6G Technology: The Time Has Come

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***Abstract*— The sixth generation of wireless communication technology, or 6G technology, was created to replace 5G. Compared to its predecessors, it promises much faster speeds, more capacity, and reduced latency, opening up new applications and advancing a number of industries. Terabits per second (Tbps) is the target data rate for 6G, which is substantially faster than 5G's gigabits per second (Gbps). In order to facilitate real-time applications and instantaneous data transfer, 6G aims for nearly zero latency, possibly as low as the microsecond level. Compared to 5G's 1 million connected devices per square kilometer, 6G will allow for a potentially 10 million more. With the help of AI and machine learning, 6G will be able to manage resources intelligently, perform better, and add new features. It is anticipated that 6G will facilitate developments in fields such as imaging, location awareness, presence technology, and the Internet of Things (IoT). A review of earlier work is presented in this paper.**

Keywords*— *6G Technology, Architecture, Applications, Artificial Intelligence, Internet of Things.

I. INTRODUCTION

Sixth-generation wireless (6G) is a communication protocol for wireless technologies that may offer lower latency and higher capacity than 5G. It may be able to achieve communication with a latency of one microsecond, which is 1,000 times faster than the estimated latency of 5G cellular technology, which is one millisecond. It is anticipated to be 5G mobile networks' replacement.

6G is currently being researched. Although scientific advances are experimenting with devices capable of operating at higher frequencies, the required high transmission speeds, the energy consumption rates, and the acceptable proportions of the related heat development in the electronic circuits are just some examples of the challenges 6G networks will face in the future. Studies estimate that 6G networks would likely operate in frequencies from 100 GHz to 3 THz due to their wide swaths of the unexplored spectrum (unused frequency waves in the electromagnetic spectrum). An anticipated 1,000-fold speedup over 5G is a communication protocol for wireless communications technologies that facilitate cellular data networks. Consistent connectivity and increased coverage are guaranteed by seamless integration with satellite, Wi-Fi, and fiber optics, particularly in rural regions.

With a potential latency of one microsecond, 6G is a wireless technology communication protocol that could offer higher capacity and lower latency than 5G. This is 1,000 times faster than the estimated 5G cellular technology latency of one millisecond throughput. It is anticipated to be 5G mobile networks' replacement. 6G research is still ongoing. The necessary high transmission speeds, the energy consumption rates, and the acceptable proportions of the related heat development in the electronic circuits are just a few of the difficulties that 6G networks will face in the future, even though scientific advancements are experimenting with devices that can operate at higher frequencies. Due to their extensive coverage of the unexplored spectrum (unused frequency waves in the electromagnetic spectrum), studies predict that 6G networks would most likely function in frequencies between 100 GHz and 3 THz.

The term "wireless cognition," which alludes to wireless networks that might enable free movement of human thoughts over the air, is frequently used by the scientific community to describe 6G. AI applications and remote robots could exchange data at amazing speeds and with excellent coverage in the future thanks to 6G's electromagnetic frequencies. The sub-Terahertz bands would also contain the 6G frequencies. Therefore, based on these many bands, researchers estimate that it could transmit extremely fast calculations across a wide range of frequencies, allowing future mobile devices to have much more amazing capabilities, like human-machine interactions.

II. METHOD

The paper in [1] outlines the network architecture and future 6G wireless communication vision. This article discusses new technologies that can help the development of the 6G architecture ensure the quality of service (QoS), including artificial intelligence, terahertz communications, wireless optical technology, free-space optical network, blockchain, three-dimensional networking, quantum communications, unmanned aerial vehicles, cell-free communications, integration of wireless information and energy transfer, integrated sensing and communication, integrated access-backhaul networks, dynamic network slicing, holographic beamforming, backscatter communication, intelligent reflecting surface, proactive caching, and big data analytics. Additionally, potential technologies and anticipated applications with 6G communication requirements are presented. Authors also outline possible obstacles and lines of inquiry to reach this objective.

A groundbreaking study regarding the possible use of 6G to support such extremely demanding applications is presented in [2]. In order to accomplish this, we simulate a 6G system and carry out a case study investigating the use of drone-swarm-based surveillance concepts in a high-definition video

monitoring application. Large volumes of video data must be sent over the network in this scenario. The obtained results demonstrate that 6G can handle these high demands on network traffic.

