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6G WIRELESS NETWORK: POTENTIAL ARCHITECTURE AND APPLICATIONS

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ABSTRACT

The standardization activities of the 5G communications are clearly over and deployment has commenced globally. To endure the competitive edge of wireless networks, industrial and academia synergy have begun to conceptualize the next generation of wireless communication systems (namely, sixth generation, (6G)) aimed at laying the foundation for the communication needs after a decade. A new wireless communication system integrated with artificial intelligence and blockchain technology is expected to be launched between 2027 and 2030. Though 5G has not been launched worldwide yet there are some major concerns, that can be addressed. These concerns may include improved QoS, low latency rate and higher system capacity. This paper presents the architecture and some of the applications of future 6G wireless communication and its network architecture. Many of the emerging technologies such as artificial intelligence, blockchain technology, quantum communications, terahertz communications, three-dimensional networking, big data analytics that can assist the 6G architecture development in guaranteeing the QoS will be discussed. We present the expected applications with the requirements and the possible technologies for 6G communication. We also outline the possible applications and research directions to reach this goal.

Keywords

5G, 6G, QoS, Blockchain technology, artificial intelligence, quantum communications

1. INTRODUCTION

There is a massive increase of traffic in the network, due to the hasty growth of numerous incipient applications in this COVID19 pandemic. As we are heading in the direction of fully automated remote management systems, there is need for continuous improvement in the communication system. 5G is the main IoE enabler in today's cellular system Era, but still, the initial premise of 5G is yet to be realized in some countries. Going beyond the digital transformation of the 2020s, we envision a future in which human possibilities and capabilities are substantially increased and augmented by 6G technology [1]. The 6G network should be architected to achieve an expansion of human experience across physical, biological and digital worlds while at the same time enabling next-generation industrial operations environment beyond Industry 4.0 in dimensions of performance such as positioning, sensing, ultra-reliability, energy efficiency and extreme real-time. Several recent papers discuss related 6G vision and technologies

[2]–[6]. Note, however, that assuming the lifetime of a network generation is about ten years, 2030 may well be the beginning year of full-fledged uptake of 6G.

6G networks will provide novel radio and access architecture for both communications and sensing purposes, AI optimized wide area network and data center co-design, as well as dynamic orchestration of personalized services to revolutionize the long tail of niche consumer interests. While demand for mobile broadband will continue to increase for consumers and enterprise alike, uptake of ultra-reliable and low latency will be largely driven by specialized and local use cases in conjunction with non-public networks, and often with augmented intelligence. This will happen as integral part of automated and secure network transformation. Objects ranging from cars, industrial machines and appliances to watches and apparel, will learn and organize themselves to fulfill our needs by automatically adapting to our behavior, environment and business processes. Energy efficiency is another key design criterion for the design of 6G, since performance of the network will depend on the energy available in the respective architectural domains.

Therefore, the development of a new communication system i.e. 6G is imperiously needed. During the last few years, traffic has grown enormously because of the introduction of smart devices and machine-to-machine (M2M) communications. Fig. 1 depicts the exponential progress of mobile connectivity. It is anticipated that the worldwide traffic volume will increase

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670 times in 2030 as compared with the mobile traffic in 2010. The International Telecommunication Union (ITU) forecasted that by the end of 2030, the overall mobile data traffic volume will exceed 5 ZB per month.

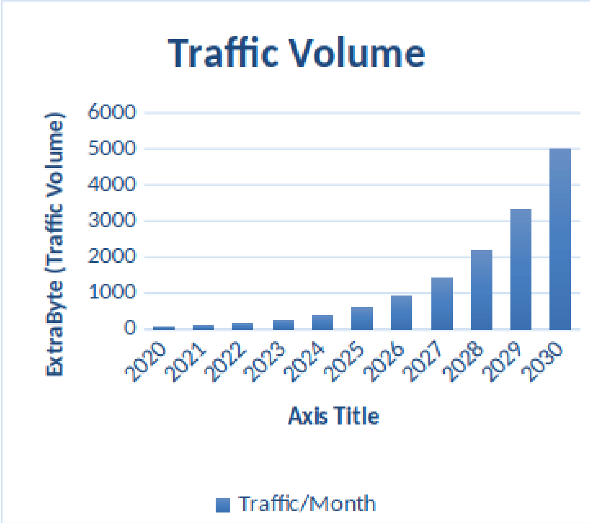

Fig. 1. Global mobile data traffic in 2020-2030 forecast by ITU.

