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6G Internet of Things: Issues, Challenges and Applications

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Abstract- Wireless communication is widely used in variety of applications for transmission of data, information, audio, video, radar and satellite signals. Wireless internet is utilized for data communication all over the world. Internet of Things (IoT) is current trends and it is used in majority of applications including health care, air pollution and water quality monitoring, process industries, agriculture, waste management, accident monitoring, home automation, smart grid, security systems etc. This proposed work discusses the development of upcoming 6G IoT technologies, its features, benefits, issues and solutions. The various security issues and application areas of 6G technologies are analyzed. The various key performance indicators related to 6G networks such as peak data rate, mobility requirements, coverage, spectral efficiency, connectivity density, latency, reliability, maximum operating frequency and energy efficiency are discussed in this work. This work will become useful for researchers to work towards developing, analyzing and rectifying the various issues and security threats related to 6G networks and to create 6G technologies more efficient. The role of 6G in IoT will increase the network coverage area, less energy consumption, cost-effective solutions, improved security, higher data transfer rate, wider bandwidth, utilization of various communication techniques, wide range of smart applications and services. The sixth generation will become very much useful for consumers, industries and government organizations to strengthen their communication capability.

Keywords— Internet of Things, 6G, Wireless Networks, Security, Applications

I. INTRODUCTION

The future generation of wireless communication is sixth generation (6G), which is entirely dynamic and more complexity. Sixth generation (6G) wireless network technology is expected to offer huge area of coverage, low power consumption, comprehensive spectral, and cost-effective with enhanced security. The deployment of modern technologies including channel coding, cloud edge computing, multiple accesses, network slicing, tremendous antenna technologies in 6G networks to meet the future needs. The upcoming 6G technology provides combined air-ground-space-sea communication network by distributed global and local networks. The focus of 6G in IoT are Industrial Internet of Things (IIoT), Satellite Internet of Things (SIoT), Healthcare Internet of Things (HIoT), Vehicular Iinternet of Things (VIoT), and Unmanned Aerial Vehicles (UAV). The modern radio frequency spectrum will increase network traffic capacity, data speed, including millimeter-wave, sub-6 GHz, terahertz, and optical communications. The key applications and state-of-the-art approaches of Integrated Sensing and Communications is proposed [1]. The performance between sensing and communication is analyzed from message to physical layer, and the cross-layer design. The 6G network will enable a new generation of intelligent applications and services using recent trends which are artificial intelligence (AI) and big data in response to the large datasets produced by diversified networks with various communication schemes, large bandwidths, a huge number of antennas, and modern 6G applications requirements. A privacy-preserving energy harvesting scheme for 6G-enabled IoT is proposed [2]. A secure and smart energy harvesting technique is designed, which includes a differential privacy-based energy harvesting mechanism. The energy efficiency of 6G network should have ten-time increase over 5G networks and a hundred-time increase over 4G networks. The state-of-the-art characteristics of Internet of Wearable Things (IoWT) are proposed to determine its advancements and benefits from 6G technologies [3]. IoWT oriented 6G technologies including long-range low-power communications, ultra-reliable low-latency communications, and in-network intelligent computing services are discussed.

