Prospect of 6G Applications Based on 5G Technology

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Abstract. 5G technology represents the fifth generation of mobile network. It is a new global wireless standard after 1G, 2G, 3G, and 4G network. After years of development, 5G technology is almost completed. Academia has begun to consider increasing the communication technique standard once again. 6G technology, which is meant to deliver 1Tb/s pear data speed and broad frequency bands of 100 GHz to 3 THz, is coming into people's vision. So the author aims to discuss the prospect of 6G application based on 5G technology. In this paper, the main features, threats, and technological differences between 5G and 6G will be evaluated and compared. Through comparative study, this paper considers that 6G technology can improve network capacity and transmission rate to meet the needs of holographic communication, meta-universe and other new applications in the future.

Keywords: 6G trends · 6G applications · 6G technologies · 6G threats · comparison between 5G and 6G

1 Introduction

It is widely believed that 4G will change lives, 5G will change society, and 6G will change the world. "5G is here, but 6G is already knocking on the door," says Alexander Pabst, Vice President, Market Segment Wireless Communications at Rohde & Schwarz, with conviction [1]. The idea that light is an electromagnetic wave was initially proposed in 1846, and it is considered that light beams transmit electromagnetic waves. Hertz defined light as an electromagnetic wave in 1889 and discovered that electromagnetic waves travel at the speed of light, as predicted by Maxwell.

Ten years later, on December 12, 1901, Marconi, an Italian engineer, made the first radio communication over the Atlantic Ocean. The transmission capacity was merely a few bits per second at the time. This ushered in a new era of radio communication based on electromagnetic waves. Since then, there have been 1G, 2G, 3G, 4G, and 5G, with 6GB coming shortly. Every decade or so, a new generation of mobile network comes along. What is being experienced is the AGE of 5G. 5G proposes not only communication between people, but also communication with machines, the large-scale Internet of things, the connection of things. 5G can be used to realize holograms, unmanned driving, and even remote operation, etc. It has realized the interconnection between people and

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the interconnection between things. 6G will help the whole society move towards a digital twin virtual and real world. Every object and person in real world will have a mapping or proxy in the virtual world. In the virtual world, human beings can simulate the operation of real society so as to make predictions and necessary interventions in the future of the real world. What happens in the virtual world can directly affect the physical world, and can even affect and touch the behavior inside the physical world. The most popular service of 6G is Artificial intelligence (AI) and extended Reality (XR), which combines virtual reality (VR), augmented reality (AR) and mixed reality (MR).

However, even though 6G technology is advanced without doubt, some believe that 5G technology is enough for human beings and that 6G technology is not necessary. The remainder of this paper will introduce the main features and threats of 5G and 6G technology separately. A comparative study will then be used to analyze the difference between 5G and 6G in their KPI and technology. This paper emphasizes the necessity of 6G technology by analyzing the changes and potential dividends brought by 6G technology to people's lives. The research of this paper enriches the relevant academic content to a certain extent, and provides a certain basis for the follow-up technology research.

2 Applications of 5G

The application of 5G technology is extensive, aiming to serve and improve people's lives. 5G applications in healthcare, urban construction and social networking make people's lives more convenient and efficient. In the application field of 5G technology, the concept of Internet of Things (IoT) is most mentioned. Smart city, smart factory and smart home are the intuitive embodiment of 5G technology. Other applications of 5G include VR, AR, UHD videos, Telemedicine, Warble services and so on. These 5G applications are not self-contained, and one app is frequently linked to another.

For example, one of the technologies of 5G can help monitor blood pressure, fat mass, and be programmed to make health recommendations based on the status of the body in the smart home idea of Internet of Things technology. This technology is related to a sophisticated sensor, which is a sort of wearable technology. While there are many areas where 5G technology can be applied, here discussed are applications in Internet of Things (IoT) area.