The key technological components required to deploy a 6G communication system are presented in [3]. The creation of an energy-efficient wireless network is the fundamental prerequisite. Intelligent Reflecting Surfaces (IRSs), which are straightforward and reasonably priced structures, are being considered as a replacement for massive MIMO in recent years. The benefits of combining IRSs with other technologies are discussed by the authors of this paper in order to satisfy the demands of next-generation wireless technologies. We go over recent studies on IRS design, IRS multi-cell application, IRS parameter optimization, and the impact of IRS in conjunction with deep learning.

First, the vision and requirements of 6G networks are discussed in [4]. The main enabling technologies that could be used by 6G networks are then discussed. We will pay close attention to index modulation, intelligent surfaces, visible light communications, and terahertz communication technologies. The presentation concludes with a number of issues facing upcoming 6G networks and possible future paths.

The purpose of the paper in [5] is to get a glimpse of the future of wireless communication and related technologies. 6G is anticipated to completely transform the digital world thanks to its higher transmission rate, enhanced spectrum efficiency, larger connection proportions, increased spectrum coherence, and significantly lower latency. The results of a thorough investigation into the development of 6G are presented in this paper. This comprehensive survey's primary focus is on 6G in relation to mobile communication and the major technologies that are anticipated to be deployed on networks enabled by 6G. This paper concludes by outlining current research projects being conducted by different research organizations.

A paper reviewing the state-of-the-art in 6G is found in [6]. With the help of cutting-edge technologies like SC, AI, and ML, authors hope to give readers a foundation in 6G research and an outline of how 6G will be utilized to develop applications. Additionally, the authors conceptualize and identify the role of 6G technology, along with its future challenges and vision. Along with a number of potential future applications for 6G, the authors have also covered the network and user side availability of 6G.

Investigating communication technologies and issues on 6G networks for the internet with the help of the Internet of Things (IOT) is the aim of the article in [7]. Based on a secondary data collection method, the researcher has established a procedure for gathering pertinent data and information about the subject matter. The researcher has used it to guide the study in the right direction. Likewise, qualitative techniques were employed in the gathered materials to make the data more comprehensible. Additionally, this research will assist readers in comprehending the appropriate efficacy of strategies to alleviate the difficulties in the 6G network system. There are several benefits and challenges associated with implementing a sixth-generation network system, including creating an environmentally friendly, cost-effective network that is compatible with mobile devices and linked to artificial intelligence (AI) technology to increase performance. issues with the nex's implementation are discussed in this paper.

In order for 6G networks to transition into green networks, research in [8] intends to concentrate on augmenting artificial intelligence in 6G networks.

A thorough review of previous research on the integration of blockchain and artificial intelligence with 6G wireless communications can be found in [9]. More precisely, authors begin with a synopsis of AI and blockchain. The authors then primarily examine the latest developments in the combination of blockchain and artificial intelligence, emphasizing the unavoidable trend of using both technologies in wireless communications. Additionally, the authors thoroughly examine how blockchain and AI can be integrated into wireless communication systems, encompassing secure services and intelligent Internet of Things (IoT) applications. In particular, some of the most talked-about core blockchain and AI-based services are presented, including content caching, spectrum management, computation allocation, security, and privacy. Moreover, authors also focus on some important IoT smart applications supported by blockchain and AI, covering smart healthcare, smart transportation, smart grid, and unmanned aerial vehicles (UAVs). The authors also go into great detail about 6G requirements, visions, and operating frequencies. The authors also examine the unresolved problems and research obstacles related to the integration of blockchain technology and artificial intelligence in 6G wireless communications. Finally, this paper attempts to give a thorough overview of blockchain and AI in 6G networks based on a large number of existing significant works. The survey's creators hope it will provide fresh insight into the study of this recently developed field and act as a guide for future research.

The paper in [10] first gives a thorough overview of the 6G vision, technical specifications, and application scenarios, covering the general consensus on 6G at the moment. The architecture of the 6G network and its main technologies are then critically evaluated. For the first time, advanced 6G verification platforms and testbeds are described in detail. Future research avenues and unresolved issues are also noted in order to further the ongoing international discussion. Lastly, the lessons learned about 6G networks thus far are reviewed.

