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Vision and Research Directions of 6G Technologies and Applications

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Abstract: *With millions of users, fifth-generation (5G) mobile communication technology is now extensively accessible in a number of nations. It is therefore time for industry and academia to turn their attention to the upcoming generation. This essay will provide an overview of the sixth-generation (6G) mobile network, covering its purposes and case studies, specifications, funded research initiatives, and technological advancements. To forecast the essential 6G requirements and showcase the 6G capabilities, we go over the Beyond 5G (B5G) evolution and advanced 5G features. In comparison to 5G, we also present the 6G scenarios, specifications, and technological elements. In addition, the state of 6G research is examined and a preliminary regulatory and specification roadmap is investigated. Next, we go over a few potential uses, their advantages, ideas, and future directions for research*

Keywords: Renewable Energy, Generator, Inverter Circuit, Horizontal Axis Wind Turbine, Wind Energy, Solar Panel

I. INTRODUCTION

The vast increase of Internet-of-Things (IoT) devices has led next-generation communication systems to strive for great spectral and energy efficiency, low latency, and huge interconnection. These IoT gadgets will enable cutting-edge services like such as virtual reality (VR) and virtual navigation, telemedicine, digital sensing, smart traffic, high definition (HD), and full HD video transmission in networked drones and robots. By 2025, there will likely be 25 billion IoT devices worldwide [1]. As a result, it will be extremely difficult for the various access mechanisms currently in use to support such a large number of devices. The current global rollout of fifth generation (5G) communication technologies is insufficient to handle the volume of IoT devices. and enhanced mobile broad band (eMBB) were listed in its Release 13 (R13) [2] as the three primary use cases for 5G.Algorithms are being developed concurrently for the next generation of communication systems, which will perform better than the current 5G networks. At most 50,000 IoTs and/or narrowband IoT (NB-IoT) devices can be supported by a standard 5G communication infrastructure per cell [2]. To be more precise, in order to achieve huge access in communication systems that go beyond 5G (B5G)/6G, a more resilient network needs to be built. We now go over the extensive body of research that has been published on numerous 6G network aspects.

II. APPLICATIONSANDEMERGING TECHNOLOGIES

New features and applications can be accessed through any communication system. 5G was the first generation to bring automation, artificial intelligence, and smart cities. These technologies were, however, only sporadically integrated. With 6G, more technologies and applications will be available that offer faster data speeds, more dependability, reduced latency, and safe, effective transmission. The primary 6G applications, trends, and technology are displayed in Fig. 1.Several of these 6G applications and technologies are covered in this section**.**

1. Artificial Intelligence: Neither 4G nor any of the earlier versions included artificial intelligence (AI). It is partially backed by 5G, which is changing the telecoms industry and opening the avenues for new and amazing uses to emerge. Nonetheless, 6G will completely support AI for automation. It will be engaged in resource allocation, network selection, and handover, all of which will improve performance, particularly in applications where delays are an issue. The key technologies of 6G are machine learning and artificial intelligence**.**

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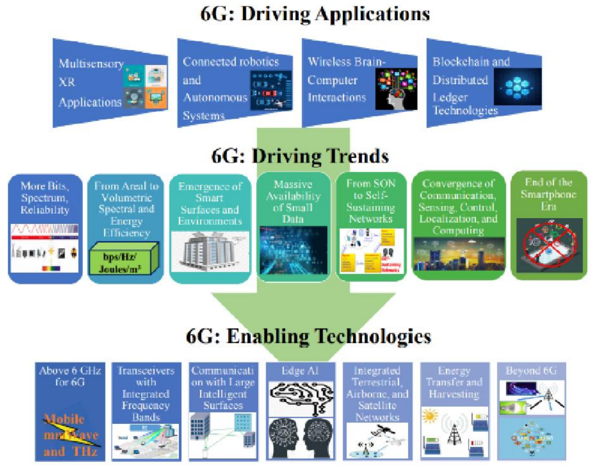

Fig. 1. 6G main Applications, trends, and technologies

2. Holographic Beamforming (HBF)

Beamforming is the process of focusing power in a limited angular range to create a focused, narrow beam with a high gain for transmitting and receiving utilizing antenna arrays. It provides increased signal to interference and noise ratio (SINR), improved throughput, and the ability to track users. A sophisticated beamforming method that makes use of Software-Defined Antenna (SDA) is holographic beamforming. The term "holographic" describes the use of a hologram by the antenna to achieve beam steering; the antenna functions as a holographic plate in an optical hologram; radio frequency (RF) signals enter the antenna from the back and scatter across its front, where small components modify the beam's direction and shape, as shown in Figure 2.SDAs are less expensive, heavier, smaller, and need less power than MIMO or conventional phased array systems. C-SWaP stands for (Cost, Size, Weight, and Power)are regarded as the primary difficulties in the design of any communication system; the use of SDAs in HBF will enable flexible and effective sending and receiving in 6G.