2.1 Public Safety

Global climatic abnormalities have become more common in recent years, with the growth in the frequency and severity of disasters. The Internet can monitor environmental instability in real time, prevent disasters in advance, provide early warning in real time, and take appropriate action to limit the risk of human life and property being destroyed by disasters. The deep-sea Internet project, which uses specially processed sensors deployed in the deep sea to monitor underwater conditions, avoid marine pollution, locate seabed resources, and even deliver more reliable tsunami warnings, was proposed by the University at Buffalo as early as 2013 [1].

The project was successfully piloted in a nearby lake, laying the groundwork for future growth. The Internet of Things can intelligently monitor index data of factors such as the atmosphere, soil, forest, and water resources, thereby improving human living conditions.

2.2 Smart Traffic

The use of Internet of Things technologies in road traffic is fairly established. Traffic congestion, sometimes even outright paralysis, has become a serious concern in cities as social vehicles have grown in popularity. Real-time traffic monitoring and rapid information transmission to drivers, allowing drivers to make appropriate route adjustments and efficiently relieve traffic congestion.

At highway intersections, an automatic road charging system (ETC) is installed, which saves time getting and returning the card at the entrance and exit and increases vehicle traffic efficiency. The positioning system aboard the bus can recognize the bus route and arrival time in real time, and passengers can choose to travel along that route to avoid wasting time. With the rise of social vehicles, parking has become a major issue, in addition to increasing traffic congestion. Many cities have implemented a smart roadside parking management system that is based on a cloud computing platform and integrates Internet of Things and mobile payment technology to share parking resources and enhance parking utilization rates and user convenience. It may achieve timely comprehension of parking information and parking position, make reservations in advance, and complete payment and other operations through the mobile APP software, which largely overcomes the problem of difficulty in parking.

2.3 Smart Home

Smart home is the basic application of the Internet of Things in the home. When there is no one at home, intelligent air conditioning can be operated remotely by clients like mobile phone interfaces to adjust the room temperature. Users' habits can even be learned to achieve automatic temperature control operation. Through the client, users can realize the switching function of the intelligent bulb, which controls the brightness and color of the bulb.

The smart toothbrush can also be connected to the client to remind users of the brushing time and brushing position. It can produce charts and oral health status according to the data of brushing. Smart cameras, window sensors, smart doorbells, smoke detectors, smart alarms and other security monitoring equipment are indispensable for families. Users can go out in time to check the real-time situation of any corner of their home at any time and place, avoiding any security risks.

3 Threats and Challenges of 5G

5G is a very developed technology and offers many improved network services. Compared with the previous generation of technology, 5G has a huge improvement in reliability, speed, and capacity, and a significant reduction in latency and error probability.

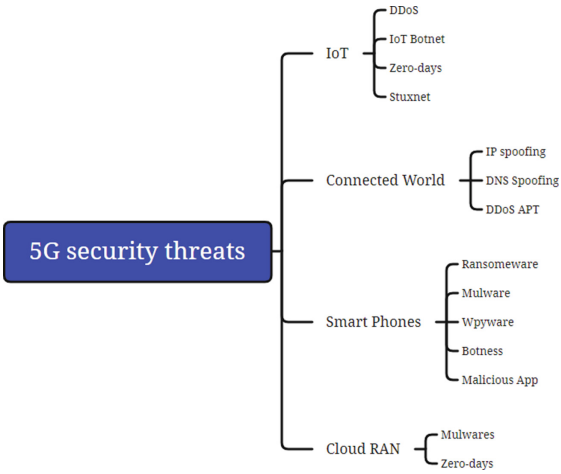

Fig. 1. 5G security threats

However, since 5G is meant to connect everyone and everything, its vast resources make it more likely to be attacked. Professional attackers could launch attacks on 5G resources. The majority of such attacks are believed to be motivated by politics and money. Here is the structure of 5G security threats [2] (as shown in Fig. 1).

IoT has the most vulnerabilities of all the dangers and is the most serious difficulty in 5G. As a result, in this ever-changing threat environment, suitable and effective security architecture and practices must be implemented [3]. In this paper, threats and challenges posed by IoT will be discussed [4].

