local datasets avoiding resource fairness challenges. Currently, two models are working in Adaptive ML. Federated learning and Distributed learning models are used for the dataset at a centralized location. In compression of Federated Learning, Distributed Machine Learning avoids resource fairness challenges because of one time-sharing of learning model parameter between the central server and end machine.

Scalable and Reliable Blockchain-Enabled 6G

Scalable and reliable blockchain-enabled 6G offers enhanced reliability and scalability while providing trade-offs between fault tolerance, security, and latency. Low-Latency and Robust consensus algorithms play a significant role in the blockchain enabling 6G systems to increase efficiency and scalability while offering trade-offs between fault-tolerant, security, and latency.

6G Network-as-an-Intelligent-Service

Network Intelligentization will enable 6G systems for efficient network management like the cost-efficient implementation of different networking functions on generic hardware using virtual machines. Network slicing includes two primary SDN and NFV enablers. SDN provides the facility of effective network management. Intelligentization would require 6G networks to be deployed to change the various parameters efficiently while delivering enhanced Performances.

Zero-Energy-Enabled 6G

A 6G wireless communication system must use renewable energy and radio-frequency-harvesting energy for its operation. The zero-energy wireless technology must return the same volume of electricity to the grid during excessive radiofrequency energy production to compensate for the resources obtained from the grid.

As we look ahead to the coming decade, the evolution towards 5G beyond/6G networks promises to deliver technologies and services that are exponentially faster than current offerings. These advancements will have far-reaching implications across various sectors, including end-users, communications, businesses, and governments. However, alongside the benefits of increased speed and efficiency, there is a corresponding rise in the potential for cyber threats and security vulnerabilities. The expanded attack surface posed by faster technologies poses significant risks to societies, businesses, and other entities. Moreover, the conventional security measures employed in 4/5G networks may prove insufficient to safeguard the increasingly complex and dynamic landscape of 6G networks. Therefore, there is a pressing need to reimagine security strategies to ensure the confidentiality, integrity, availability, and authenticity of future networks. Additionally, privacy-by-design principles must be ingrained into the fabric of 6G networks to address concerns surrounding data privacy, location privacy, identity privacy, and the privacy of other metadata. In essence, researchers must embark on the development of innovative security and privacy solutions tailored to the unique challenges of 6G networks. These solutions should leverage emerging technologies such as quantum computing to enhance resilience against sophisticated cyber threats. Furthermore, there is a need to strike a balance between affordability and robust security, ensuring that these solutions are accessible while providing robust protection against evolving threats.

CONCLUSION

The standardization of 5G wireless networking was completed successfully. The 5G technology hopefully certainly has been widely available starting in 2020, and experts are focused on the investigative process of 6G wireless communications to provide excellent 6G communication services in 2030. The 6G system will bring network support to higher levels than the past generations. This article analysed a thorough report on the security problems associated with 6G wireless communication networks. First, we present the evolution and security threats landscape from 1G to 6G networks. Then we explored the potential applications of 6G networking technologies. Finally, this paper concludes with a detailed discussion of security issues, research challenges, possible solutions and future research direction in 6G that enable critical technologies. Finally, it outlines the opportunities and directions to accomplish the target of 6G connectivity. We assume that this review will encourage the researcher's involvement in more study into the security concerns and vulnerabilities of the 6G network.

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LIST OF ACRONYMS

AI - Artificial Intelligence
1G - 1 Generations
2G - 2 Generations
3G - 3 Generations
4G - 4 Generations
5G - 5 Generations
6G - 6 Generations
AR/VR - Augmented Reality/Virtual Reality
BCI - Brain-Computer Interactions
BS - Base Station
CDMA - Code Division Multiple Access
CRAS - Connected Robotics and Autonomous Systems
DLT - Distributed Ledger Technologies
DoS - Denial of Service
DRL - Deep Reinforcement Learning
DVB - Digital Video Broadcasting
EI - Environmental intelligence
GSM - Global System for Mobile Communications
IEEE - Institute of Electrical and Electronics Engineers
IoE - Internet of Everything
IoT - Internet of Things
IP - Internet Protocol
MAC - Medium Access Control
MIMO - Multiple Input and Multiple Output
MIMP - Mitigation Implementation and Monitoring Plan
MITM - Man in the Middle Attack
ML - Machine Learning
MMS - Multimedia Messaging Service
MMTC - Massive Machine-Type Communication
NFV - Network functions virtualization
NGI - Next Generation Internet
NP - Nondeterministic Polynomial Time
OI - Operational intelligence
SDN - Software-Defined Networking
SI - Service intelligence
TDMA - Time-division multiple access
UAV - Unmanned Aerial Vehicle
UMTS - Universal Mobile Telecommunications System
URLLC - Ultra-Reliable Low-Latency Communication
VLC - Visible Light Communication
VR - Virtual Reality
WCDMA - Wideband Code Division Multiple Access
XR - Extended Reality

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