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Approaching the Development of 6G mobile wireless networks

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ABSTRACT

While 5G is being introduced and deployed around the world, research institutions around the globe have begun to look on the far side of 5G, and 6G is anticipated to develop into green systems that deliver the prime nature of Service and vitality potency. To fulfill the requests of future applications, important enhancements should be made in versatile system architecture. Wireless technology FG (Future generation) mobile communications will have higher data transmission rates in 6G and. 7G. Wireless technology is continuously one of the hottest areas that are developing at a high speed, with advanced techniques emerging in all the fields of mobile and wireless communications.

This paper presents a nearby review of wireless advancement towards 6G systems after that we try to tell the expectation of future wireless communication style in 2030, when the 6G will start. Our aim is to enable the network with world-class broadband abilities, setting up a future-verification basis for new thoughts and chances to expand on. The Communications Revolution begins here.

Keywords: *6G, 6G architecture, Mobile Technology, Wireless Communication, VLC .*

1. INTRODUCTION

With the completion of the first full set of 5G standards and the commercial public rollout which began in 2019, it can be expected that the 5G wireless mobile communication system with three major technical features (enhanced Mobile BroadBand, eMBB; massive Machine-Type-Communications, mMTC; ultra-Reliable Low-Latency Communications, uRLLC) will support the wireless communication needs of the information society in the next decade (2020-2030), becoming the largest and most complex communication network ever. Glancing back at the advancement of mobile communication, it takes around one decade from the underlying idea research to the business arrangement, though its ensuing use goes on for at least an additional 10 years. That is, when the past generation mobile network enters the business stage, the next generation starts an idea examination.

In previous years, a few nations have given vital designs for the advancement of 6G. In 2018, Fin-land declared the 6G beginning Flagship program, an eight-year program with the general volume of $290 million to build up an entire 6G biological system [?]. The U.K. what's more, German governments have put resources into some potential advances for6G like quantum technology, and furthermore the US started to inquire about on terahertz-based 6G versatile systems. The Minister of Industry and Information Technology in China has made the official assertion that the nation has concentrated on the advancement of 6G. The main technical objectives for 6G networks are going to be Ultra-high data rate (up to 1Tbps), ultra-low latency, High energy efficiency for resource-constrained devices, Ubiquitous global network coverage.•Trusted and intelligent connectivity across the whole network.

2. Evolution Of Wireless Communication Service.

Looking back at the evolution of mobile communication, it takes about one decade from the initial concept research to the commercial deployment, whereas its subsequent usage lasts for a minimum of another 10 years. That is, once the previous generation mobile network enters the commercial phase, the next generation begins concept analysis.

1. 1st Generation wireless communication service (1970-1980)

1G, which was introduced in the 1980s, is the first generation of commercial wireless telephone systems using Analog based technologies. It was called the “mobile” telephone system, comparing with the “fixed” or “wired” telephone system. The total cost of maintenance was relatively high, the main usage of the system was a business call, and the main customers were called VIPs. The rechargeable battery of this generation wasn’t sophisticated enough that the personal terminals were relatively large, and used mainly in automobiles.

2. 2nd Generation wireless communication service (1990-2000)

2nd Generation wireless communication system was constructed with Digital technologies. The size of the personal terminal became smaller than that of the 1st Generation, thus it was possible to carry in hand. And the cost of personal usage became reasonable. Just before the beginning of the 3rd Generation, 2.5 Generation networks started in 1999, which supported not only voice communication but mobile internets services such as e-mail and Web access. At this generation, mobile wireless communication was spread widely, thus even ordinal high school students could have their own mobile terminals. Many people must remember “i-mode” as the key-word of 2.5 generation.

3. 3rd Generation wireless communication service (2004-2005)

3rd Generation of wireless communication service system could treat high-speed data communication. The main usage wasn't voiced communication but a connection to the Internet. There were several kinds of international standards, and they could cover a wide area on the earth, thus it made us possible to international roaming. I addition, the cost of handy terminals became almost negligible and new in terminal released in every season. The key-word of this generation was "FOMA", and so on.