3.1 Unification of Technical Standards

The standards of the traditional Internet are not suitable for the Internet of Things. Different devices on the Internet of Things have different interfaces and different technical standards. To establish a unified architecture for the IoT, a unified technical standard for the IoT is the problem. Many IoT professionals have begun to advocate for worldwide protocol standardization. However, because of its intrinsic fragmentation, the IoT industry will almost never require an all-encompassing standard. Fit-for-purpose IoT protocols for their implementation will continue to evolve along the road just as new applications arise within the IoT sector [5].

3.2 Safety Problem

Although the traditional Internet is established and widely utilized, it still has security flaws. The Internet of Things has a more complex architecture and no unifying standard as an evolving product, resulting in more noticeable security issues in numerous aspects. The sensor network is the most important realization technology. How to maintain the integrity of the network for a long time in the natural environment where sensors are exposed, especially those sensors situated in hostile environments, raises new criteria

for sensor technology. The sensor network must be capable of self-healing. Human factors, as well as environmental factors, have an impact on this. Another important implementation technology is RFID, which involves embedding electronic tags in goods ahead of time in order to achieve real-time monitoring. This is bound to expose the owners of some labels' personal information, and there are issues with personal information security. It is not only about the protection of personal information, but also about collaboration between businesses and countries. The implications of an attack on the network will be far more unthinkable. It's critical to figure out how to strike a balance between information and security while using the Internet of Things.

3.3 Problems of Management Platform

Since the Internet of Things is a sophisticated network system with application sectors spanning many aspects of life, there will obviously be a lot of overlap. There will be a lot of information redundancy, repeated effort, and repeated construction if the network system does not have a specialized comprehensive platform for information categorization management. This will result in a waste of resources. Each industry's application is unique, with high costs and low efficiency, and it cannot reflect the benefits of the Internet of Things, which is bound to have an impact on the Internet of Things' promotion. A unified administration platform for the Internet of Things is urgently needed to unite the resources of many businesses so that it can form a complete industrial chain.

3.4 Cost Problem

Countries are actively supporting the Internet of Things. Behind the seemingly endless blooming of a hundred flowers, there are few IoT projects that can be truly invested in and used on a large scale. The sensor network is a multi-hop self-organizing network that is easily damaged by environmental factors or human factors. The maintenance cost of the sensor network is high to ensure that the network is unobstructed and reliable information can be transmitted securely in real time. Without universally acceptable costs, the development of the IoT can only be empty talk.

4 Applications of 6G

By 2030, the digital world will be deeply integrated with the physical world, many scenes that are still fantasy will become reality, and human life will be greatly changed. Similar to previous generations of mobile communication technology, most performance indicators of 6G will be improved by 10–100 times compared to 5G. To make it intuitive, downloading a movie can be completed in 1 s, while the network delay of 0.1 ms is almost imperceptible to human beings. In the 6G era people will find more and more things with endogenous intelligence. All electronic devices are meant to be connected together with the help of 6G technology. Some of the application scenarios explored in the 6G era include: super-powered transportation, body domain networks, machine collaboration, multi-sensory mixed reality, virtual assistant, emotional and tactile communication, tactile Internet, holography, intelligent interaction, and spatial communication.

6G technology can also be applied in healthcare systems, communication smart society, automated communication systems, the industrial sector and so many other areas. Here are some of the common uses of 6G technology.

4.1 Extended Reality

The most popular application of 6G is extended Reality (XR), which combines virtual reality (VR), augmented reality (AR) and mixed reality (MR). It allows geographically dispersed people to get the feeling of being in the same space. For example, although the conductor, violinist, drummer, and singer are not in the same place, the performance team can still give the audience a wonderful concert through 6G. 6G can also make virtual things created in the real environment more changeable with people's will, the device and sensory seamless connection, and remote holographic reality, which makes distance education, collaborative design, telemedicine, telecommuting, advanced THREE-DIMENSIONAL simulation and training, and national defense applications have a deeper imagination space [3].

4.2 Haptic Internet

The message of the future will go beyond pictures, words, sound and video. They can include transmitting taste, touch, and even emotions. 6G technology can greatly improve the efficiency of network communication and learning, and even directly stimulate the cerebral cortex of the human body, thus forming the physical memory, which is a revolution in learning style.

