Research on 5G Key Technologies and Challenges

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Abstract. Communication technology is an essential science and technology in today's society. In this era of rapid development, 5G communication technology is more widely used, but it also faces many challenges and opportunities. This paper firstly combs the communication methods of different times and analyzes some bottlenecks of communication science. Then the key technologies of 5G communication are discussed including MIMO, sparse multiple access, full duplex. A detailed study of the problems faced by the 5G is carried out in this paper, and the problems of the frequency band, spectrum, system capacity, cost and terminal equipment are analyzed. It provides a reference and benchmark for further research of scholars in the future.

1. Introduction
Communication technology is an important and indispensable science and technology in today's society. And 5G communication technology is at the forefront. In this era of rapid development, 5G communication technology is more widely used, but it also faces many challenges and opportunities. Firstly, this paper combs the communication methods of different times, and analyses some bottlenecks of communication science. Then the key technologies of 5G communication are discussed, including MIMO, sparse multiple access, full duplex technology. Unlike previous studies, this paper mainly studies the problems faced by 5G in detail and focuses on the analysis of frequency band, spectrum, system capacity, cost and terminal equipment. It provides a reference and benchmark for the further research of scholars in the future. Furthermore, this paper looks forward to the revolutionary changes that 5G technology will bring to society, especially mobile Internet and Internet of Things, after breaking through the relevant bottlenecks.

2. 5G development
2.1. From 1G to 4G
The first generation mobile communication system (1G) is an analog communication system [1], which represents the use of analog FN modulation in wireless transmission to convert speech between 300 Hz and 3400 Hz to high frequency carrier frequency MHz. However, due to many defects of the analog communication system, theft and serial number often occur. Then there are 2G of communication [1,2,3]. Compared with 1G, 2G has a qualitative leap from analog communication signal to digital communication signal. Compared with the first generation communication, the second generation communication has a high degree of confidentiality, improves, and can provide a variety of services. Followed by the arrival of the 3G era. The International Telecommunication Union (ITU) has issued four standard formats for three G of communications, CDMA2000, respectively WCDMA, TD-SCDMA and WIMAX[4]. Among them, everybody can be familiar with is CDMA of code division
multiple access technologies. Code division multiple access is the technical basis of 3G. In 2014, 4G finally landed in China. 4G includes TD-LTE and FDD-LTE, setting 3G and WLAN together with 100 Mbps of theoretical download speed and 12.5 Mbps of upload speed for data transmission, high-quality audio, video and picture transmission. Until today, 4G remains the mainstream of mobile communication in society. Before 5G commercialization, 4G will also occupy the top for some time[5].

2.2. 5G
5G communication has greatly changed compared with its previous generations, greatly improved in speed, stability, peak value, etc. As the next generation of 4G communications, 5G will be promoted simultaneously in three dimensions: (1) New wireless transmission technology is introduced to increase resource utilization by more than 10 times on the basis of 4G; (2) The throughput of the entire system is increased by about 25 times by introducing new architectures and deeper intelligence capabilities; (3) With further mining and developing new frequency resources, the frequency of wireless mobile communication in the future is further improved. 5G's arrival raises the overall level of mobile communications by one level and promotes the development of the Internet of things with its superior transmission speed to achieve various items and network connection to meet the needs of the Internet of things. But at the same time, 5G also faces a huge challenge. When emerging technologies come, the speed and quantity are greatly increased. User's total cost will not rise. Instead, we should make a decline. This needs to achieve 5G in the unit flow of the price has a huge breakthrough. The increase of transmission speed brings about the increase of users' usage of traffic. Under the overall trend of rising quantity and falling prices, the cost problem is destined to become a major operator online 5G a major obstacle [6].

3. 5G key technologies

3.1. Multiple access technology
Dilute code multiple access technologies are one of the key technologies in 5G. By using this technique, the amount of information can be greatly increased when the length of the string does not change much [7]. The information is layered, for example, in video calls, the sound and picture are transmitted in different communication bands to achieve the goal of improving speed and stability. The demand for information transmission in the future will be greatly increased because of the development of the Internet of things. Increasing the frequency spectrum multiplexing by sparse code multiple access technologies can improve the utilization rate of unit string.

3.2. Large-scale MIMO technology
The traditional MIMO is to improve the capacity, data rate and transmission reliability of the communication system by providing multiple antennas at the transmitter and receiver[8]. However, the traditional MIMO technology is limited by the size, power consumption and appearance of the mobile terminal. To further improve the data transmission ability, the most intuitive way is to increase the number of data streams transmitted in parallel or the number of antenna ports in the base station. Large-scale MIMO technology means that the base station is equipped with 100 to hundreds of antennas, serving multiple users at the same time on the same video resources, and the mobile terminal generally adopts the communication mode of single antenna reception. With the increase of scale, the antenna density is too high and too close to the transmission channel. It is easy to show correlation and will also produce pilot pollution. How to make good use of large-scale MIMO technology will be a big difficulty[9]. Mobile phone has been an indispensable daily necessity for modern people, and some people regard mobile phone as life. The powerful function of mobile phones is based on mobile networks. During the next 50 years, the human demand for mobile phones and communications will increase greatly, and 4G will not be able to do this difficult task. 5G uses millimeter wave and the network communication speed increases 100 times or even more than 1000 times. But millimeter waves also have very obvious defects about weak penetration, which makes 5G signal can not be transmitted for
long distance. Fortunately, the solution is also very simple such as reducing the size of the base station, setting up a street lamp-like micro-base station in every corner of the city, and making up for the lack of distance through number.

