

An overview of 6G wireless systems

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Abstract. With the demand of low latency communication explodes, the inherent limitations of the fifth generation communication is constantly exposed to the public. Such 5G shortcomings are spurring worldwide activities focused on defining the next-generation 6G wireless communication system. So the paper offers an overview of 6G wireless systems based on existing literature and statistical data. The paper concentrate on the driving forces in the development of 6G. In the meanwhile, the paper presents some potential application scenarios in the future. In the last section, the paper points out some challenges that are most likely to encounter in the coming development of 6G. Based on current prospect of 6G, it is likely that 6G features low latency and high efficiency and has 100 times better transmission capacity than 5G. The future applications are holographic telecommunications, mutual interaction of emotional thinking, and digital twinning. In conclusion, integrated with different technologies like AI, Terahertz Communications, and blockchain, 6G features many advantages and will permeate into people's daily lives.

Keywords: 6G, Driving forces, Application scenarios, Teraheartz communication.

1. Introduction

Fifth generation (5G) mobile communication systems have entered the stage of commercial development for several years, providing users with fast network services as well as a host of novel opportunities to various industries [1]. Since the requirement for higher rates was the main driver of wireless network evolution, 5G is insufficient. International industrial, academic, and standards groups have started researching sixth generation (6G) wireless communication systems in preparation for the creation of a quicker generation of telecommunications in the future. It has been attempted to define 6G in terms of needs, application scenarios, important technologies, etc. by the publication of a number of white papers and survey studies. The International Telecommunication Union's Radiocommunication Sector has been working on the 6G vision and is anticipated to come to an agreement on what 6G will be by the middle of 2023, although there are still many unresolved concerns in the relevant worldwide debates, according to the literature now in circulation.

In previous studies, they mainly concentrated on the technologies and interactions with other subjects to assure that 6G can be widely and successfully used. In Terahertz Propagation Characteristics for 6G Mobile Communication Systems, it is shown that using terahertz bands beyond 100 GHz can satisfy the need for extremely high-speed communication because a noticeably wider frequency spectrum can be used than in 5G [2]. In Sensing Based Contention Access for 6G Low Latency Networks, in order to avoid contention within limited radio resources, it examines a useful

sensing design broadcasting without a grant to provide a shared resource allocation framework for potential sixth generation networks [3].

This paper takes a deep dive into various potential scenarios for sixth-generation communication based on technology developed and underdeveloped. With these scenarios to better help humans, we can better imagine the future lifestyle accompanied by 6G. The paper is divided into three main parts: driving forces, potential application scenarios, and future research directions.

2. The concept and driving forces of 6G

Early in 1940s, the first generation mobile communication standard come into the world for faster and more accurate transmission of significance military use. In the coming years, humans underwent a radical desire for more excellent communication in whatever business, political and daily life. As a result, mobile communication standards are constantly being updated and upgraded. Up till now, the standard of mobile communication technology has evolved to its fifth generation(5G). Therefore, the next telecommunication generation is on the agenda. Although many infrastructure is still being developed in many countries, we are supposed to move our eyes into the coming decades, where the next generation 6G is required to satisfy the future demands for information and communications technology [4]. The driving forces of 6G mainly come from the three aspects below.

2.1. The economical stimulation

The world economy is experiencing an unprecedented pace of development. Whatever countries or corporations require a much more efficient network to transmit information and accelerate the economy, globalization needs to reduce the cost of transmitting information. In recent years, state-of-the-art technologies have developed a lot, which greatly improve productivity, and the cost of information and knowledge transmission continues to decline. Data flow has become an important traction of material capital flow, technology flow, capital flow and talent flow. Platforms have become an important organizational form for gathering resources, promoting collaboration, improving efficiency and building ecology, and the international division of labor extends from the physical world to the digital world.