4. 4th Generation wireless communication service (2009-Present)

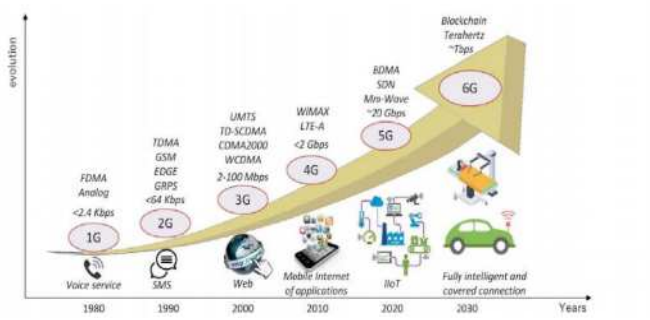
The key-word of the 4th generation of wireless communication service was "broadband", which was based on IP technology. The communication speed of this system can be achieved 100Mbps - 1Gbps in theory and this performance is very close to that of Optical network. From the point of view of the personal terminal, "Smartphone" became the standard device. The terminal has a very sophisticated human interface, fine graphic display, and finger touch operation, so it is easy to use newly developed Internet-related services like SNS, YouTube, and so on. The other key-word of this generation is IoT, Internet of Things. Because the cost of semiconductor devices became very low, every device in our life, home-keeping equipment, sensor, even automobile can be built-in Internet access ability. It isn't suitable to call this generation of wireless communication as a "cellular phone".

5. 5th Generation wireless communication service (2020-Present)

The latest generation of wireless technologies, 5G networks, promises an era of ubiquitous, secure, and high-capacity radio networks. With extremely low latency levels, high energy efficiency, and a comprehensive Gbps capacity, the applications of 5G technology extend to a plethora of industries and fields beyond traditional telecom. Some of the exciting 5G applications include self-driving vehicles, VR/AR, smart manufacturing, telehealth services, smart cities, and many more. The 5G provides 10 times more capacity than other existing systems. It expected speed will be up to 1Gbps, with almost no limits supporting Wireless World Wide Web (WWWW). It is more reliable and faster at a lower cost. It provides high capacity, large phone memory, faster data transmission, supports interactive multimedia, etc. Combined with the above content, 5G mobile communication will completely replace 4G mobile communication into the mainstream communication network in the future, so as to ensure that the different needs of different users can be better satisfied.

6. 6th Generation Wireless Communication Service (203x-)

The Sixth Generation or 6G Mobile and Wireless Communication Network is a revolutionary technology aiming to provide unbelievably high data rates or very fast Internet speed access on-air through wireless and mobile devices possibly up to 11 Gbps. its main backbone is thought to be based on 5G technology. It is imaginary to provide users/customers on the fly high Internet access rates without any fluctuations even if a user is traveling or in a remote location. Specially designed Nano Antennas will be implemented at different geographical locations or positions along roadsides, villages, malls, airports, hospitals, etc to broadcast such high-speed electromagnetic signals. The air fiber combination will be the best method to broadcast much-secured information from transmitters to destinations. The radio over fiber system is already in running state, but with the advent of this 6G technology, the earth's mankind will be much closer to any extraterrestrial civilization in our universe.



1. **6G Overall Vision/ Potential Key Technologies**

The goal of 6G is to meet the needs of the information society ten years later (2030 -), so the6G vision should be those needs that 5G cannot meet and need to be further upgraded. Based on the demand that 5G can meet and the development trend of other related fields, we think that 6Gvision can be summarized with the 10 given below. These 10 keywords together constitute the 6G overall vision of "Wherever you think, everything follows your heart"

i. Intelligent connectivity (AI)

Artificial Intelligence (AI) is one of the hottest topics at present, and almost all fields are exploring the use of AI technology. The combination of wireless mobile communication networks and AI to make AI a better-enabling network has also become an inevitable trend. At present, people have begun to try to use AI technology in 5G system, but the current combination of 5G and AI can only be regarded as the optimization of traditional network architecture using AI, rather than a new intelligent communication network system based on AI. Firstly, the application of AI technology in the 5G network is relatively late. It was not until recent years that we really started to study and try to apply AI technology in the 5G network, and the 5G network architecture itself has already been finalized. Secondly, although the AI technology is developing very fast and has also demonstrated its strong ability in some areas, it is still in the exploratory stage in more fields. The research on the combination of AI and wireless communication technology is just beginning, and a long-term research process is needed before the real technology matures. However, the trend of AI shows us the possibility of technology maturity in the next decade. At the same time, considering that the future 6G network structure will be more and more huge and heterogeneous, and the business types and application scenarios will become more and more complex and changeable, it is almost inevitable to make full use of AI technology to solve this complex demand.

