

Research on the Advantages and its application Analysis of 5G

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Keywords: 5G; advantages; revolution; network

Abstract: At this stage, the application and development of 5G communication technology has attracted much attention. It can effectively solve the problems in 4G communication technology and improve the speed of data stream transmission. Based on this, this paper discussed the advantages and its application of 5G. We first introduced the development of the network, then analyzed the characteristics of 5G wireless communication technology, then expounded the main technologies of 5G wireless communication, next analyzed the advantages of 5G, and finally introduced the application of 5G technology in six aspects and it has certain significance for the promotion and future application of 5G technology.

1. Introduction

Wireless communication technology is extremely important in people's daily life and work, and largely meets people's needs for network use. In the 4G era, users' network experience is continuously enriched, and 5G technology has also been invested in research and development. The development of the communication industry is the important transmission of social development and it has provided unlimited development potential for the social economy. At present, China's network communication has undergone changes from 2G, 3G to 4G, and the social response is extremely strong, making 5G wireless communication technology more development opportunities, and will bring people a unique web experience.

2. The Development Of Network

In 1979, the first cellular network in the world was born in Tokyo, Japan and it was operated by Nippon Telephone and Telegraph (NTT) Japan. About two years later, the cellular network technology spread to Europe. Since 1981 cellular network complete the first update from first analog generation network to second analog generation network. About ten years later third generation technology (3G) appeared, and in communication perspective there is a law that communication technology updates one generation every ten years [1]. Every technological breakthrough has brought significant changes to economy and industry. The first generation of wireless communication network is based on analogy signal having the ability to transmit voice, the second-generation mobile communications network is based on digital signal and it supports text messaging and enabled telecoms operators and traditional handset makers. About ten years later, 3G network was born, it's high data transmission rates and increased capacity allow multimedia transmitting. While 4G is an integration of 3G and WLAN, and it's bandwidth and speed of 4G network are improved by this evolution, what's more, this technology reduced communication fee which makes it available for common people [2]. As 4G network mature and commercialize, a series of emerging things appears, such as instant messaging, online shopping, and mobile games. It is believed that 5G technologies can bring some revolution on industry and people's daily life. About ten years later after 4G was born, the first wave of 5G has just arrived. 5G is a paradigm shift compared with previous four generations, as 5G has many new features composed of extreme high carrier frequencies with enlarged bandwidths and high densities of base station and device [3]. In order to prepare for the coming of 5G, Working Party (WP) is preparing evaluation criteria from

2017, and at the same time ITU-R is going to set the standards for 5G and this work is expected to be completed by late 2019 [4].

3. 5G Wireless Communication Technology Features

3.1 Data Transmission Speed Is Fast

Compared with 4G, the first problem 5G needs to solve is high speed. Only when the network speed is improved, can the user experience and feeling be greatly improved. Only when the network can face the VR / UHD service, can it be unrestricted. Only when the network speed requirements are very high, can it be widely promoted and used. Therefore, the first feature of 5G defines the speed increase. As a new mobile communication network technology, the transmission speed can reach several tens of GB per second, and its transmission speed is up to 1 Gbps in the 2 GHz band, which is extremely advantageous.

In fact, as with every generation of communication technology, it is difficult to describe exactly how much 5G speed is. On the one hand, the peak speed is different from the actual experience speed of users, and the speed of different technologies in different periods will be different. The peak value of 5G base station is required to be no less than 20GB / s. of course, this speed is the peak speed, not the experience of every user. With the use of new technology, there is still room for improvement. Such a speed means that users can download a high-definition movie every second, and may also support VR video. Such high speed provides opportunities and possibilities for businesses with high speed requirements in the future.

3.2 Great Compatibility

5G wireless communication technology is based on the original communication technology, forming a wireless network technology platform, involving wireless technologies such as NFC and bluetooth, with good compatibility, making people more secure in the network payment process.

3.3 Extend Battery Life

When using 5G wireless network, there are many small tasks, and it depends on the continuous running support of the application. In this case, in order to realize real-time update, the email will send various types of request information to the server. 5G technology can review the power waste situation during operation and avoid excessive power loss, to extend battery life.