4. Problems in communications technology
Everyone has experienced no signal and mobile data connection instability. This paper also analyzes the causes of connection instability.

4.1. Dobler Effect
The Dobler effect refers to the decrease of the velocity difference between the target and the electromagnetic wave due to the high speed movement of the target. As shown in Fig.1, in front of the moving wave source, the wave is compressed and the wavelength becomes shorter and the frequency becomes higher. The opposite effect will be produced behind the moving wave source. The wavelength becomes longer and the frequency becomes lower. Because of the change of frequency, the signal becomes unstable, which is the Dobler effect.

![Doppler effect](image)

Figure 1. Doppler effect

4.2. Ground interference
There are many buildings in the urban area, the reinforced structure of the building will produce a certain amount of communication shielding to the communication signal. In the area far from the base station, the signal will be weak or no signal. 5G communication uses millimeter wave communication and it has the problem of poor penetration because the urban area has no small disadvantage. Increasing the number of base stations is a good solution, but operating costs and including maintenance will also be greatly increased. The future trend is the reduction of public communication costs, and the fundamental purpose of operators is to make profits. On the fundamental premise of keeping profits, 5G many seemingly easy to solve problems will emerge and become thorny problems.

4.3. Network frequency band and network speed
Before the arrival of the 5G, most of the communication bands had been occupied. The communication band that 5G can use directly is much smaller than other communication such as 4G and 3G. Before the sparse code multiple access technology goes further, similar frequency bands will have serious problems such as crosstalk. 5G compared with 4G, the speed has a qualitative overflight, but with the development of Internet of things technology, the number of items 5G connected will increase exponentially. The theoretical speed of 5G, for example, is 100 times that of 4G, but because of the Internet of things, the number of items that need mobile communication increases to 200 times, so the speed advantage of 5G communication may decline.
5. 5G challenges

5.1. Insufficient frequency bands
Frequency band reuse and low frequency band tillage are two direct ways to solve the shortage of frequency bands. Frequency band utilization is still defective for 5G. 5G can only be solved by opening new frequency bands or temporarily borrowing some special frequency bands during peak periods, or by requirements in different bands. For example, in real-time video calls, the more complex picture signals are transmitted with 5G, while the simpler sound signals are transmitted separately with 4G or other paths, and the pictures are reorganized at the receiving party. This method can improve the speed and reduce the frequency band.

5.2. Cost control
Another challenge for 5G is cost. At present, the communication industry has several fixed costs: early project establishment, equipment bidding, equipment procurement costs; organization of construction, handling materials, housing rental, construction costs, base station supporting facilities, equipment, air conditioning, UPS batteries, transmission cables and so on. These are the cost that the communication company can not bypass. When 5G are charged according to current billing standards, after a hundred times faster, perhaps hundreds of MB of traffic disappear in a blink of an eye. To enable the 5G to occupy a larger seat in the market, the price must have an advantage over the 4G, at least not a 5G shortboard. How to ensure the total price drop under the condition of increasing usage is another difficult problem for technicians to overcome.

5.3. Performance of terminal equipment
With the rise of mobile Internet, terminals continue to develop towards the portable, intelligent, diversified direction, the number of network terminals in the future will be explosive growth, the Internet era of users long tail demand, mobile Internet era of user fragmentation demand, will be fully reflected in the form of terminal equipment. For users, friendly user experience and application diversification become the core competitiveness of service terminals.

Battery is one of the biggest difficulties in hardware development in 5G. A large number of high-tech 5G communication needs to be built on sufficient and complete hardware facilities. But for a long time, technology has been constantly improving, but battery technology is still developing at an extremely slow rate, and its capacitance is still the largest relationship with volume. 5G the pursuit of a large number, then reducing the volume is one of the necessary links. If the volume is reduced, the battery capacity will inevitably decrease. High energy consumption encountered low capacity 5G equipment life becomes a major problem.

6. Summary and outlook

6.1. 5G Road
5G has shown its popularity and popularity before it is officially put into use. Judging from the heat of the Huawei company, it has broken through the US blockade and has sold 40,000 5G base stations around the world, including Switzerland, Hungary and other European countries. In the age of high-speed network information transmission, 5G seems to have unparalleled advantages. the process from 4G to 5G can be said to be a qualitative leap. After the Internet of things is completely mature, human beings will break through the limit of the total amount of items controlled by individual units.