ii. Deep Connectivity

Traditional cellular networks (including 5G networks to be deployed on a large scale) have the concept of deep coverage, mainly to optimize the deep coverage of indoor access requirements. To achieve deep indoor coverage, outdoor macro base stations are usually used to cover indoor or deploy wireless nodes indoors. 4G and previous generations of cellular network systems are aimed at people-centered communication needs, and deep coverage is optimized for typical indoor scenarios of human activities. After the technology evolution and engineering experience accumulation of multi-generation wireless communication system, the optimization technology of typical indoor scene coverage for human activity sites has been very

mature. Starting from 5G, the object of communication has expanded from human-centered communication to the simultaneous communication of things, that is, the so-called interconnection of all things. Therefore, the design and deployment of 5G and future wireless communication networks need to take into account both the deep coverage requirements of people and objects, especially the deep coverage of the ITU scenarios. Therefore, we expect that in the next 10 years (2030 ~) of 6G systems, access requirements will evolve from deep coverage to "Deep connectivity".

iii. Holographic Connectivity

AR/VR (Virtual and Augmented Reality) is considered to be one of the most important requirements of 5G, especially for one of the typical applications with high throughput requirements of 5G. 5G will be able to support the transformation of AR/VR of current wired or fixed wireless access into wireless mobile AR/VR of broader scenarios. Once AR/VR can be used more easily and conveniently without location restriction, it will promote the rapid development of AR/VR services, and then stimulate the rapid development and maturity of AR/VR technology and equipment itself. It can be expected that in ten years (2030 ~), the media interaction will be mainly planar multimedia, high fidelity AR/VR interaction, even holographic information interaction, and wireless holographic communication will become a reality. High fidelity AR/VR will be ubiquitous, and holographic communication and display can also be carried out at any time and anywhere so that people can enjoy fully immersed holographic interactive experience at any time and place, that is, to realize the communication vision of so-called "holographic connectivity".

iv. Ubiquitous Connectivity

Traditional cellular networks also need for wireless access anywhere and anytime. However, as mentioned earlier, the 5G system will greatly expand the space scope and the type of information exchange on the Internet of Things, relative to the communication requirements of people. The range of activities of the equipment will greatly expand the geographic space of communication access, including unmanned detectors deployed in the deep, deep sea or deep space, human/unmanned aerial vehicles in the middle and high altitude, autonomous robots in the harsh environment, intelligent remote control equipment and so on. Besides, with the rapid development of science and technology in the fields of astronautics, deep-sea exploration, and other fields, and the improvement of survival ability in some extreme natural environments, human activity space is also expanding rapidly. For example, in 2030-2040, there may be more opportunities for people to enter outer space, and the communication needs between satellites and the ground, between satellites and between spacecraft will be more common than the special communication needs to be limited to a few professional fields of scientific exploration, and the traces of human activities on the ground will be more likely to appear in the polar, desert hinterland, etc

v. Optical wireless technology

OWC technologies are envisioned for 6G communications in addition to RF-based communications for all possible device-to-access networks; these networks also access network-to-backhaul/fronthaul network connectivity. OWC technologies are already being used since 4G communication systems. However, it will be used more widely to meet the demands of 6G communication systems. OWC technologies, such as light fidelity, visible light communication, optical camera communication, and FSO communication based on the optical band are already well-known technologies. Researchers have been working on enhancing the performance and overcoming the challenges of these technologies. Communication based on optical wireless technologies can provide very high data rates, low latencies, and secure communications. LiDAR, which is also based on the optical band, is a promising technology for very-high-resolution 3D mapping in 6G communications.

vi. FSO backhaul network

It is not always possible to have optical fiber connectivity as a backhaul network because of remote geographical locations and complexities. The FSO backhaul network is very promising for 5GB communication systems. The transmitter and receiver characteristics of the FSO system are similar to those of optical fiber networks. Therefore, the data transfer in the FSO system is comparable with the optical fiber system. Hence, along with the optical fiber networks, FSO is an excellent technology for providing backhaul connectivity in 6G. Using FSO, it is possible to have very long range communications even at a distance of more than 10,000 km. FSO supports high-capacity backhaul connectivity for remote and non-remote areas, such as the sea, outer space, underwater, isolated islands; FSO also supports cellular BS connectivity. Massive multiple input, multiple output technique: One key technique to improve spectral efficiency is the application of the MIMO technique. When the MIMO technique improves, the spectral efficiency also improves. Therefore, a massive MIMO technology will be crucial in the 6G system.