The 6G WCN framework is presented in [11] along with an example of its main technologies. With the help of a communication scenario demonstration, the various 6G technologies are thoroughly explained, improving key performance indicators with significant variations. The explanation of 6G with the technologies that significantly affect the characteristics of a wireless communication network, including data rate, spectrum efficiency, energy efficiency, connection density, and reliability, is the main contribution of this paper. Each of these technologies has the potential to completely transform the next WCN.

The article in[12] functions as a thorough introduction to 6G by offering a broad overview, a current analysis of the key literature, and an educational tutorial-style presentation format.

According to our vision, 6G will be built upon three core components: the Internet of Everything, wireless, and artificial intelligence. 6G can therefore eventually develop into the Intelligent Network of Everything and act as a foundation for mobile intelligence, the next significant development in mobile communication. Mobile intelligence has the potential to make anything intelligent, connected, and aware of its surroundings. This will completely change how systems, apps, and devices are made, how they work and communicate with one another and with people, and how they can be used to benefit individuals, society, and the entire world. The primary details of 6G, such as its essential components, disruptive applications, and important use cases, are covered after high-level visioning. Particular attention is paid to a wide range of prospective 6G technologies, each of which is presented in a tutorial fashion along with a discussion of the literature, future research directions, opportunities, challenges, history, and future. Lastly, we make some predictions about what will happen after 6G and provide the first high-level overview of 7G. Overall, the goal of this article is to give a comprehensive overview of 6G so that it can be used as a resource and source of inspiration for future research and development projects in industry, academia, and standardization organizations.

With an emphasis on resource management, self-healing, and network security, the paper in [13] suggests an AI-driven framework for 6G networks. It uses machine learning to improve fault recovery, lower latency, and make better decisions in real time. The efficacy of the framework is confirmed by simulations, which also provide scalable solutions for 6G deployment.

The article in [14] reveals how 6G is changing industries, bringing about economic growth, and addressing societal issues. Using contemporary technologies such as terahertz waves and massive MIMO systems, which 6G networks dominate, to achieve data rates, latency, and reliability, the latter provides progressive implementations across various domains. The new idea of human-machine interaction with the new 6G technology is nothing more than a hope for an inventive future. Its applications extend beyond reality to include remote surgery using real-time machines and automated smart factories, as well as communication of autonomous vehicles and immersive experiences. Secondly, a more inclusive society with less economic inequality will result from 6G, which ushers in a new era of growth. 6G networks have the potential to accelerate justice and empower those who were previously marginalized by creating jobs, increasing wealth, and lowering greenhouse gas emissions. Although 6G has many potential risks, particularly in the form of privacy violations, cyberattacks, and network vulnerabilities, the technology itself may also be the cause of these issues. This is supported by the proactive risk management planning, robust security protocols, and the guarantee that 6G networks won't be violated.

The 6G concept is first explained in detail in the study in [15]. The operation of the proposed framework is verified at higher-order modulating plans to achieve higher spectrum efficiencies using performance indicators like error vector size, symbol constellations, and antenna array radiating beams. The performance findings strongly recommend using more data flows per user in order to achieve higher speeds that satisfy $6 \mathbf{G}$ wireless networks' requirements. They also recommend using a particular mMIMO antenna configuration based on the percentage of distinct data flows per user.

The survey article in [16] attempts to clarify the user-centric concept by thoroughly examining all of the different facets of 6G network architecture from a user-centric standpoint.

The study examines the promising features of 6G in [17], such as advanced sensing, accurate localization, and high-quality imaging. Machine learning (ML) and artificial intelligence (AI) will be extensively integrated into 6G technology, particularly in smart cities, where they will play a critical role in raising the standard of living for residents. 6G-enabled apps will support cutting-edge services that improve urban living experiences, tackle environmental issues, and offer more effective solutions across industries by integrating various components for monitoring, analysis, planning, and execution.