Generally speaking, if 5G can break through the above bottleneck, the current communication conditions can be greatly improved. 5G has a number of application scenarios, including ultra-high-speed scenarios to provide high-speed data network access for future mobile broadband users, and support for large-scale crowds to provide high-quality mobile broadband experience for high-density areas or occasions. Best experience anytime is to ensure that users still enjoy high-quality services in the mobile state. Ultra-reliable real-time connection is to ensure that new applications and user instances
meet strict standards in terms of delay and reliability. Ubiquitous physical communication is to ensure efficient handling of a wide range of device communications including machine-type devices and sensors. [14]

6.2. Prospect of 5G Technology
In the near future, there may be a lot of new careers coming with the emergence of 5G. For example, after the Internet of things farmers, they just need to sit at home. It can remote the control of the farm tools and to manage one or more farms. ITU divides 5G application scenarios into two categories: mobile Internet and Internet of things. In addition to supporting the development of mobile Internet, it will also solve the massive wireless communication needs of machines and greatly promote the development [15,16] in the fields of car networking, industrial Internet and so on. As far as the current planning is concerned, the 5G network not only has a higher transmission rate, but also presents the characteristics of low delay, high reliability and low power consumption in transmission, and the low power consumption can better support the Internet of things applications. The so-called Internet of things is "everything interconnected ". The so-called mass Internet of things refers to at least 1 million devices per square kilometer are connected all the time. The application scenarios of the massive Internet of things roughly include the following parts: asset tracking, intelligent agriculture, smart city, energy or utility monitoring, physical infrastructure, smart home, remote monitoring, beacon and online shopping. Mass Internet of things is 5G compared with previous generations of a new application field. Among these use cases, we can see 5G of transformative impact.

There are many examples of this. The Internet of things will be a new era. When the world is completely Internet of things, there may be a "global village" that can complete a day's mission without leaving home. People enjoy the world at will through drones and VR technology. Moreover, in the future, doctors can operate on distant emergency patients through mechanical arms, and their visual and operational communications can not be separated from five G lines delayed within one ms. With the popularization of 5G and the continuous development of the application market, the distance in space can no longer limit human activities, but also greatly improves the connection between the virtual world and the real world.

7. Conclusion
The research and development of 5G is in its infancy and is about to enter a critical period of development. Its key indicators and technical requirements will be released in the next few years, which will lead to a new round of changes in China's mobile communication industry.

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References
[1] Jia Shiqi. Development of mobile communication networks [J].World of Communication,2017(19):68-69.
[2] Zhang Huihui, Hu Jiwen, Li Tingjun. A Review of the History of Mobile Communications Electronic production,2013(24):114.
[3] Chi Weiqiang. Development and Application of Mobile Communication Technology [J].] and Information and Communications,2014(01):253.
[4] Zhang Chuanjun, Chen Yang. Analysis of Wireless Transmission Technology of the Third Generation Mobile Communication System [J].]1 Electronic production,2013(11):135.
[5] Tao Gang. Architecture and Key Technologies [J].] of the 4th Generation Mobile Communication System Information and Computers (Theoretical Edition),2018(21):151-152.
[6] Pu Zancheng. Development and Research on the Application of the Fifth Generation Mobile Communication Technology Modern Industrial Economy and Informatization 8(14):117-118.
[7] Wang Jun. A D]. Study on Multiple Access Technology of Sparse Code Beijing University of posts and Telecommunications.
[8] Zhang Suoxing, Tao Tao. Massive MIMO key technology advances [J]. Information and Communications, 2018(11):236-238.
[9] Harsh Verdhwan Singh, Shrivishal Tripathi. Compact UWB MIMO antenna with cross - shaped unconnected ground stub using characteristic mode analysis[J]. Microwave and Optical Technology Letters, 2019, 61 (7).
[10] Networks-Telecommunications; Studies from University of Liverpool Reveal New Findings on Telecommunications (Fast Iterative Semi-blind Receiver for Ullc In Short-frame Full-duplex Systems With Cfo) [J]. Computers, Networks&Communications, 2019.
[11] Zhang Bo. The Application Analysis of Millimeter Wave Technology for 5 G [J].; and Digital Communications World, 2019(03):63.
[12] Zhong Min. Key Technologies [J]. of Millimeter Wave in 5 G Applications Digital Communications World, 2019(01):1-4
[13] Zhao Fangfei. Research and Simulation of the Key Technologies of Low Delay and High Reliable Communication for 5 G [D].; and Beijing University of posts and Telecommunications, 2018.
[14] Zhai Guannan, Li Zhaoyong 5 G Concept and Related Applications of Wireless Communication Technology [J.] and Telecommunication Network Technology, 2013(9).
[15] Da Chung. The 5G is coming, the car network development enters the fast lane [J.] the China Radio, 2019(02):46-47.
[16] Zhang Yunyong. 5G Industrial Internet [J.] will be fully enabled Telecommunications Science, 2019,35(01):1-8.