Technologies that may require a sixth-generation (6G) network system may include are ubiquitous computing, multisensory data fusion ,and regulation in sensing and actuation. 6G wireless networks may also help in facilitating Sustainable Development Goals (SDGs). 6G Wireless Network can be thought of as a network having extremely fast data rates , low latency rate, Improved agility and exposure, competent connection and highly unfailing secured network. 6G is expected to have data- rates in the order of terabits per second and a latency of less than 1ms. It is expected to drive the Internet of Everything[7]. Spectrum espoused in 5G was millimeter spectrum having frequency range 30-300GHz , Whereas 6G will have an advantage over previous network system having relatively high frequency spectrum approximately from 300 GHz to 10 THz. Spectrum having higher frequency is much required as what we have seen in this COVID19 pandemic. Everyone is using bandwidth most of the time. So to fulfill the worldwide need of people, 6G will be required in coming years. Apart from providing higher frequency spectrum, 6G communications will provide higher data rates. Though, having so many advantages over 5G networks, there will be some hindrances in 6G while transmitting at a developed frequency range. This and other problems that may be encountered with THz transmissions are discussed in this paper. Additionally, basic architecture and an overview of the future 6G communication system are discussed in this paper.

Fig. 2. 6G wireless Network major Highlights

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Also, the other emerging technologies such as RIS, Artificial Intelligence (AI),Augmented Reality will be discussed in this paper. Nevertheless, there are some tasks with procurement of channel statistics and concerns about health risks There is limited literature to address these concerns; thus, the need for this review. It is also believed that AI is very critical in actualizing 6G. For enabling intelligent networks, Artificial Neural Networks, Deep Neural Networks. Although, at present, it is not possible to predict the future of 6G. Some of the important issues that will be discussed in this paper are (1) increasing wireless connectivity and mobile data • Expected service requirements for 6G networks • comparison of 6G communication systems with 5G systems. • The roles of different technologies in 5G and 6G • Possible challenges and research directions to reach the 6G goal are described.

2. RELATED SURVEY ARTICLES

Several chapters and papers are providing a visualization of the upcoming communication network i.e. 6G mobile networks. Some literature also provides a view on enabling technologies, potential applications, requirements, and potential challenges. The researchers in [1] are providing a user's image of the requirements for the establishment of the 6G network. Researchers also tried to predict some crucial technologies for 6G. In [2] the researchers explained the design principles of 6G, the key driving factors for 6G (i.e., massive connectivity, and time-sensitive/time engineered applications).In [3] authors discoursed the growth of mobile networks from 5G to the 6G network. Precisely in the paper, the authors tried to focus on what can be architectural changes required for shifting 5G networks into the 6G networks. Researchers in [4], present an inclusive depiction of 6G communication networks, future applications, emergent trends, and different challenges. The authors in [5] presented a vision of the 6G for wireless communications and discuss the applications and critical abilities of 6G. They also refer to glsai as a key enabling technology in the 6G era to achieve autonomous networks and produce innovative services/applications. In [6] researchers discussed the different applications from the 6G networks perspective. In [7], the main focus of researchers was to define the need for upcoming wireless communicational networks depending upon the needs of society and technology. Then, the scenarios that may not be possible with the 5G networks, such as holographic communications, smart environments, and high-precision industrial manufacturing are discussed. A similar work is discussed in [8] where the basic 6G network requirements and blueprint of the latest technologies that may be required to implement 6G are discussed. Additionally,

pre-encounters or problems that may be faced during the implementation of 6G are presented. In [9], the researchers highlighted the basic 6G requirements considering case studies like glsar and glsvr. In [10] an organized summary of 6G networks is presented. The summary involves different use cases, challenges, enabling technologies for the development of 6G. In

[11] researchers engrossed in the upcoming wireless communication network with the vision of 6G networks that will overcome the 5G. In [12], a survey considering essential services, scope, requirement, technologies, the vision of the 6G mobile systems is performed. Considering all the reviews, We can say that a single paper or paper can not cover all the aspects of 6G Networks.

3. 6G SYSTEM ARCHITECTURE

6G wireless networks will be comprised of a gigantic total of connected devices and with the base stations (BSs)/access points (APs). The number of devices can work at the same time to make a CoMP using Multiple BSs/Aps. The Enormous data produced by these large number of devices will require a large number of resources to serve their demand and may require robust backhauling links. The processor must include machine learning algorithms and moreover, Artificial Intelligence paradigms may utilize optical fiber or photonic communications. Remote users, in 6G communication systems, can use several relays or transmitters for a remote user to transmit. The use of AI in the Network will allow all the devices to identify the location and features of the access point and base point in their purlieu, and all of the BSs/APs would be aware of the locations, features, and QoS requirements of devices in their purlieu. In order to get the maximum benefit from the wireless networks, optimization methodologies can be adapted. For proper utilization of resources among different end-users, the CPU should be firm to manage and switch them when required. Major modules that may be present in 6G wireless networks that will help to implement 6G are depicted in Fig. 3. One of the major components that will enhance the next generation wireless is the air interface. OFDM was a vital component in 4G and CDMA was the Key Component in 3G. Similarly, the development of the new air interface will be an essential component of 6G system architecture.

