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FUTURE TECHNOLOGIES AND CHALLENGES OF 6G - AN ANALYSIS

Suryashree Pandey[1], Bidisha Paul[2], Abhinandan Sarkar[3]

[1,3]Assistant Professor, Department of Electronics & Telecommunication Engineering,

Shree Ramkrishna Institute of Science & Technology, Kolkata, W.B, India

[2]Assistant Professor, Department of Electrical Engineering,

Shree Ramkrishna Institute of Science & Technology, Kolkata, W.B, India

Abstract

A number of intelligent applications are being integrated with the advent of 5G wireless communications technology. However, 5G specs firmly meagre the needs of new emerging technologies. Data rate, capacity, latency, dependability, resource sharing, and energy per bit are a few of these. Research is concentrating on 6G wireless communications, which is allowing many technologies and creating new applications, to satisfy these demanding requirements. The most recent research on 6G technology and applications is reviewed in this paper, along with the accompanying research issues.

Keywords—*5G, 6G wireless communication, requirements, capacity, data rate, applications, challenges*

1. INTRODUCTION

A new communication system has been launched almost every 10 years, enhancing QoS and adding new features and technology. Although 5G has been launched recently, 6G communication system is the focus of current research. The rationale is that 5G offers a high-standard infrastructure that makes a range of technologies possible, including self-driving cars, artificial intelligence, mobile broadband communication, the Internet of Things, and smart cities. But as the use of smart gadgets increases year after year, the amount of data flow will expand dramatically, this limits the 5G communication network's capabilities as shown in fig.1.

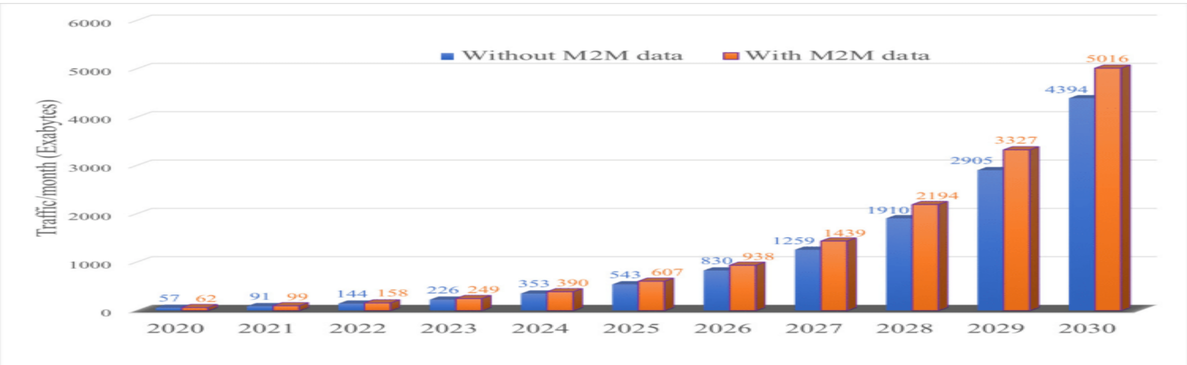

Fig. 1: ITU Global mobile data traffic Prediction [1]

Due to these limitations, a brand-new communication system is now possible that offers more capacity, incredibly low latency, high data transfer, secure error-free communication, and complete wireless coverage. Table 1. contrasts the key attributes and innovations of both 5G and 6G. The Internet of Everything, the Internet of Nano-

Things, and the Internet of Bodies will all be supported by 6G, which will also be able to link everything, integrate various technologies and applications, enable holographic, haptic, space, and underwater communications.[2]

Characteristic	5G	6G
Operating frequency	3 - 300 GHz	upto 1 THz
Uplink data rate	10 Gbps	1 Tbps
Downlink data rate	20 Gbps	1 Tbps
Traffic capacity	10 Mbps/m^2	1 - 10 Gbps/m^2
Localization precision	10 cm on 2D	1 cm on 3D
Uniform user experience	50 Mbps 2D	10 Gbps 3D
Time buffer	not real-time	real-time
Center of gravity	user	service
Satellite integration	No	Fully
AI integration	Partially	Fully
XR integration	Partially	Fully
Haptic communication integration	Partially	Fully
Automation integration	Partially	Fully
Spectral efficiency	10 bps/Hz/m^2	1000 bps/Hz/m^2
Reliability	10^{-5}	10^{-9}
Maximum mobility	500 km/h	1000 km/hr
U-plane latency	0.5 msec	0.1 msec
C-plane latency	10 msec	1 msec
Processing delay	100 ns	10 ns