4. 5G Wireless Communication Technology

4.1 New Multi-Antenna Transmission Technology

With the rapid development of China's communication industry and the lack of spectrum resources, communication technology will improve spectrum utilization as a future development direction and target. Applying LSAS technology to this process can improve interference suppression gain and array gain, so that the spectrum efficiency is fully improved. At the same time, LSAS technology can also achieve spatial location division, after division, to provide services for multiple users.

4.2 High Frequency Transmission Technology

At present, low-band resources are limited, and it is difficult to meet people's actual network requirements. In the application process of 5G wireless communication technology, it has high bandwidth requirements. In order to give full play to its application advantages, its RF devices are adjusted to suitable working frequencies and frequency bands to achieve high frequency band expansion. The spectrum of this frequency band has rich resources and continuous large bandwidth, which can meet the communication requirements of short distance and high speed transmission rate. The electromagnetic wave is mostly diameter transmission, the transmission performance is low, and the application is difficult.

4.3 Dense Network Technology

The data traffic is increasing. It is necessary to integrate the deployment-intensive cell construction with 5G communication. Applying low-power nodes in the network, increasing network hotspots and coverage areas, and increasing the capacity of the network system. The increase of the density of the community construction makes the overall topology of the network more complex and cause some signal interference problems. It makes that 5G technology application space more extensive that increasing the research and development of intensive network technology to ensure that the network structure has strong anti-interference and flexibility, in order to meet the various needs of users.

5. THE Advantages OF 5G

Arunabha states that 5G is improved in many aspects not only about the common key performance indicators such as capacity and coverage, but also especially the new aspects including transmission speed, capacity, and extreme connection density [5]. The spectrum used in 5G network is different from the previous generations and this is the main reason why 5G technology has better performance in many aspects compared with previous generations. So this section will discuss the good performance of 5G and explain the reasons. Network signals can be transmitted through a number of media such as twisted pair, light, radio waves, microwave and laser. However most signals applied in communication technologies are transmitted by electromagnetic waves. 3G and 4G network mainly use the spectrum ranges from 1880Hz to 2635Hz as better propagation characteristics can be provided in the available spectrum resource which ranges below 3000Hz. However 5G network signal will use millimeter wave frequency band which ranges from 30GHz to 300 GHz and this available spectrum resources are about more than 200 times more than 4G network spectrum which ranges below 3GHz [6]. From the perspective of communication principle, the maximum signal bandwidth of wireless communication depends on carrier frequency as it just about 5% of the carry frequency bandwidth, so the higher the carrier frequency is, the larger the signal bandwidth can be employed. In millimeter wave, the spectrum around 28GHz and 60GHz are two most appropriate frequency band to carry 5G network signal. Furthermore, the available spectrum bandwidth around 28GHz can reach 1GHz, and the available signal bandwidth nears 60GHz can reach 2GHz so the total spectrum bandwidth which can carry 5G network signal is roughly about 3GHz. As for 4G-ITE network, its highest carry frequency bandwidth is about 2GHz, so its available spectrum bandwidth is only 100MHz. As for the range of millimeter-wave spectrum, 5G bandwidth can be increased around ten times. When the bits of information needed to be transmitted is certain, the broadened spectrum bandwidth enables the speed of 5G technology almost ten times faster than 4G network. In the theoretical perspective the latency will be decreased in the same degree, theoretically the latency of 4G network is about 10~20 ms, and the latency of 5G is only about 1~4 ms. The low latency makes real-time transmission and terminal real-time response possible, which is essential for the development of industrial automation. On the other aspect 5G spectrum also increases the network capacity according to Shannon's theorem, this theorem shows that the limited channel capacity with noise can be calculated by the following formula:

$$C = W \log_2 \left(1 + \frac{S}{N} \right)$$

Where W is the spectrum bandwidth, S is the average power of the signal, N is the average power of the noise and C is the capacity of the network, this formula shows the network capacity is proportional to the network bandwidth so it can be derived that the bandwidth is also enlarged in 5G technology. Network capacity enlarged means more devices can access network at the same time, the high data throughput of 1 million terminal devices access per square kilometre can be realized in 5G millimeter wave. Furthermore the air-interface design and the network architecture is also improved compared with previous generation network, air Interface" is a wireless transmission specification between base stations and mobile phones. Geng Wu states that the channel characteristics is

determined by the radio spectrum used in wireless communications and they finally affect the air-interface design and the network architecture [7]. The air-interface design and network architecture of 5G can support extreme access density with 1 million terminal devices access in network per square kilometre at the same time, and this ability can largely promote the development of industry automation.