III. RESULTS AND DISCUSSION

A. 6G Architecture

The architecture of 6G technology is expected to be extremely intelligent, sustainable, and cyber-resilient, with an emphasis on utilizing new spectrum technologies, AI, and advanced computing. A possible quantum communication backbone, improved edge computing, and a modular design are important features. In addition, the architecture will prioritize digital inclusion, security, and privacy with an eye toward cost reduction and ubiquitous connectivity.

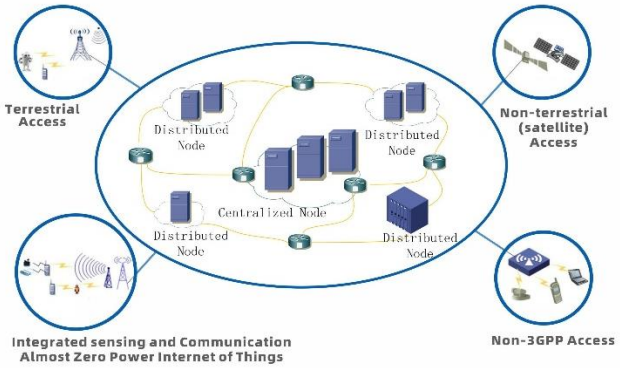

Figure 1. 6G Architecture

From the standpoint of the air interface, multiple protocol layers may be shared by various planes. Every plane has a different protocol layer configuration, though. Consequently, it is possible to reuse protocol layers across various planes. Each plane's unique requirements can be satisfied in the interim. According to CN, every plane comprises distinct network functions, each with specific duties as illustrated in Fig. 1. 6G may introduce additional planes based on the control plane and user plane, as well as data planes, depending on the plane and

function characteristics. The planes work together to support the essential native traits, such as native security, native intelligence, and native computing. This makes the services available to users. In addition to supporting basic information services like ISAC and converged computing services like integrated Al and communication (IAIAC), it also supports super communication services like 6G NTN and AZP-loT.lt.

B. 6G applications

It is anticipated that 6G applications will transform a number of industries through improvements in computing, sensing, and communication. Improved mobile broadband, fixed wireless access, integrated communication and sensing, and new opportunities for automation and artificial intelligence are a few examples. Additionally, a wide range of services will be made possible by 6G, including remote surgery, smart cities, autonomous cars, holographic communication, and immersive extended reality. A summary of the applications is shown in Fig.2.

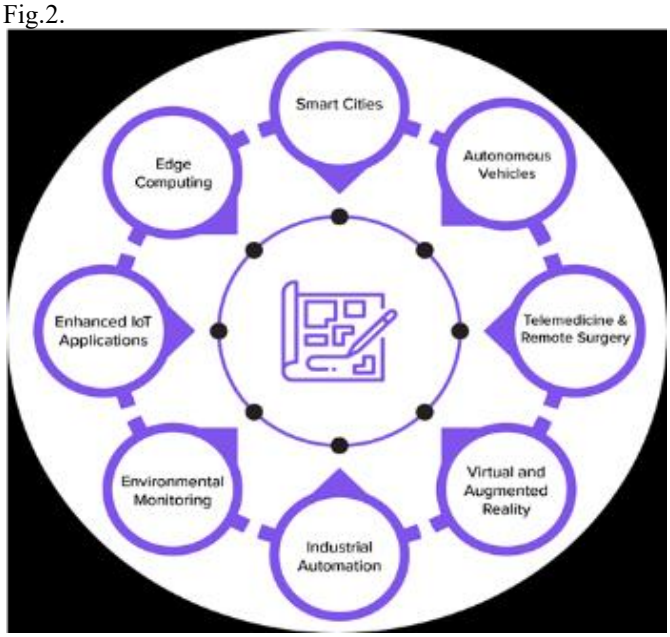

Figure 2. Block Diagram of 6G Applications

IV. CONCLUSION

With much faster speeds, reduced latency, and increased capacity over 5G, 6G technology promises to revolutionize connectivity. Numerous new applications and use cases in a variety of industries, including manufacturing, entertainment, healthcare, and smart cities, will be made possible by this evolution. Although it is still in the early stages of development, 6G is anticipated to be commercially available by the early 2030s, with major improvements anticipated around 2028.

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