2.2. The continuous increasing requirements

As technology evolves, these technologies are in urgent need of higher accuracy with faster transmit speeds, which means they would like to build a transmission channel between different parts like data base and terminals. Consider the case of Virtual Reality (VR): following computation on edge cloud servers, the frames of VR must be recorded and encoded before being broadcast over the downlink network. In order to provide a better user experience, VR services must therefore have exceptionally low latency. Under the current circumstances of 5G, it enables VR with basic function but is far from excellent. Therefore, technologies like VR require 6G for further development.

2.3. Emerging subject to integrate

ICT technologies such as blockchain and cloud computing, as well as new materials, antennas, and other processes have emerged in recent years. These technologies provide the foundation for the evolvement of the sixth telecommunication generation. The blockchain is a decentralized database that was initially used in a Bitcoin transaction. A chain of data blocks are formed whenever an event occurs and are verified in a decentralized manner using consensus algorithms [5]. Therefore, robust data security guarantees are necessary for users to successfully deploy 6G apps. Thus, blockchain is introduced to enable in a transparent and trustless environment desired in the 6G network.

3. The technology insurance of 6G

As the evolution of previous mobile communication network generation, the main structure and target is analogous to 5G, inheriting the benefits achieved in 5G [5]. To achieve the higher standard of 6G,

various high quality is a necessity. Several profound and promising technologies for 6G are going to be introduced briefly.

3.1. Artificial Intelligence

AI artificial intelligence enable a large amount of data transformed into information and knowledge, and automate decision-making and task execution. Highly-developed intelligence is one of the dominant factor of the sixth generation autonomous networks [6]. Before 5G, AI has never been employed in telecommunication filed. 6G will be fully supported by AI for automation and intelligence. The transition from cognitive radio to intelligent radio will be possible thanks to 6G's AI-enhanced capabilities. Machine learning developments produce more intelligent networks for real-time 6G communications. AI in communication will streamline and enhance the delivery of real-time data.

3.2. Terahertz Communications

The bandwidth can be expanded to improve spectral efficiency. By extending the bandwidths and utilizing cutting-edge massive multiple-input multiple-output (MIMO) technologies, it is possible. In order to increase data speeds and enable new applications, 5G adds mmWave frequencies. To satisfy even more demand, 6G, however, plans to extend the frequency band's limits to THz. The RF band is presently insufficient to satisfy the increased needs of 6G because it has virtually reached its capacity. In 6G communication, the THz band will be crucial [7]. Obstacles, climate, and humidity are potential influential factor of interfering transmission signals. Plus, study shows that THz waves may be harmful to optic organs for humans such as eyes. So profound research is required before Terahertz transmissions come into real use [8].

3.3. Ultra-massive MIMO

The ultra-massive multiple-input multiple output (MIMO) technology is commonly acknowledged as the evolution of the massive MIMO technology. Having employed in 5G network, MIMO can greatly increase the efficiency of frequency spectrum and energy as well as simplify upper level user scheduling. The ultra-massive MIMO technology can achieve higher spectral efficiency, wider and more flexible network coverage, higher positioning precision, and higher energy efficiency in a wider frequency range with new materials as well as technologies and functions. These include reconfigurable intelligent surfaces, AI, and sensing technologies [9].

4. Potential application scenarios

4.1. Holographic communications

Holography refers to the technique used to present the real, three-dimensional image of an object. Holographic communications enable people to sense the synchronized and real three-dimensional image during phone calls and other scenarios like video games. The advancement of 6G will ensure the capabilities of wireless networks to realize holographic information transmission. In August 2022, the telecommunications corporation Ericsson released a video that envisioned the future application of holographic communications during a phone call. In the video, two people interact with the three-dimensional image presented in front of them, and they even touch each other. To realize this scenario, the device needs to capture images through ready-made and accessible mobile phones or tablets and assist artificial intelligence to create a complete 3D holographic experience that can run on networks. Decode and process holographic data streams on these devices, then render and accurately display them in the user's environment on the terminal device.