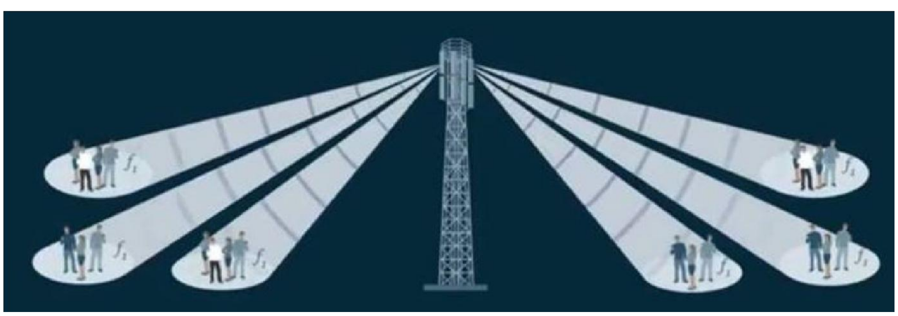

Fig. 2. Holographic Beamforming

3. Extended Reality: A new word that encompasses Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) is Extended Reality (XR). VR stands for virtual reality created on a computer.putting on a headset that projects sounds and visuals to create a virtual environment. AR makes use of the physical world and enhances it using a particular gadget, like a smartphone. The Global Positioning System (GPS), movies, and audios can all be utilized to create an engaging atmosphere. One well-known example of AR is Pok¬emon. With mixed reality (MR), the real and virtual worlds combine to create a complex experience. All of the combined real and virtual environments make up XR. Because of its robust connectivity, fast data rate, high resolution, and low latency, 6G will be highly helpful for this function**.**

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4.Blockchain Technology: The distributed, cryptographically secured blocks that make up the data in blockchain technology are linked to one another. Utilizing blockchain technology, management and arranging large amounts of data and controlling massive 6G connectivity. In order to solve the issue of the enormous spectrum requirements in 6G and to provide safe, inexpensive, intelligent, and effective spectrum usage, it will also be employed in spectrum sharing, which will allow users to share the same spectrum. The QoS will be improved by integrating deep reinforcement learning with blockchain technology, enabling the sharing of intelligent resources, putting in place an enhanced caching system, and increasing network flexibility.

5. Automation: At the moment, robotics, automation, and autonomous systems are the main areas of study. These technologies-such as robot-to-robot and robot-to-server communication-will be supported by 6G, enabling direct communication between them and the server as well as between them. 6G will offer complete automation, which includes automated systems, devices, and control procedures. Unmanned aerial vehicles (UAVs), which will be utilized in wireless communications to provide high data rates in place of traditional base stations (BS), will be supported by 6G.

6. Healthcare: Due to time delays and limited data rates, earlier wireless communication technologies did not offer electronic healthcare. Through XR, robotics, automation, and artificial intelligence, 6G will enable secure connection, high performance, ultra-low latency, high data rate, and high reliability, enabling the full existence of remote surgeries as shown in Fig. 3. Additionally, the THz band's tiny wavelength facilitates communication and the development of nanosensors, opening the door to the creation of novel nanoscale technologies that can function inside the human body.

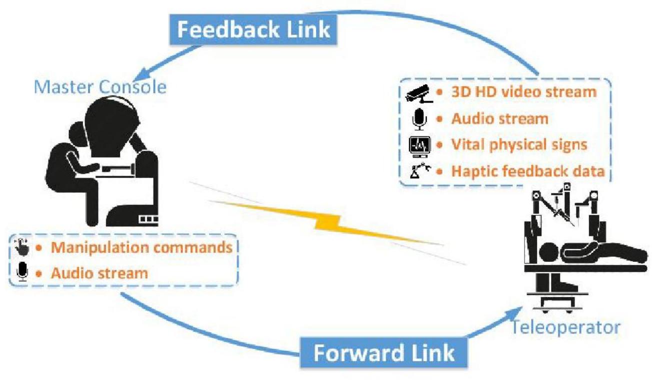

Fig. 4. A loop explaining the communication between the master console and the tele-operator

7. Wireless Brain-Computer Interface: The use of wearable technology has grown recently, and some of these applications involve brain-computer interfaces (BCIs). Smart embedded systems, smart wearable headsets, and devices and smart body implants. Brain-computer interface (BCI) technologies provide brain-to-external discrete device communication, with the devices handling brain signal analysis and translation. Affective computing technologies, which allow devices to change in operation based on the user's mood, will also be incorporated into BCI. Because BCI applications need greater spectrum resources, large bit rates, very low latency, and high dependability, their use has been restricted. More applications, such as the five sense information transfer-which transfers data produced by a person's five senses to enable interaction with the environment-will be supported by 6G, nevertheless.