vii. Blockchain

Blockchain will be an important technology to manage massive data in future communication systems. Blockchains are just one form of the distributed ledger technology. A distributed ledger is a database that is distributed across numerous nodes or computing devices. Each node replicates and saves an identical copy of the ledger. The blockchain is managed by peer-to-peer networks. It can exist without being managed by a centralized authority or a server. The data on a blockchain is gathered together and structured in blocks. The blocks are connected to one another and secured using cryptography. The blockchain is essentially a perfect complement to the massive IoT with improved interoperability, security, privacy, reliability, and scalability. Therefore, the blockchain technology will provide several facilities, such as interoperability across devices, traceability of massive data, autonomic interactions of different IoT systems, and reliability for the massive connectivity of 6G communication systems.

viii. 3D networking

The 6G system will integrate the ground and airborne networks to support communications for users in the vertical extension. The 3D BSs will be provided through low orbit satellites and UAVs. The addition of new dimensions in terms of altitude and related degrees of freedom makes 3D connectivity considerably different from the conventional 2D networks.

ix. Dynamic network slicing

Dynamic network slicing permits a network operator to allow dedicated virtual networks to support the optimized delivery of any service toward a wide range of users, vehicles, machines, and industries. It is one of the most important elements for management when a large number of users are connected to a large number of heterogeneous networks in 5GB communication systems.

x. Holographic beamforming

Beamforming is a signal processing procedure by which an array of antennas can be steered to transmit radio signals in a specific direction. It is a subset of smart antennas or advanced antenna systems. The beamforming technique has several advantages, such as a high signal-to-noise ratio, interference prevention, and rejection, and high network efficiency. Holographic beamforming (HBF) is a new method for beamforming that is considerably different from the MIMO systems because it uses software-defined antennas. HBF will be a very effective approach in 6G for the efficient and flexible transmission and reception of signals in multi-antenna communication devices. Big data analytics: Big data analytics is a complex process for analyzing a variety of large data sets or big data. This process uncovers information, such as hidden patterns, unknown correlations, and customer inclinations, to ensure perfect data management. The big data is collected from a wide variety of sources, such as videos, social networks, images, and sensors. This technology will be widely used for handling of huge data in 6G systems.

2. **Features/Advantages of 6G Technology:**

The most important requirement for 6G wireless networks is the capability of handling massive volumes of data and very high-data-rate connectivity per device. Below are the features/advantages of the future 6G technology;

1. Ultra fast access of Internet.
2. Data rates will be up to 10-11 Gbps.
3. Home automation and other related applications.
4. Smart Homes, Cities and Villages.
5. May be used in the production of Energy from galactic world.
6. Space technology, Defense applications will be modified with 6G networks.
7. Home based ATM systems.
8. Satellite to Satellite Communication for the development of mankind.
9. Natural Calamities will be controlled with 6G networks.
10. Sea to Space Communication.
11. Mind to Mind Communication may be possible.

2.1 6G Challenges

Several technical problems need to be solved before the 6G communication systems can be successfully deployed. A few of possible concerns are briefly discussed below.

1. High propagation and atmospheric absorption of THz

The high THz frequencies provide high data rates. However, the THz bands need to overcome an important challenge for data transfer over relatively long distances because of the high propagation loss, and atmospheric absorption characteristics [1]. We require a new design for the transceiver architecture for the THz communication systems. The transceiver must be able to operate at high frequencies, and we need to ensure the full use of very widely available bandwidths. A very small gain and an effective area of the distinct THz band antennas is another challenge of THz communication. Health and safety concerns related to THz band communications also need to be addressed.

2. Complexity in resource management for 3D networking

The 3D networking extended in the vertical direction. Hence, a new dimension was added. Moreover, multiple adversaries may intercept legitimate information, which may significantly degrade the overall system performance. Therefore, new techniques for resource management and optimization for mobility support, routing protocol, and multiple access are essential. Scheduling needs a new network design.

3. Heterogeneous hardware constraints

In 6G, a very large number of heterogeneous types of communication systems, such as frequency bands, communication topologies, service delivery, and so on, will be involved. Moreover, the access points and mobile terminals will be significantly different in the hardware settings. The massive MIMO technique will be further upgraded from 5G to 6G, and this might require a more complex architecture. It will also complicate the communication protocol and the algorithm design. However, machine learning and AI will be included in communication. Moreover, the hardware design for different communication systems is different. Unsupervised and reinforcement learning may create complexities in hardware implementation as well. Consequently, it will be challenging to integrate all the communication systems into a single platform.