4.3 Body Area Network

Body area network refers to the use of more substitutable and implantable body organs in the future, and even the installation of nano-robots in the body to dynamically monitor the operation of various organs in the body. In the network, real-time tracking and modelling of the running state of the human body can be carried out in order to forecast and intervene on lesions in advance, hence improving the quality of human lives.

5 Possible Threats and Challenges of 6G

The threats and challenges of 6G are more theoretical. The threats to 6G technology are as following:

5.1 Technical Bottlenecks

Through new technology and modes of cooperation, 6G can help the network itself achieve rapid iteration. At the same time, the 6G network can realize self-birth, autonomy, and self-evolution, rather than relying on people to study and introduce a new feature or version. The operator should learn from the Internet company, to learn each other's rapid iterations on products and business [6].

Table 1. Parameters of 4G compared with 5G

	4F-Cat 3	4G-Cat-12	5G-UE	5G-2 UE
Downlink Peak Data Rate	75 Mbps	420 Mbps	885 Mbps	1465 Mbps
Uplink Peak Data Rate	22 Mbps	87 Mbps	92 Mbps	91 Mbps
Latency (one-way)	13 ms	12 ms	3.71 ms	4.96 ms
Packet Error Rate	0.3%	0.2%	0.39%	0.67%

5.2 Security Issues

As the resources of 6G technology become more accessible to the general public, the number of devices that can be attacked is increasing. Endogenous security, big data, security, and AI will become integral parts of the network. 6G technology needs to form an intelligent consensus of information and an intelligent defense of the network [7].

5.3 Difficulties in Collaboration

Network business needs are more diverse. There has been a lot of crossover in 5G applications, and the evolution of 6G technology has made industry standard customization more difficult. It is critical to have an interdisciplinary, cross-field collision of ideas and collaboration. International organizations need to play a bigger role in making standards more transparent and in line with the technology of most countries.

5.4 Cost Problem

Energy consumption increases as the generation of the network increases. 6G network needs to be autonomous and independent without manual intervention or maintenance to limit network costs [8].

6 Forecast of 6G KPI

Generally, 6G technology will be implemented around 2030. KPI of 6G can only be predicted. In this paper, the KPI of 4G and 5G based on existing data will be valued and compared with each other, thus predicting the KPI of 6G technology (Tables 1 and 2).

According to the data obtained by IEEE researchers, compared with 4G, pear data rate of 5G has significantly increased. Increased bandwidth, alternative coding, and improved modulation are used to produce high throughput. One of the primary promises of 5G is that the latency experienced with 4G would be substantially decreased to roughly 1 ms.

Moreover, latency can be kept low even when the network's traffic load is high. In terms of packet error rate (PER), if packet loss occurs, the data connection layer of the radio channel should fix the transmission mistakes. Because we tested PER at a higher layer, we anticipated seeing it only when lower levels failed to restore packets [9].

Table 2. Experimentation and 5G KPI measurements results

Deployment Parameters	Athens		Malaga	Limassol	Surrey	Berlin
Core Network	Amarisoft EPC Rel.15 (Athens 1)	Athonet EPC Rel.15 (Athens 2)	Athonet EPC Rel.15	Amarisoft EPC Rel. 15	5GIC Rel.15 4G Core	Open5GCore Rel.5
3GPP Mode	NSA Option 3a		NSA Option 3x	NSA Option 3	NSA Option 3	SA
Frequency	4G: 2.1GHz, 5G: 3.5 GHz		4G: 2.6GHz, 5G: 3.5 GHz	4G: 2.1GHz, 5G: 3.5 GHz	4G: 700MHz, 2.6GHz, 5G: 3.5 GHz	5G: 3.7 GHz
Bandwidth	4G: 10 MHz, 5G: 50 MHz		4G: 20 MHz, 5G: 40 MHz	4G: 10 MHz 5G: 50 MHz	4G: 20 MHz, 5G: 100 MHz	5G: 100 MHz
MIMO Layers	4G: MIMO 2x2 5G: MIMO 2x2		4G: MIMO 4x4, 5G: MIMO 2x2	4G: MIMO 2x2, 5G: MIMO 2x2	4G: Omni 5G: MIMO 64x64	5G: MIMO 2x2
Duplex Mode	4G: FDD, 5G: TDD		4G: FDD 5G: TDD	4G: FDD 5G: TDD	4G: FDD & TDD 5G: TDD	5G: TDD
TDD DL:UL ratio	7:2		8:2	7:2	8:2	8:2
UE	Samsung A90 5G		Samsung Galaxy Note 10 5G	Samsung A90 5G	Huawei 5G CPE Pro	Huawei P40 Huawei CPE 5G Pro & Pro2
Chipset	Qualcomm SM8150 Snapdragon 855		Exynos 9825	Qualcomm SM8150 Snapdragon 855	Balong 5000 multi-mode	Kirin 990 5G Balong 5000 multi-mode