6. Application Of 5g

6.1 Industry Automation

5G plays an important role in the development of industry automation and it is believed that it is the technological enabler for industry 4.0. The term of Industries 4.0 was initially proposed in Germany which is going to realize the automation of factory in order to improve production efficiency eventually. The integration of IoT and Cyber Physical Systems is the essential part in the industrial automation area [8]. Industries 4.0 aims to transform manufacturing to intelligence by taking the advantages of the combination of communication technology and Cyber-Physical System. In the 21st century, Industry 4.0 aims to to share information, analyse and use information to guide operations intelligently based on the connection of manufacturing machines and internet of things (IoT). It also incorporates cutting-edge technologies including robotics, artificial intelligence IoT, and other cognitive technologies [9]. All these technologies applied in it are inseparable from the support of communication technology. While the development of Industry 4.0 is limited by 3G/4G networks before, because there are so many shortcomings of 3/4G network. This network can't meet demands of industry automation such as the connections reliability of wireless is not enough for some critical applications and for that the target reliability should be 99.999%. In the transmission aspect the end to end delay is too long to be predictable for remote control and actuation. From the perspective of hardware, there exists two limitations, one limitation is mainly caused by the energy consumption of devices which is too large to meet battery life duration targets, and the other one is the network inability of supporting extreme density of IoT devices [10]. However when 5G is mature enough to be applied in industry, these problems will be solved as 5G have been improved in many aspects compared with previous generations of network. The frequency bandwidth applied in 5G is enlarged almost 200 times and the access density is enlarged almost one thousand times as many as 4G network, for this reason the target performance of wireless connections reliability rates can be more than 99.999% and the latency of transmission can be reduced from 10~20 ms to less 1 ms. In addition 5G network is a low-power consuming technology, because sending millimeter wave signal consumes less power than 3/4G signal, so the low power consuming will extend the battery life duration and eliminate the limitation of hardware. Furthermore the big capacity of 5G can hand extreme assess density of devices. 5G technology has been improved in many aspects and and its advanced features can meet the needs of industry 4.0. It can be stated that 5G is the main enabler to the development of industries 4.0 and it will promote the development of intelligent manufacturing [11].

6.2 Self-driving

In addition to industry, 5G have improved human's daily life in many aspects including transportation, medical treatment, entertainment and some other aspects. In the future when vehicles are equipped with 5G network they will be safer and smarter then before. In the era of 3/4G there also exists some cars equipped with self driving function, however there are some problems affecting users experience, what is worse sometimes self-driving is danger. There are some accidents caused be self driving cars when the function is based on 3/4G network, for example the first accidence caused by self-driving happened in USA in January 30th 2016, and the driver died instantly. After that expert studied the accident and came to a conclusion the main reasons is that the transmission speed of current 3/4G is not fast enough to realize real time date transmission, on this condition vehicles can not response according to the changing road conditions instantly. However in the future the numbers of cars will continue to increase and the communication between vehicles will

exponentially increase. At that time the network access density will increase almost one thousand times and massive amounts of data need to be transmitted in real time. However the spectrum of 3/4G is limited and the transmission delay near 10~20 ms so this network can't support the access density and the transmission rate is not fast enough for real time transmission. However 5G can solve this problem and make self-driving cars more intelligent and safer than before. It is an essential technology for the development of intelligent vehicle, as 5G applications have the features which is key for self-driving cars to travel safely. Ultra-high data transmission rate and super-low latency can enable cars realize real-time data transmission and response instantly when run into unexpected situation [12].