Wireless communication system is the most essential components of Internet of Things (IoT) infrastructure. This element serves as the bridge for dual communication for control message delivery and collecting the data. In IoT, a large number of users devices with sensors or without sensor are linked and communicate through tactile Internet. The fundamental feature of IoT is it allows real-time communication among systems with a range of activities of community, and commercial use. The advancement of ultra-dense heterogeneous network deployment, high capacity, low bit error rate, and modern applications creates a new framework for wireless communication. The sixth generation wireless networking produces several challenges towards network functions, management, planning, designing, and troubleshooting. The production and utilization of wireless information is transferring from human-centric to machine-oriented communications, making future wireless network operations even more complex. The 6G system is analyzed with respect to the various scenarios, needs, characteristics, challenges, performance indicating parameters, architecture, and enabling technologies [4, 13, 16, 22]. Industries and institutions should focus towards next generation technology. The new methodologies for employing distributed computational means with better context perception will become increasingly essential in order to minimize the complexity of future wireless network operations. The future 6G vehicular intelligence and its networking, communications, computing and intelligence are discussed [5]. In 6G technology, vehicles may become another essential needs for people besides smartphones, and non-polluting, highly safe as well as full-autonomous vehicles. The role of blockchain for 6G technology and requirements are discussed [6]. The issues in deployment are addressed while combining blockchain in 6G and its possible solutions. The sixth generation features and applications that are not supported in 5G network is proposed [7]. 6G technologies with respect to interactivity, intelligence and connectivity are discussed. The state-of-art technologies and development towards 6G revolution is proposed [8]. The frameworks for present and ongoing research projects and activities, are reviewed. The various technological advances towards 6G including intent-based networking, TeraHertz communication, artificial intelligence, blockchain, smart devices communication, and quantum communication are focused [9]. These technologies will explore 6G to be more suitable for future network services and applications. The major issues in 5G and 6G networks arrangement and the usage of Artificial Intelligence-driven solutions are addressed [10]. 6G networks will increase the number of services offered over various technological areas. The characteristics of network concentration in terms of both base station and end device densification are investigated [11]. The design aspects for the future multi-tier heavy network related to base station and end device densification is provided. The various issues in the 5G communication network which drives research towards 6G communication network is addressed [12]. The objectives, design principles and the case-study of 6G architecture operational design is done. The security and privacy issues related to 6G in the physical, connection, and service layers are discussed [14, 23]. 6G networks are vulnerable to modern threat vectors from new radio technologies, such as the exposed location of radio stripes in ultra-massive MIMO systems at Terahertz bands and attacks against pervasive intelligence. The various needs to develop 6G network architecture is presented [15]. The essential networking and communication methodologies required to design the 6G networks are discussed. The services provided by IoT are integrated with cloud computing, edge computing and big data technologies [17]. It provides consumers safety and efficient environment for browsing the Internet, exchanging and managing huge number of data.

Table 1 shows the various generations in networking and its target applications. First generation (1G) is introduced in the year 1980 and it is developed for communication of voice signal over telephone. The voice signal is transmitted and received between the sender and the receiver. The second generation (2G) is developed in the year 1990 and its operation is sending and receiving text message through Short Messaging Service (SMS) technology.

Table 1 Network generations and its target applications

Technologies	Developed Year	Usage
1G	1980	Voice communication
2G	1990	Text message
3G	2000	Internet access
4G	2010	Internet of applications
5G	2020	Broadband and IoT
6G	Expected in 2030	Full digital and connected world

The third generation (3G) technology came to market in the year 2000 and it is focused on providing the internet access to individuals and corporate networks. The fourth generation (4G) is developed in the year 2010 and the internet is utilized communicating the information in various applications. The fifth generation (5G) is developed in the year 2020 and the usage of broadband services came into effect. Many internet service providers offered broadband services to the public and private organizations. Industrial devices and home appliances are enabled with internet to access the data anywhere by using the concept of IoT. The research and development towards sixth generation (6G) technologies is on-going and its target is to develop entirely digital operations and to utilize digital networks for information transmission across various applications.

The 6G technology will be transformative and will modify the wireless evolution with more demanding requirements such as higher capacity, lower latency, wide connectivity, greater security, high quality of experience, low consumption of power, and stable link. The 6G network dimensions towards air interface and related potential technologies is proposed [18]. The various research challenges including hardware complexity, variable radio resource allocation, pre-emptive scheduling, power efficiency, security and privacy are discussed. The key performance indicators needed for 5G and 6G networks are proposed [19]. The challenges related to pilot contamination, channel estimation, precoding, user scheduling, energy efficiency, and signal detection in a massive MIMO system are addressed. IoT-oriented wireless network operation is a challenging task for managing the large aspects in heterogeneous traffic including meeting all service-quality criteria such as monitoring network reliability, managing data security, achieving a cost-effective way for an effective network deployment, exploration with a focus on distant and stand-alone locations, reducing the cost of wireless communications use, increasing the life time of mobile battery, and to accomplish high data rate. The challenges and vision of various communication industries and different layers in 5G IoT systems are discussed [20]. The fourth generation network is not enough and efficient to establish connectivity between multiple devices, high data rate, large bandwidth, low-latency quality of service, and low interference. The four element multi-band multi-input multi-output (MIMO) antenna system for 4G, 5G and IoT applications is proposed [21]. It is applicable for usage in 4G as well as 5G networks and internet of things devices.