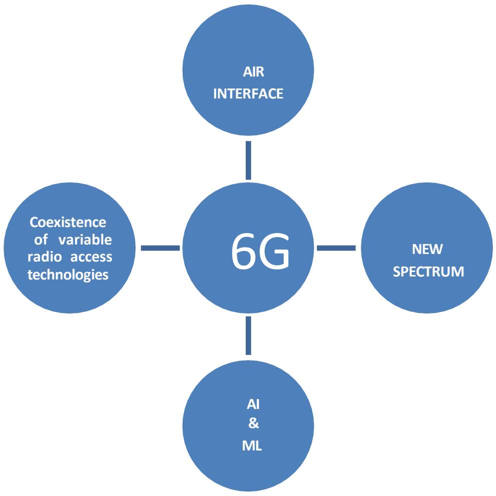

Fig. 3 Major Components in the 6G System

AI and ML will play an important role in the self-organization, self- healing, self-configuration of 6G wireless systems. The New spectrum will also be an active component in the 6G system architecture.

3.1 Air interface

As the new wireless network 6G will focus on tremendously catholic bandwidth and terahertz frequency range, there will be difficulty in maintaining the network efficiency. Also having a transmission architecture that is secure and will have adequate range will be the solution here. There will be an improvement in coverage because of the handiness of extraordinarily catholic bandwidths.

The major role that will help develop devices to the tradeoff between spectrum enactment, power efficiency, and coverage will lead to the need for a component i.e. air interface that allows additional deliberation can be rewarded to single-carrier structures. The OFDM structure would be reentered for lower spectrum and a high peak-to-average power ratio (PAPR) makes the power amplifiers complex and expensive.

Different scientists have suggested that the non-orthogonal multiple access (NOMA) will be a favorable new scheme for the B5G/6G mobile networks. With the help of NOMA, different clients can use complete resources at the same time. Though it is also proposed that RSMA will be a promising technology for 6G communication systems [13,14,15]. Both these policies depend on common successive interference cancellations (SIC) to decipher the data for the user. A new AI-based software-defined air interface is presented in [16], where the authors proposed an intelligent air interface switching system for user QoS enhancement.

3.2 New spectrum

In 5G wireless networks mmWave is considered to be the main component, but due to some reasons, it is not used fully. There should be some improvement when Base stations and satellites are connected. Before 5G, different services like TVservices, military communications, and even cellular communication require a separate spectrum[17].

Therefore, the idea of using simultaneously mmWave, THz band, and the visible light spectrum were proposed [18,19,20,21,22]. These bands are certainly not used for any communiqué. The problematic situation arises as there is a higher frequency band, there is attenuation in signal very swiftly about the space covered which can be thought of as 3G or 4G BS can cover several miles whereas a 5G or 6G BS can cover a few hundreds of meters. To resolve this issue in mmWave and THz communications, the idea of using massive multiple inputs and multiple outputs (MIMO) and beamforming emerged.

3.3 AI & ML

6G wireless networks and many IoT devices are using AI with Machine learning paradigms that also include deep neural networks (DNNs) [23]. AI and ML algorithms are used to implement link and system-level solutions. AI-empowered 6G wireless network is likely to outspread numerous features including self-configuration, aggregation, opportunistic set-up, and context awareness [24]. This system will offer secure, fast, and pervasive networking for humans and machines and it will become the core of society's digital transition. Wide-ranging incipient developments which include self-driving cars and voice assistants have been made possible by recent advancements in

ML research. Recent wireless networks have increased complexity, requiring smarter methods for handling any losses and handling network features which can be done by introducing solutions for ML and SDN. When AI is combined with wireless paradigms that may result in tremendous enhancements. Resource allocation and utilization can be managed as per user requirements. Optimality in the wireless network will improve by choosing AI and ML.

3.4 Coexistence of variable radio access technologies

6G wireless networks will have a global networking structure where clients will not only select the best network available but can also predict or check the current scenario of the channel and also will be able to check its QoS at any other node. So, 6G communication should be modeled in such a way that it will converge all of the wireless technologies at a single place such as Communiqué with different technologies like Wi-Fi, Bluetooth, UWB, VLC, UAVs, biosensors, and satellite communications can all integrate into 6G and will be under single standard so that they can be connected at a single platform. Most of the IoT devices can now be connected with Wi-Fi operating at 2.4 GHz [25,26,27].

Merging all these will result in cost savings. The applications and structures that were deployed in previous technologies should be converged in 6G. Additionally, it also includes new technologies, such as AI/ML, VLC, quantum communications (QC), and quantum machine learning (QML).