6.3 Medical Treatment

5G technology also impacts the development of medical instruments and creates new possibilities in the medical field. Since the 1950s, there are appeals to use computers and electronic instruments in medical field. With the development of communication technology medical treatment have reached great advancements, which is mainly because of the evolution of Internet and mobile communications. However the remote treatment have not been widely used for some restrictions of network. 5G will bring overall improvement of the network layer, which largely meets the demand of remote medical treatment in the aspects of reliability and real-time response. Based on real-time transmission of medical images and videos, doctor can perform remote diagnose and surgery for patients more efficiently. In the era of 5G, more wireless intelligent devices will emerge. Intelligent terminals like bracelets, intelligent measuring instruments or other things like this will form a complete data recording system, medical devices constantly acquire patients medical data, such as electronic medical records, physical activity frequency, and medical images. In this system doctors can collect and analysis medical data and with the support of 5G technology, experts can deeply mine massive medical data to identify common characteristics of some particular diseases, it is helpful for doctors to make more precise diagnose and apply specific treatment on patients. In addition, the combination of 5G and big data enables flexible interaction between doctors, patients and even hospitals, in this case, the information of patient's medical records are shared between medical institutions, so doctors who works in different places can consult the patient's medical records at any time. Based on the remote treatment, 5G can also promote the balance distribution of medical resources. In China medical resources distribution is not balanced, most of the high-quality medical resources are distributed in big cities while in remote areas the resources is scare and medical technology is outdated. With the help of 5G technology, doctors can retrieve patients' medical records more quickly, and remote diagnosis can be conducted in this case. Furthermore remote consultations and surgery also help to eliminate regional restrictions. 5G technology will promote the development of medical instruments and facilitate diagnosis base on accessible medical records, what is more, the development of remote diagnosis and surgery can eliminate the unfairness in some degree between big city and remote area.

6.4 Entertainment

5G technology will not only promote the development of industry, but also creates new entertainment models and immersive interactive experience. Videos, games, shopping and some other areas in entertainment will be changed fundamentally. 5G will inevitably promote development of Augmented Reality technology which plays an important role in social media and entertainment industry. This is an emerging technology combing reality and virtual objects in a real environment. It aims to enhance the users experience in the real world by AR equipment. When users use AR device, people in the real world can feel the combined scene of virtual objects and reality. In the future 5G will add a new and palpable dimension to entertainment by promoting the development of AR. However this technology is not yet mature, some limitations of network restricts its development to some extent, for example AR technology requires real-time rendering of images, and at the same time in order to transmit image data it require big network capacity. However the limited bandwidth of 3/4G network does not have ability to process massive amounts of data at the same time and this

network can not realize the real-time rendering of images without delay. These are the main reasons why AR users sometimes feel a sense of vertigo. When 5G technology is combined with AR, these restrictions will be eliminated, so AR technology will drive the development of entertainment industry.

6.5 Light Field Camera

Unlike previous cameras, light field cameras take pictures first and then focus. Depending on the light field technology, only the composition work can be done during the photo taking process. This technology can effectively compensate for the shortcomings in the current camera, and the camera is beneficial in snapping, as long as the object being photographed is within the focal length of the camera, all optical information can be recorded during the photographing process. After the photographing is completed, the focus is based on actual needs. Based on the above considerations, the camera has a large capacity. The space required for a single photo is 200m, and the transmission speed and storage space requirements are relatively high. 5G wireless communication technology can meet the needs of this type of camera. 5G technology can also be applied to the security monitoring system with its unique advantages.

6.6 Android Applications

Nowadays, the mobile intelligent device terminal system is mostly Android system, and the application of the system in mobile devices is very advantageous. It is based on Linux and is essentially a free and open source operating system. Android is a layered architecture consisting of four layers: application layer, application framework layer, system kernel layer and system runtime layer. 5G nanocore technology can be applied in the system kernel layer. With this technology, Android hardware drivers and basic files are properly separated. Because the Android system has open features, its security is difficult to guarantee in the specific application process. 5G nanotechnology has good confidentiality characteristics and enhances encryption levels by applying quantum cryptography.

7. 5G Wireless Communication Technology Development Trend

Under the current social background, people's communication requirements are increasing day by day, and the research and development of 5G network technology has been intensified. Although the core system has not been clearly defined, the development prospect is extremely broad. Compared with the previous communication technology, 5G wireless communication technology has great advantages in transmission speed and energy consumption, can meet the management, network and business development requirements, and provides a broad application development space for communication technology.