Figure 1 shows the core applications of 6G networks. The sixth generation technology is to be utilized in vast range of applications that are smart home, IoT, security systems, autonomous vehicles, Unmanned Aerial Vehicle (UAV), blockchain, renewable energy, big data analytics, 3D scanning, wearable sensors, cloud computing, robotics, artificial intelligence, etc. The technologies for 6G to enable mobile Artificial Intelligence (AI) applications, and AI-enabled techniques for design and optimization of 6G network is discussed [24]. Artificial Intelligence will play a major role in developing and optimizing 6G architectures, protocols, and operations. The solution for deployment of 5G or 6G and IoT devices is provided for optical wireless communication technologies [25]. These include visible light communication, light fidelity, optical camera communication, and free space optics communication. IoT with 6G networks are very much essential for factory automation, diagnosing the patients admitted in emergency ward, industrial safety and security applications, home automation, military, satellite communications, aircraft and automotive applications, smart grid, building automation, smart traffic management, smart cities, future agriculture, condition monitoring of complex industrial devices, operator safety, banking sectors, early detection and prevention of natural disasters such as earthquake, tsunami, floods, etc. The emotion-aware healthcare system is proposed using a strong emotion detection module [26]. The various IoT devices are utilized to acquire speech and image signals of a patient in a smart home. The noise signal exists in physical layer and network capacity improvement in IoT based cognitive MIMO-OFDM (Multi-Input Multi-Output - Orthogonal Frequency Division Multiplexing) systems is presented [27]. The noise signal is removed to the primary consumer through a low complexity subspace projection technique.

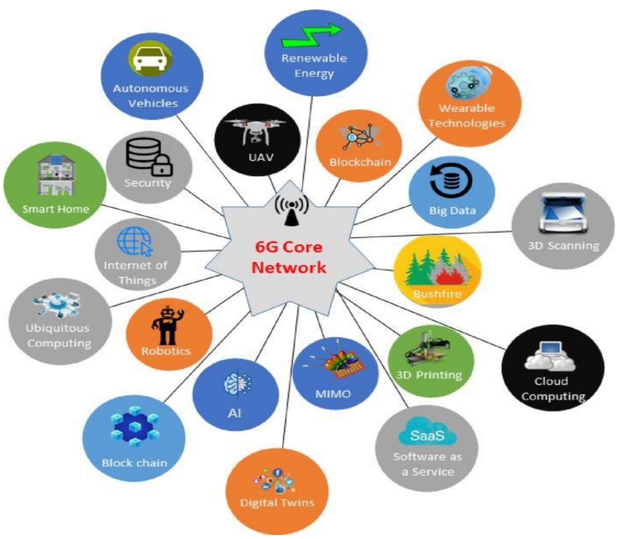

Figure 1 Applications of 6G Networks

The overview of millimetre-wave 5G antennas for cellular handset is proposed [28]. The two types of mesh-grid phased-array antennas featuring reconfigurable horizontal and vertical polarizations are designed, fabricated, and measured. The network capacity is enhanced through the proposed user grouping approaches in massive Multi-Input Multi-Output (MIMO) systems [29]. The concept of overlapping user grouping is introduced by accomplishing the favourable propagation property in massive MIMO systems. The UAV (Unmanned Aerial Vehicles) aided wireless communications is summarized by introducing the basic networking architecture and main channel characteristics [30]. The key performance indicators are highlighted by using the UAV controlled mobility. The issues in design of backhaul network using the optical fibers and hybrid radio frequency backhauls and free space optics technologies are addressed [31]. The design of network can be examined by taking into account the varying reliability of hybrid radio frequency backhauls and free space optics networks.6G technologies will offer several advantages including high speed, large number of devices connection, reduces the majority of manual work and focuses towards automation. This upcoming 6G will be a great benefit for medical doctors, automotive industries to upgrade their standards, bank customer services, smart mobile service providers, industrial owners, and government sectors.

II. SECURITY ISSUES IN 6G NETWORKS

The major security and privacy issues in the 6G networks are authentication, access control, malicious behavior, data confidentiality, and integrity. The closed loop network automation may introduce security threats such as Denial of Service (DoS), deception and Man-In-The-Middle (MITM) attacks. DoS attacks can be performed by sequentially adding fake heavy load in virtual network functions to increase the capacity of virtual machines. The higher data rates in the advanced mobile broadband will create challenges regarding traffic processing for security such as identification of attacks, analysis of traffic pattern and pervasive encryption. The major security challenge is implementing the security mechanism in the resource constrained devices. When the security mechanism becomes more complex, then the high performance hardware is required to take up additional computational capability, high power to execute the algorithm and high speed.

The first generation (1G) network was developed in the year 1980, especially for voice communications services. The data transmission takes place for voice communication using analog modulation. This generation has multiple problems, including no assurance on security, low distance and speed. The data transmission in telephone communication has no guarantee because the data is not encrypted and no privacy. The entire network and its consumers are affected due to security vulnerabilities such as third party access, and no confidentiality of message.