Table 1. Comparison between 5G and 6G

In this article, the key obstacles to the attainment of the 6G objectives are discussed in section 3 along with a few upcoming technologies and applications launched and created by the 6G communication technology in section 2

2. AREA OF EMERGENCE AND APPLICATION

Every communication system makes room for new functions and uses. The introduction of AI, automation, and and secure, effective transmission. The primary 6G applications, trends, and technology are depicted in Fig. 2. Some of these 6G technologies and applications are covered in this section.

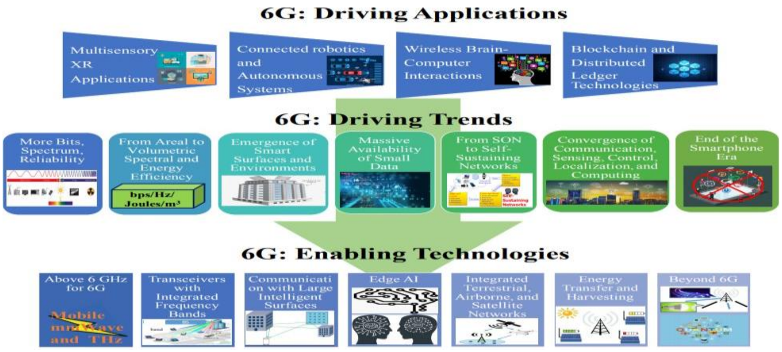

Fig. 2: 6G primary Applications, trends, and technologies [3]

2.i. Tetra-Hertz Communication

The demand for wireless communications technology is outpacing the RF band's capacity, which is practically full. The THz band, with a frequency range of 0.1 to 10 THz, will be essential for 6G, providing increased bandwidth, capacity, ultra-high data speeds, and secure transmission. The Internet of Nano-Things will be supported by the THz band, which will enable the construction of microscopic cells with dimensions ranging from nanometer to micrometre. It will also provide very high-speed communications with a coverage range of up to 10 m. Since Tbps lines cannot be supported by technologies operating in frequency ranges below 0.1 THz, 6G will be the first wireless communication system to do so.[4-6].

2.ii. Cell free communication

In future generations, it was suggested that Unmanned Aerial Vehicles (UAV) be employed in areas without infrastructure. However, 6G will make full advantage of this technology, enabling cell-free connectivity. The user's call ought to be sent to the new cell when the user equipment (UE) switches from one cell coverage to another. The user's call may be disconnected as a result of this failed handover, which may lower the system's QoS. Since the UE will be connected to the whole network rather than just a single cell in 6G, the issue of cellular coverage will be solved. Utilizing UAV will enable the integration of several technologies, enabling the user experience to utilize the technology with the best coverage without requiring any manual device adjustments.

2.iii. Artificial Intelligence

There was no use of artificial intelligence (AI) in 3G or 2G or 1G or 4G. It is backed in part by 5G, which is changing the telecoms industry and creating way for new, amazing applications. However, 6G will completely facilitate automation using AI. In order to improve performance, particularly for delay-sensitive applications, it will be involved in handover, network selection, and resource allocation. The key technologies of 6G are artificial intelligence and machine learning. [8-12].