5G wireless communication technology has great development advantages, can meet the daily network needs of users, make its daily work more convenient, and realize the rapid development of the communication industry. In the development process of China's 5G communication industry, a clear development is proposed for 5G communication technology planning. Whether based on business support or other aspects, we must continuously improve its transmission rate. At the same time, we must simultaneously apply wireless technologies such as radio frequency to provide users with a high-quality network experience. The method refers to the dynamic traffic standard, reasonably configures the communication system resources, realizes the technical application cost control and the 5G technology communication signal range expansion.

8. Conclusion

In conclusion, 5G have many advantages compared with previous generation network as it is improved in many aspects such as broadened bandwidth, enlarged capacity and increased speed. With this good features 5G technology can promotes the development of industry automation and

change human daily life. This article explains why 5G have been improved compared with previous network and then lists some technological revolution caused by 5G network. In the perspective of technology, 5G signal mainly use the millimeter-wave which range from 3GHz to 300 GHz, and this is the main reasons why 5G can have features of low latency, big network capacity, and extremely high connection density. Because of these features 5G becomes an essential enabler for industrial automation including Industry 4.0 and self-driving technology, in addition to industry, 5G technology will inevitably affect some other aspects of human life such as medical treatment and entertainment. When 5G technology matures, the mode of production and lifestyle will change dramatically.

References

- [1] Sharma, Pankaj. Evolution of mobile wireless communication networks-1G to 5G as well as future prospective of next generation communication network [J]. *International Journal of Computer Science and Mobile Computing*. 2013 (8): 47-53.
- [2] Gawas, A. U. An overview on evolution of mobile wireless communication networks: 1G-6G [J]. *International Journal on Recent and Innovation Trends in Computing and Communication*. 2015 (5): 3130-3133.
- [3] Andrews, Jeffrey G., Stefano Buzzi, Wan Choi, Stephen Hanly, Angel Lozano, Anthony C. K. Soong, and Jianzhong Charlie Zhang. What Will 5G Be? [J]. *IEEE Journal on Selected Areas in Communications*, Special Issue on 5G Communication Systems, Editorial/Tutorial Paper. 2014(9): 160-167.
- [4] Shafi, Mansoor, et al. 5G: A tutorial overview of standards, trials, challenges, deployment, and practice [J]. *IEEE Journal on Selected Areas In Communications*. 2017 (6): 1201-1221.
- [5] Shankaranarayanan, N.K, and Arunabha Ghosh. 5G [J]. *IEEE Internet Computing* 2017 (21): 8-10.
- [6] Xu, Xiaoling, Mei Liu, Jianbin Xiong, and Gaowei Lei. Key technology and application of millimeter wave communications for 5G: a survey [J]. *Cluster Computing*. 2018 (12): 1-13.
- [7] Geng Wu., Huaning Niu, Papathanassiou, and Li, Q. 5G network capacity: key elements and technologies [J]. *IEEE Vehicular Technology Magazine*. 2014 (9): 71-78.
- [8] Vogel-Heuser, Birgit, and Dieter Hess. Guest editorial industry 4.0–prerequisites and visions [J]. *IEEE Transactions on Automation Science and Engineering*. 2016 (13): 411-413.
- [9] Rao, Sriganesh K., and Ramjee Prasad. Impact of 5G technologies on industry 4.0[J]. *Wireless Personal Communications*. 2018 (10): 145-159.
- [10] Cheng, Xiang, et al. 5G-enabled cooperative intelligent vehicular (5GenCIV) framework: When Benz meets Marconi [J]. *IEEE Intelligent Systems*. 2017 (32): 53-59.
- [11] De Mattos, Willian D., and Paulo RL Gondim. M-health solutions using 5G networks and M2M communications [J]. *IT Professional*. 2016 (18): 24-29.
- [12] Campbell, Karen, et al. The 5G economy: How 5G technology will contribute to the global economy [J]. *IHS Economics and IHS Technology*. 2017 (4): 16.