4. Autonomous wireless systems

The 6G system will provide full support to automation systems such as autonomous car, UAVs, and Industry 4.0 based on AI. To make autonomous wireless systems, we need to have the convergence of many heterogeneous sub-systems, such as autonomous computing, interoperable processes, system of systems, machine learning, autonomous cloud, machines of systems, and heterogeneous wireless systems [60]. Thus, the overall system development becomes complex and challenging. For example, developing a fully autonomous system for the driverless vehicle will be much more challenging because 6G researchers need to design fully automated self-driving vehicles that perform better than the human-controlled vehicles.

5. Modeling of sub-mmWave (THz) frequencies

The propagation characteristics of the mmWave and sub-mmWave (THz) is subject to atmospheric conditions; therefore, absorptive and dispersive effects are seen [61]. The atmospheric condition is frequently changeable and thus quite unpredictable. Therefore, the channel modeling of this band is relatively complex, and this band does not have any perfect channel model.

6. Device capability

The 6G system will provide a number of new features. Devices, such as smartphones, should have the capability to cope with the new features. In particular, it is challenging to support 1 Tbps throughput, AI, XR, and integrated sensing with communication features using individual devices. The 5G devices may not support few of the 6G features, and the capability improvement in 6G devices may increase the cost as well. There will be billions of devices connected to the 5G technology; therefore, we need to ensure that those devices are compatible with the 6G technology also.

7. High-capacity backhaul connectivity

The access networks in 6G will have a very high density. Moreover, these access networks are diverse in nature and widespread within a geographical location. Each of these access networks will support very high-data-rate connectivity for diverse types of users. The backhaul networks in 6G must handle the huge volume of data for connecting between the access networks and the core network to support high-data-rate services at the user level; otherwise, a bottleneck will be created. The optical fiber and FSO networks are possible solutions for high-capacity backhaul connectivity; therefore, any improvement in the capacity of these networks is challenging for the exponentially growing data demands of 6G.

8. Spectrum and interference management

Due to the scarcity of the spectrum resources and interference issues, it is very important to efficiently manage the 6G spectra including the spectrum-sharing strategies and innovative spectrum management techniques. Efficient spectrum management is important for achieving the maximum resource utilization with QoS maximization. In 6G, researchers have to address concerns, such as how to share the spectrum, and how to manage the spectrum mechanism in the heterogeneous networks that synchronize the transmission at the same frequency. Researchers also need to investigate how the interference can be cancelled using the standard interference cancellation methods, such as parallel interference cancellation, and successive interference cancellation.

9. Beam management in THz communications

Beamforming through massive MIMO systems is promising technology for supporting high-data-rate communications. However, beam management in sub-mmWave, that is, the THz band is challenging because of the propagation characteristics of the sub-mmWave. Hence, efficient beam management against unfavorable propagation characteristics will be challenging for

10. **Higher Energy Efficiency**

The ultra-large-scale mobile communication network has become an indispensable part of the world's energy consumption. It not only produces huge carbon emissions but also occupies a considerable part of the operating costs. In the future, 6G networks will have ultra-high throughput,ultra-large bandwidth, and ultra-large number of ubiquitous wireless nodes, which will bring unprecedented challenges to energy consumption. Spectrum efficiency and spectrum bandwidth increases, throughput can be increased greatly, but the energy efficiency problem will be more serious. We have to reduce energy consumption per bit (J/bit) as far as possible. The ubiquitous and dense sensors of wireless sensing networks filled with human production and living space will bring two energy consumption problems: first, the huge number of sensors will bring high total energy consumption; second, how to supply energy conveniently and effectively for ubiquitous deployment is also a challenge. Also, massive data processing power consumption for"Intelligent connectivity" and ultra-large antenna processing power consumption are the challenges of power consumption faced by future 6G networks. Faced with the huge energy consumption pressure of the future 6G network, green energy-saving communication is particularly important and urgent [45].

3. CONCLUSION

The concept of wireless mobile generation is currently attracting a great deal of interest, as each generation of communication system brings new and exciting features. The 5G communication system, which is currently being launched worldwide as of April 2020, has exciting features. However, 5G will not be able to fully support the growing demand for wireless communication in 2030. Therefore, 6G will need to be rolled out. Research on 6G is still in its infancy and in the study phase. In this paper, 10 keywords are used to summarize the future 6G vision. These four keywords together constitute the 6G overall vision of "Wherever you think, everything follows your heart". The 6G vision is exciting, and the key candidate technologies of 6G are full of challenges. The future will be a completely data-driven society in which people and things are connected universally, almost instantaneously (milliseconds) to form an incredibly fully connected utopian world.

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