2.iv. Holographic Beamforming

By concentrating the power in a small angular range, beamforming uses an antenna array to guide a narrow beam with a high gain for transmitting and receiving. Better coverage and throughput, a greater signal to interference and noise ratio (SINR), and the ability to track people are among features it offers. A sophisticated beamforming technique that makes use of Software-Defined Antennas (SDA) is called holographic beamforming. RF signals from a radio flow into the back of the antenna and scatter across its front, where tiny elements adjust the shape and direction of the beam as shown in Fig. 3. This technique is known as holographic beam steering, where the antenna is like a holographic plate in an optical hologram. Using SDAs in HBF would enable flexible and effective transmission and receiving in 6G since C-SWaP (Cost, Size, Weight, and Power) are regarded to be the key problems in any communication system designs.[13]

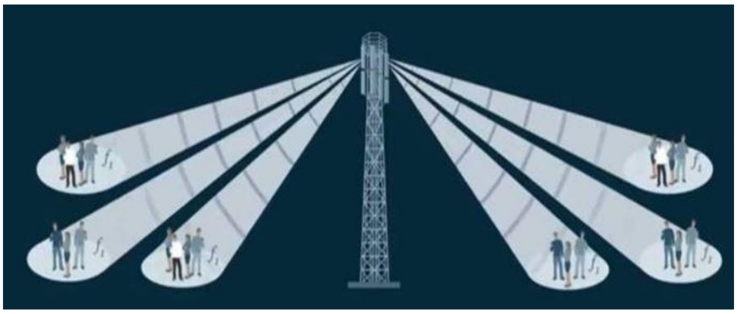

Fig. 3: Holographic Beamforming [13]

2.v. Extended Reality

Virtual reality (VR), augmented reality (AR), and mixed reality (MR) are now collectively referred to as "extended reality" (XR). A headgear that produces sounds and visuals to create an artificial environment is used in virtual reality (VR). Using a particular gadget, such a cell phone, AR augments the real environment. The combination of audio, video, and GPS might be combined to create an interactive environment. A well-known example of AR is Poke'mon. Through the fusion of the actual and virtual worlds, MR creates a complex environment. XR is the fusion of the physical and digital worlds. Due to its robust connectivity, fast data rate, high resolution, and low latency, 6G will be highly helpful for this function.[14]

2.vi. Blockchain Technology

The distributed blocks that make up the data in the blockchain technology are connected to one another and cryptographically safeguarded. Blockchain will be utilised for large data management, 6G connection management, and big data organization. It will also be utilized for spectrum sharing, allowing users to share the same spectrum to address the issue of 6G's enormous spectrum demand and provide safe, affordable, intelligent, and efficient spectrum utilization. The network will become more flexible by deploying an advanced caching system, integrating the blockchain with AI, and employing deep reinforcement learning to increase QoS.[15]

2.vii. Automation

At the moment, researchers are concentrating on robotics, automation, and autonomous systems. These technologies will be supported by 6G, enabling direct connection between them and the server as well as direct communication inside them, i.e., robot to robot and robot to server communication. The 6G network will offer total automation, including fully automated systems, devices, and control procedures. Unmanned aerial vehicles (UAVs), which will be utilized in wireless communications and provide high data rates instead of the conventional base stations (BS), will be supported by 6G.[16]

2.viii. Wireless Power Transfer

With the use of wireless energy transmission, 6G would be able to adequately power the batteries in gadgets like smartphones and sensors. Since Wireless Information and Energy transport (WIET) employs the same fields and waves as communication systems, 6G base stations will be utilized to transport electricity. A cutting-edge technology called WIET will enable the creation of smart gadgets without batteries, enable wireless network charging, and prolong the battery life of other devices.[17]

2.ix. Wireless Brain Computer Interface

Recent years have seen a rise in the usage of wearable technology, including certain BCI applications. Smart wearable headsets, smart embedded devices, and smart body implants are examples of BCI applications. Using BCI technology, the brain will be able to interface with external separate devices that will be in charge of decoding and analyzing brain signals. [3]. Affective computing technologies, which change how a device works depending on the user's mood, will also be a part of BCI. Because BCI applications demand greater spectrum resources, large data rates, extremely low latency, and high dependability, their adoption has been constrained. However, 6G will support additional applications, such as the transfer of five sense information, in which the human body's five senses create data that is transferred over 6G to enable interaction with the environment.