6G is a new generation of network technology. When compared to 5G, 6G is expected to have higher performance. For example, the peak data rate as well as the experience data rate of 6G should be higher than that of 5G. Measuring objects like spectrum efficiency, energy efficiency, and regional traffic capacity should also be increased. 6G technology should have a shorter processing latency and have more mobility. The predicted parameters of 6G have been listed in Fig. 2.

7 Discussion

The 5G mobile network is a worldwide wireless standard that includes a variety of supporting technologies to meet user needs. 5G applications are heavily reliant on 5G technology features. For example, 'Virtual reality' relies on 5G's large bandwidth and low latency. 'Smart energy' relies on 5G's high reliability, broad coverage, and low latency. In short, 5G technologies create conditions for 5G applications (Figs. 3 and 4).

6G is still under development. Flexibility and adaptability, self-sufficiency, dispersed intelligence, and a vast intelligence surface are all required in 6G technology. The 6G network's smart connectivity is intended to include:

- Remote radio heads (RRH)
- Visible light communications (VLC)
- Mounted Network equipments over moving objects, e.g., autonomous vehicles
- Drones
- Base stations (BSs)

The technological differences between 5G and 6G are shown in Fig. 5.

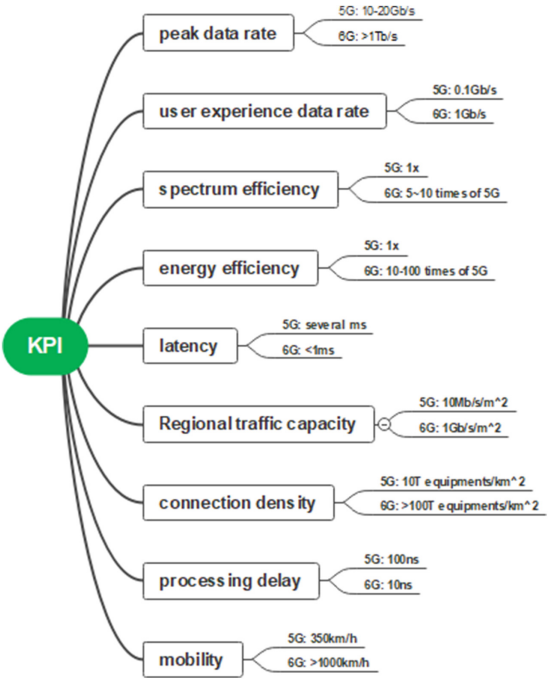

Fig. 2. KPI prediction of 6G compared with 5G

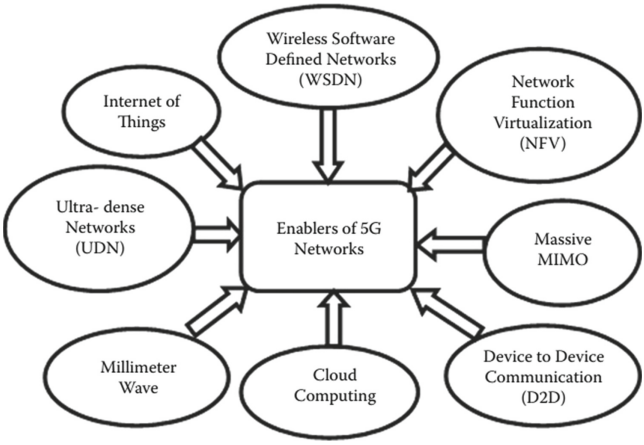

Fig. 3. Enablers of 5G technologies

The next-generation technology focuses on larger interface surfaces and Quantum Communication. 6G technologies' various integrated capabilities facilitate a variety of multidisciplinary applications. Based on 5G technology such as mm-Wave communication, AI, Polarcode, NOMA and ultra-dense network, 6G has developed new technologies