Fig. 4 gives an overview of the evolution of the wireless generation, with timelines, from 1G to 6G with respect to applications, network characteristics, and technology.

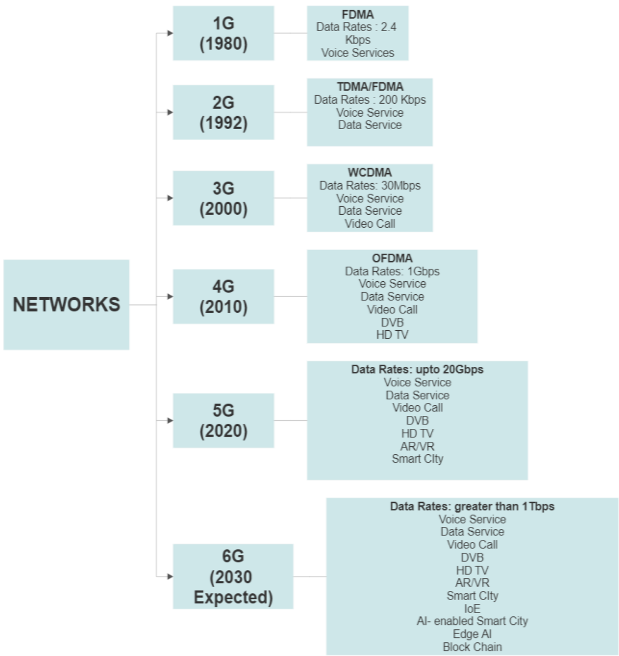

Fig. 4 Evolution of wireless communication from 1G to 6G showing Applications and Network characteristics

4. APPLICATIONS OF 6G WIRLESS NETWORK

Every new cellular system generation is driven by innovative applications. 6G is no exception: It will be borne out of an unparalleled emergence of exciting new applications and technological trends that will shape its performance targets while radically redefining standard 5G services. In this section, we first introduce the main applications that motivate 6G deployment and, then, discuss ensuing technological trends, target performance metrics, and new service requirements. Modern society is influenced by intelligent and smart machines. These machines can communicate with each other and with human beings. Some applications of 6G wireless communication are described below.

4.1 Super-Smart Society: Smart homes including IoTs are being used currently. The introduction of the new wireless communication network 6G, will help to build smart societies that will bring a new change in life leading to improvements in lifestyle by monitoring the environment and automating tasks using AI-based paradigms [28]. Societies will become super- smart by using the latest gadgets and autonomous vehicles, and so on. Besides, it may be possible to see more self-driven cars based on 6G wireless technology. Smart homes become a reality because any device in a remote location can be controlled by using a command given from a smart device.

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4.2 Smart Healthcare and Medical Communication: Innovations in Medical health systems will also be benefited from the 6G wireless networks including AR/VR, holographic telepresence will result In building advanced healthcare systems [28]. 6G communication will also facilitate remote surgeries. Large chunks of medical data can be quickly transferred with High-data-rate, low latency, ultra- reliable (zero-error) 6G network Because of Thz bandwidth in 6G helps in terahertz pulse imaging in dermatology, pharmaceutical diligence, and medical imaging. With the integration of AI and ML in healthcare, 6G networks will help to detect diseases by perceiving the body illness of sick individuals competently. 6G can also be helpful in various health operations such as emergency care, medical checkups, cleaning contaminated floors, and the supply of medication in rural areas, autonomous robotics can be used.

4.3 Senses Information Transfer: Humans use their senses to experience the world around them. The data from these senses can be communicated remotely using new wireless transmission that includes making procedures that can understand the neurological process through sensory integration. Senses from the body of human and from the environment can be detected effectively using BCI technology.

4.4 Communication in space and deep sea:

The next decade will promote Space tourism in which different Humans from every aspect of life will be traveling to space. Many Organizations are planning for enhancing space tourism. Once this will be successful there will be commercial space flights. Space research is also a key parameter [29].

Also, 6G will result in enhancing the communication range worldwide. Also, Autonomous and intelligent robots will be placed in harsh environmental areas for communication and research purposes [30]. Deep-sea exploration such as oil exploration and mineral exploration can become a reality with the help of 6G.

5. CONCLUSIONS

Every generation of communication system brings advanced. Although 5G communication system that should be officially launched worldwide in 2020, has so many advanced features. But by the end of the decade, 5G will not be able to support the growing demand for wireless communication in 2030 entirely. Therefore, 6G needs to be rolled out. As the 6G is still a new term and is in the study phase. This paper tries to show some basic components that should be in 6G and a few advanced applications of it. Wireless technologies have always revolutionized everything on the globe. In this paper, we also tried to show some aspects of 6G wireless networks with different perspectives.

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