2.x. Healthcare

Other wireless communication technologies lacked electronic healthcare due to slow data rates and timing issues. Through XR, robotics, automation, and AI, 6G will offer secure connection, high performance, ultra-low latency, high data rate, and high reliability, enabling the complete existence of remote surgeries as shown in Fig. 4. Additionally, the THz band's short wavelength promotes communication and the development of nano-sensors, enabling the creation of novel nano-sized devices that can function inside the human body.[18-23]

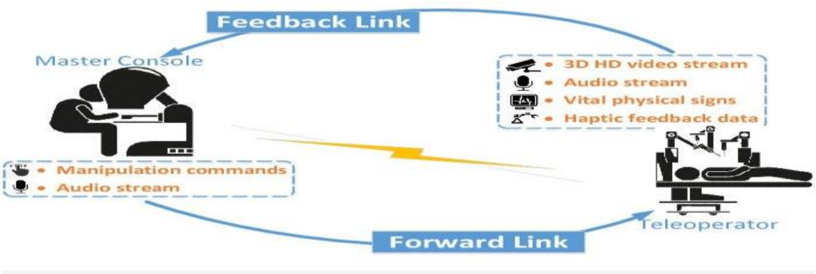

Fig. 4: A loop explaining the communication between themaster console and the tele-operator [24]

3. CHALLENGES

There are certain challenging criteria for 6G wireless communication that must be met in order to meet the expectations of the global technological market. The key tough subjects are examined and addressed in this part.

3.i. Tetra-Hertz Band

The THz spectrum presents a problem for the 6G wireless communication technology. Despite offering high data speeds, the high frequencies make it difficult to reduce the significant path loss. The air absorption and propagation loss for long-distance communications are quite high. This is a significant problem that demands attention. To solve the issue of frequency dispersion, new multipath channel models must be created due to the wide bandwidth. The THz band cannot be effectively modulated or coded using current methods. Implementing novel modulation and coding algorithms is therefore difficult in research. To combat air losses, new transceivers should be developed to operate on the high-frequency band while providing very broad bandwidth, high power, high sensitivity, and low noise figure. The researchers face several difficulties due to health and safety concerns brought on by high power and frequency. [4]

3.ii. Device Capability

Not all wireless communication methods were supported by devices. Companies have been developing 5G-capable gadgets recently, and as we explained in section 2.iii., these devices should also be able to handle 6G and all further wireless communication generations. The 1 Tbps data rate and the high operational frequencies should be tolerated by devices implementing 6G wire-free communication technology. Additionally, devices should allow device-to-device connectivity, AI, and XR interactions. Nowadays, cellphones nearly always require daily charging, consuming more energy than previously. The 6G network will support billions of devices besides smartphones, thus effective energy transmission techniques, particularly wireless ones, should be taken into consideration. Additionally, linked gadgets should be designed to accommodate a variety of charging ways. These gadget capabilities are expensive and difficult to use. [25,26]

3.iii. Network Security

In addition to connecting smartphones, the 6G wireless network will also link satellites, AI, XR, and automation smart devices. The security methods used in 5G will not be adequate in 6G, so new security techniques with cutting-edge cryptographic methods, such as physical layer security techniques and integrated network security techniques with low cost, low complexity, and very high security, should be taken into consideration. [27].

3.iv. Transceivers & Antenna Designs

There are certain transceiver and antenna designs supporting each wireless communication technology's standards, as described in section 3.i. The development of devices with millimeter-sized components was difficult for 5G. However, it will be more difficult with 6G. High-frequency bands in THz are supported by 6G wireless communication technologies, along with resource and spectrum sharing. The transceivers should be able to support this technology if their antennas are built with components that are either nanometer- or micrometer-sized and meet the specifications for holographic beam-forming as in. Transceivers based on meta-surfaces may be the answer to this problem, improving both throughput and QoS. But combining meta-surface with OFDM-MIMO is a really difficult task.[28-32]

4. CONCLUSIONS

The debut of 5G in 2020 won't be able to meet demand in 2030, which will just continue to rise. Therefore, 6G research should be carried out in order to achieve its objectives by 2030. The new characteristics of 6G as well as potential applications and technology that will be used in 6G are discussed in this article. The main issues with 6G's technology are discussed. Conclusion: 6G will enable a super-smart society with everything connected to the network, enhance network performance, integrate various technologies, and raise QoS.

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