The second generation (2G) network is based on digital modulation technique which is Time Division Multiple Access (TDMA) to enable voice and short messaging services. The Global System for Mobile Communications (GSM) standard introduced which offers security services such as authentication, and protection of data transmission, privacy, and personal information. Authentication mechanism is utilized by the Network service providers to determine and authorize users. The data is converted into unreadable cipher text by the process of encryption. Encryption preserves the user messages and ensures confidentiality. The privacy is achieved through Temporary Mobile Subscriber Identity (TMSI) and radio path encryption. Unfortunately, there exists more vulnerability in 2G network security. The lack of security mechanism in 2G network is one-way authentication in which the network can authenticate the consumer, but the consumer cannot be authenticated against the network. This leads to the unauthorized base stations serve as authorized members to steal consumers data and private information. In addition, the issue regarding end-to-end encryption problem occurs in one-way communication link is encrypted. The link is subjected to security attacks due to unencrypting of other parts of the network. The TMSI privacy solutions and radio path encryption are not enough to preserve 2G networks and are vulnerable to variety of intrusions.

The 3G network was developed in the year 2000 to enhance the data transmission rate upto 2 Mega-bits per second and provide access to the internet. The third generation network focus on number of the security threats present in 2G networks. The two-way authentication and key agreement is enabled in 3G networks to authenticate both sender and receiver. It establishes entire access control security mechanism, including space interface security and user authentication. The security of the space interface is used to preserve communications over wireless medium and consumers. Internet Protocol (IP) susceptibilities and attacks are the major threat to 3G networks. The attacks on communication link between the source and the destination as well as local networks also create 3G network threats. The threats on wireless networks are classified into unauthorized information access, unauthorized network access, integrity threats, and denial of service (DoS) attacks.

III. SECURITY ISSUES IN 4G AND 5G NETWORKS

The fourth generation (4G) network offered upto 1 Giga-bit per second speed for downlink transmission and 500 Mega-bit per second for uplink communication. The huge spectrum efficiency and low latency is achieved in 4G networks. The 4G networks are capable of performing complex applications such as High-Definition Television and digital video broadcasting. The security issues of 4G networks are unauthorized access of wireless radio link, eavesdropping, network authentication, tampering, and data modification. The 4G network is more susceptible to security attacks than previous mobile radio networks due to the large number of indirect connection between consumers and mobile devices. The 4G standards and protocols face various Medium Access Control (MAC) layer susceptibilities, including eavesdropping and replay attacks. The 4G networks are also vulnerable to data integrity attacks, issues of unauthorized access, and location tracking using the MAC layer protocols.

The fifth generation (5G) network achieves enhanced data rate and usage of complex devices and highly secured architecture. The key feature in 5G is it offers ultra-reliable and low-latency communication. The network coverage of 5G increases and it allows more number of devices connected with high quality of service achieved. The architecture of 5G network is analyzed to classify the security and privacy threats. The 5G network architecture consists of includes core networks, backhaul networks, and access networks. The security threats become high due to the usage of large number of devices and network access methods in 5G networks. Backhaul networks present between the access and core networks and it is connected using microwave links, wireless medium, satellite communications, and conventional transmission cables. The modern technique utilized for increasing the data transfer rate create security vulnerabilities. The 6G network will have huge security criteria and require larger network coverage than ew 6G applications will have more criteria and need greater network capacity than 5G networks. The highly efficient security solutions are required to confirm service and network resources availability.

Challenges in 6G Networks

The challenges of 6G technologies are architectural design, supporting technologies, security issues and its solutions. The various security attacks against 6G network architecture and applications are Denial of Service (DoS), Distributed Denial of Service (DDoS) against authentication servers, energy depletion attacks, and user tracking. The major challenges in 6G networks are security and energy efficiency. The data security becomes challenging task due to the more number of devices connected in 6G networks. The security issues greatly impact on all networks are lack of authentication mechanism and resource constraints. The energy efficient hardware is required to compile complex security algorithms. The key technology to be focused in 6G are hybrid architecture, enabling devices more smart through artificial intelligence and machine learning algorithms, and proposing application-specific design. The 6G network architecture should be entirely flexible to provide the dynamic networking topology to serve any given data consumption model between communication end devices. The sensor nodes become hybrid and it is widely utilized for network operations.