III. RESEARCH CHALLENGES

In order to meet global technological needs, 6G wireless communication must meet certain demanding specifications. The primary difficult subjects covered in this section include examined and talked about.

1.TeraHertz Band: The THz band presents the biggest obstacle to the 6G wireless communication technology. Despite offering high data speeds, overcoming the significant route loss is a major problem because to the high frequencies. The air absorption and propagation loss are particularly significant for long-distance communications. This is a significant problem that requires attention. In order to address the issue of frequency dispersion, new multipath channel models must be created due to the vast bandwidth . For the THz band, the current coding and modulation methods are insufficient. As a result, research on new modulation and coding schemes is difficult. To overcome the atmospheric resistance, new transceivers should be built with a high-frequency band that supports a very big bandwidth, high power, high sensitivity, and low noise figure. low noise figure and great sensitivity to compensate for air losses. Concerns about health and safety resulting from high power and frequency are another major obstacle facing the researchers.

2. Device Capabilities: Not every wireless communication technology was compatible with the devices. Companies have been developing 5G-capable devices lately; as section II-B discusses, these devices need to be able to handle 6G and all the other wireless communication generations. 6G wireless communication devices should be able to withstand high operating frequencies and a data throughput of 1 Tbps. Additionally, gadgets ought to enable AI, XR, and device-to-device connectivity for interacting with other devices. Nowadays, smartphones require more energy to charge than they did in the past—almost every day. The 6G network will link billions of devices—not just smartphones—to the internet. As a result, effective energy transfer techniques, particularly wireless techniques, should be taken into account, and connected devices should be designed to accommodate various charging strategies. These device capabilities are expensive and difficult to use.

3. Network Security: Satellites and smart equipment used in automation, artificial intelligence, XR, and smart cities will be connected by a 6G wireless communications network in addition to smartphones. The security methods employed will not be adequate in 6G, so new security strategies utilizing cutting-edge cryptographic techniques should be taken into account. These strategies include integrated network security techniques and physical layer security approaches, which are both inexpensive, difficult, and extremely secure.

4. Transceiver and Antenna Designs: As stated in section III-A, there are certain transceiver and antenna designs that support the specifications of each wireless communication technology.The development of 5G devices with millimeter-scale components proved a problem. In 6G, though, it will be more difficult. The high-frequency band in THz is supported by 6G wireless communication technology, which also allows for resource and spectrum sharing. The antennas on the transceivers should be constructed with the necessary size, with nanometer to micrometer components meeting the specifications for holographic beamforming. Transceivers based on metasur faces may be able to solve this problem and improve throughput and quality of service. However, there is a significant issue when integrating metasurface with OFDM-MIMO.

IV. FUTURE PROSPECTS

Even as 5G is still being deployed globally, rumors about its quicker successor, 6G, are starting to generate interest. 6G, which is anticipated to go on sale in 2030, promises to be a revolutionary advancement in terms of speed as well as the way it can change society and our way of life. Quickly downloading a film? 100 times faster than 5G, 6G is expected to deliver mind-blowing speeds of up to 1 terabit per second (Tbps). Real-time uses such as holographic communication and remote surgery are made possible by this. Don't bother buffering! Near-instantaneous response times are the goal of 6G, which is essential for applications where milliseconds count, such as industrial automation and driverless cars. Imagine billions of smoothly connected devices. The Internet of Things (IoT) revolution, from smart cities to connected homes, will be fueled by 6G's capability. The network itself will be integrated with processing power, not merely in the cloud. Real-time AI applications made possible by this "edge intelligence" will improve efficiency in everything from traffic control to individualized healthcare.6G might interact with senses other than displays. Consider smelling the aroma of a digital meal or experiencing the texture of virtual goods. These are but a few examples of what could be. 6G may have an impact on all facets of our lives, including entertainment and education, as well as industry and international cooperation But there are still difficulties. Important obstacles include building the necessary infrastructure, guaranteeing fair access, and resolving security issues. Responsible planning, innovation, and teamwork are the paving stones on the path to 6G.

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V. CONCLUSION

In 2020 release of 5G telecommunications technology will not be able to meet the escalating needs by 2030. Consequently, studies in 6G ought to be carried out to be ability to accomplish its objectives by 2030. This document outlines the new features of 6G as well as potential uses and technologies that will be used in the network. The primary technological obstacles for 6G are outlined. It is concluded that 6G would boost QoS, integrate various technologies, and enhance network performance, enabling a super-smart society with everything networked.

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