4.2. The mutual interaction of emotional thinking

It is anticipated that new study areas like emotional interaction and brain-computer interaction (brain-computer interface) would see advancements based on the upcoming 6G mobile communication

network. Intelligent agents with perceptual ability, cognitive ability, and even thinking will completely replace traditional intelligent interactive devices, and the dominating and being dominated relationship between humans and intelligent agents will begin to transform into a more equal human-like interaction with emotion, temperature and equality. Through voice communication or facial expression detection, an intelligent system with the capacity for emotional engagement can keep tabs on the user's psychological and emotional condition and alter their emotions in time to minimize health hazards.

4.3. Digital twinning

With the continuous development of perception, communication and artificial intelligence technology, entities or processes in the physical world will be digitally mirrored in the digital world, and people, people and things, and things can realize intelligent interaction by mapping in the digital world. By low latency transmission by 6G and advanced algorithm models to generate perception and cognitive intelligence, the digital world can simulate, verify, predict and control physical entities or processes so as to obtain the optimal state of the physical world [10].

5. Future research directions

It is projected that the sixth generation of wireless technologies, or 6G, would include a number of additional needs, standards, and potential applications. We examined 6G from a variety of perspectives using the hierarchy below, and we have a general understanding of how short 6G is. The first is how to receive customers' support when it comes to commercial sales. The second shortness is that many technologies are not mature enough and some are only at its innate stage. Last but not the least, 6G requires a safe and stable environment to guarantee its function [11].

Potential architecture technologies such as distributed, heaven and earth integration, internal intelligence, internal security and other key capability technologies such as network programming and data service will be organically integrated to jointly achieve the overall architecture of the 6G network [12]. It is expected that in the next few years, with the deepening of research on 6G network architecture and key technologies, the following four aspects will deserve attention:

The innovation of network technology will play a more important role in the 6G network, and the innovation of network architecture will be one of the core innovations of 6G. After decades of rapid development in the communication industry, the performance of air interface transmission gradually approaches the limit of Shannon's theorem. New network technologies, especially the innovation of network architecture, are expected to significantly improve the network capability and provide users with a more extreme business experience.

Cross-border integration of DOICT technology drives the evolution of 6G network architecture. OT demand from production and operation is a new element of 6G. Collaborative data technology DT, operation technology OT, information technology IT and communication technology CT will jointly drive network reform and capability upgrades, and help the digital and intelligent development of the whole society and the whole field.

The combination of IP networking technology and mobile network will become a breakthrough opportunity for 6G network development. IP technology is fundamental and relies on bottom-up innovation mechanism, so innovation is difficult and the period is long. However, the IP network field has been actively innovated in recent years, and the integration and innovation of mobile network are expected to promote the leapfrog development of 6G network.

The network architecture scheme shall gradually converge to form a global unified 6G network architecture standard. The technical layout of 6G network architecture has begun, and the development direction of some technologies is gradually forming consensus. It is necessary to organically integrate various potential technologies and network architecture, interact with open source development, accelerate the convergence of solutions, and lay a solid foundation for the unification of global standards.

6. Conclusion

With the emergence and integration of different technologies like AI, Terahertz Communications and blockchain, 6G features many advantages. The network latency has decreased from milliseconds to sub milliseconds or even microseconds, resulting in a significant improvement in communication performance. In the meantime, 6G solves the problem of integrating multiple types of network communication and promotes the full coverage of wireless networks. The driving forces of 6G come from all angles. For one thing, the need for more efficiency and a more accurate transmission channel is increasing. Another thing is that more and more potential scenarios are envisioned and realized. Much more effort and testing are supposed to be done in the coming future. In addition, the application scenarios are various in our daily lives, such as holographic communication, mutual interaction of emotional thinking, and digital twinning. These possible scenarios are highly likely to change humans' lives with more convenience and humanization. Last but not least, in the long term, though it is proven that it is highly essential to develop 6G infrastructure, there still exists a great deal of uncertainty in 6G's future development. In the meantime, it will combine plenty of related technologies to improve the current 6G structure. Since 6G is in its incipient stage, it will vary from time to time in the coming future.

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