The deployment of 6G in IoT generates different forms types of traffic, power consumption, bit rates, reliability, security and privacy. The objective of this work is to address the IoT-oriented 6G cellular network to meet the data needs that are expected by increasing with the deployment of a massive number of devices. Now-a-days, smartphones and smart sensors are used by large number of people. Most of the electronic instruments are enabled with the internet that allows accessing of data world-wide. The usage of smartphone increases rapidly and it would reach eighty billion by the end of the year 2030.The easier the datais accessible and collectable in 6G technology leads to the huge risk of security and privacy protection. The detailed analysis towards technology is required for designing and deploying 6G in IoT.

Table 2 Comparison of 5G and 6G Technologies

Key Parameters	5G	6G
Coverage	About 70 %	Above 99%
Network Latency	1 ms	10-100 µs
Connectivity density	10^6 devices/km^2	10^7 devices/km^2
Highest data rate	20 Gigabits per second	100 Gigabits per second
Mobility support	350 km/hour	More than 1000 km/hour
Receiver sensitivity	About -120 dBm	Less than -130 dBm
Mobile Traffic Capacity	10 Megabits/second/m^2	1 Gigabit/second/m^2
Satellite Integration	No	Fully
Maximum Spectral Efficiency	30 bits per second/Hz	100 bits per second/Hz
Maximum frequency	90 Giga Hertz	1 Tera Hertz

Table 2 indicates the comparison of key parameters on 5G and 6G technologies. The coverage of 6G network is highly improves as compared to 5G network. The sixth generation technology achieves higher data transfer rate of 100 Giga-bits per second which is five times greater than 5G technology. The target of 6G network is to connect billions of network devices to exchange data, and information. The devices to be used in 6G networks require stable battery power for network operations. The security issues becomes very high and lot of challenges takes place in 6G networks to achieve quality of service.

IV. 6G INTERNET OF THINGS

The 5G networks has started to operate worldwide and the target of 5G is to enhance the usage of IoT technologies and applications with connecting the large, ensuring secure operations and less amount of delay in exchange of information. The fifth generation is not adequate for IoT devices to communicate various types of information in real time applications. Due to these limitations, 6G technologies are preferred to enhance network coverage, to reduce the delay in data transmission, and to achieve higher data transfer rate than 5G networks. The research and development towards 6G technology is a very early stage. 6G is expected to be developed around the year 2030. The sixth generation technology creates a great impact on the communication of data, information, audio, video and satellite signals. 6G will change our life style and working style and utilization of internet in majority of applications. 6G is related to the connection of mobile networks, Wi-Fi devices, internet enables industrial operations and security functions. 6G becomes the future of wireless internet and it is used in wide variety of applications for exchanging information all over the world. The 6G technologies includes advances in automation and networking of automotive vehicles, mobile phones, homes, drones, and industries. 6G also include artificial intelligence and edge computing to create networks more intelligent, and to achieve high speed internet operations. A 6G base station is a wireless communications station used to receive and send cellular signals. IoT based 6G wireless networks will be preferred in processing large amount of incoming data from the sensors. The individual's quality of life improved in smart cities which offer effective space utilization, traffic reduction, and pollution free environment.

The upcoming sixth generation cellular communication will integrate several communication equipment ranging from sensors to High Definition video transmission equipment, link with high-speed trains and aircraft. The design complexity of hardware will increase due to the variable data size need to be transmitted. The bandwidth of 6G network will be higher, ranging from 3GHz to 60GHz. The highly efficient hardware is required to enable data transmission at any frequency in this band. The design of RF filters, amplifiers, and antenna should support 6G networks. The multi-stage signal processing is essential to take-up the data communication across 6G networks. The lot of research challenges exists for 6G networks and researchers should focus on various issues and to develop efficient 6G communication technology.

V. CONCLUSION

The advent of wireless communications systems has offered higher data transfer rates and wide range of applications. The future 6G technology will create new challenges related to network coverage, speed, number of devices connection, security and target applications. This proposed work is the extensive review of various network generations, its challenges and solutions. This work focuses on 6G technologies, issues in implementing 6G in real-time applications and the target applications. 6G technology of mobile networks will setup modern standards to accomplish unreachable performance requirements in 5G networks. The developing 6G networks will have the ability to reach high-performance connectivity with large numbers of devices connected. The target of 6G technologies is to make fully digital world and enabling devices used in satellites, industries, hospitals, automobiles to transmit data across digital networks. This work enables the researchers and scientists to work towards the essential requirements of 6G technologies including security, target applications, automation, latency in processing, and energy efficient operations before implementation in real-time applications.

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