PARAMETERS CATEGORY	LATENCY	MOBILITY	SPECTRUM EFFICIENCY	USER EXPERIENCED DATA RATE	PEAK DATA RATE	AREA TRAFFIC CAPACITY	ENERGY EFFICIENCY	CONNECTION DENSITY
eMBB	Med	High	High	High	High	High	High	High
URLLC	High	High	Low	Low	Low	Low	Low	Low
mMTC	Low	Low	Low	Low	Low	Low	Med	High

Fig. 4. 5G Requirements according to the use cases

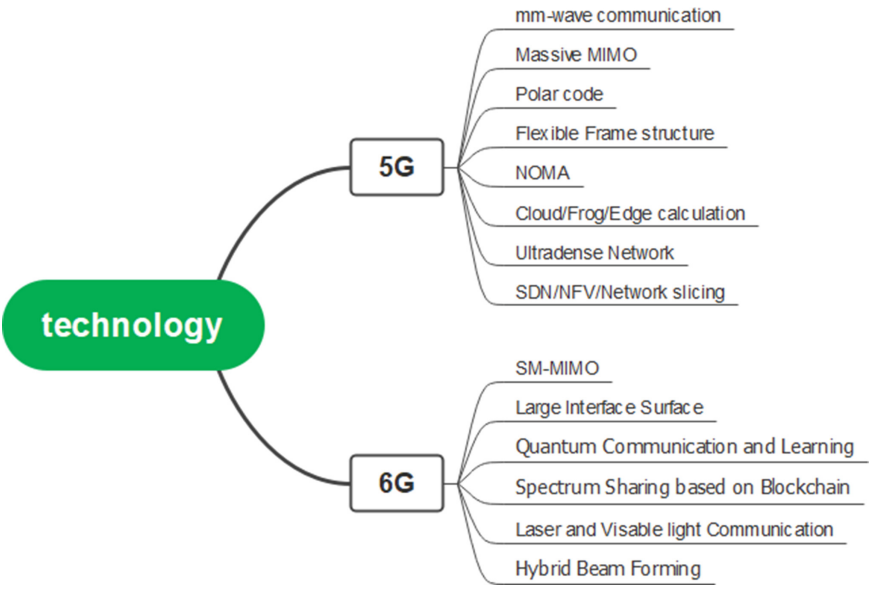

Fig. 5. Technology difference between 6G and 5G

like SM-MIMO and Hybrid Beam Forming, improving cellular indicators such as data rate, throughput, and efficiency [3, 10].

8 Conclusion

Because 6G is currently under investigation, a specific connotation cannot be determined at once. In terms of communication technology, 6G is sometimes referred to as a substitute for 5G. 6G will vastly outperform 5G and provide a plethora of new areas of interest to fulfil the growing demands of future communication. This paper evaluates and compares the main features, threats, and technological differences between 5G and 6G and finds that 6G technology has potential applications in areas such as Extended Reality, Haptic Internet, and Body network. Despite the 6G network's threats, it can bring changes to people's lives and has potential dividends. As a result, 6G technology is necessary. Hopefully, the development of 6G technology can be promoted. This paper

only conducts qualitative research on the possible future trend of 6G based on current 5G technology. Studies of this predictability are relatively sketchy. In future research, further qualitative analysis of 6G technology parameters is required based on the measurement data in the laboratory, so as to further study the application and threat of 6G technology.

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