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New directions for adapting intelligent communication and standardization towards 6G

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Abstract

Rapid advancements in wireless communication technology have made it easier to transfer digital data globally. With the complete assistance of artificial intelligence, the sixth-generation (6G) system—a new paradigm in wireless communication—is anticipated to be put into use between 2027 and 2030. Faster system capacity, faster data rate, lower latency, higher security, and better quality of service (QoS) in comparison to the 5G system are some of the main concerns that need to be addressed beyond 5G. Combining the growing need for more network coverage, lower latency, and greater data rates is the aim of 6G. It is recommended that to meet these needs and enable new services and applications, intelligent communication be implemented. The main enablers and facilitators for implementing intelligent communication beyond 5G are outlined in this paper. The article provides the horizon of new adaptations and standardization for integrating 6G intelligent communication in future networks and outlines the requirements and use case scenarios for 6G. It also highlights the potential of 6G and key enablers from the standpoint of flexibility. It examines key research gaps like spectrum efficiency, network parameters, infrastructure deployment, and security flaws in past transitions while contrasting 5G and 6G communication. To overcome these challenges, modernizing 6G research domains are essential. Therefore this review article focuses on the importance of 6G wireless communication and its network architecture also provides the technological paradigm shift from 5G to 6G. Furthermore, it highlights popular domains such as Artificial Intelligence, Internet of Things, Managing Big Data, Wireless Mobile networks, and Massive MIMO (Multiple Input Multiple Output), Quantum communication, Block chain Technology, Terahertz Communications (THz), Cell-free Communications and Intelligent Reflecting Surface as research objectives.

Keywords: Internet of things, Block chain Technology, Massive MIMO, Quantum Communication, Terahertz Communications (THz), Cell-Free Communications, Intelligent Reflecting Surface

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1. Introduction

Global deployment of fifth-generation (5G) communications is imminent, with a significantly larger feature set than fourth-generation communications. Over the past two decades, there has been an exponential increase in demand for wireless communication. With the initiation of 6G, the world is about to enter a new era of innovation and technological developments that have the potential to completely transform communication. Bandwidth usage is one of the study areas where 6G is evolving to achieve major improvements. 6G networks can attain higher spectral efficiency by utilizing sophisticated antenna technology and higher frequencies. This can facilitate faster data rates and meet the growing needs of data-intensive applications. Another important issue that 6G to deal with is low latency. Ultra-low latency communication (uRLLC) is made possible by the advent of technologies like network slicing, edge computing, and sophisticated signaling mechanisms, which enable real-time services in daily life. This will have far-reaching effects on things like remote surgery, driverless cars, and immersive virtual reality. Overtime, cellular

communication technology has undergone significant advancements [1].
Mobile technology capabilities increased to include mobile internet access, video calling, and multimedia services with 3G, from the analog voice calling of 1G to the digital voice calling and text messaging of 2G. While online gaming and high-quality video streaming were made possible by 4G, 5G increased data throughput, decreased latency, and allowed for the simultaneous connection of numerous devices. **Figure 1** shows the early stage of development from 1G to 6G and beyond. 5G involves evolution phases, contributions of each generation, defining key objectives, and exploring new possibilities for the next level of wireless communication [2].

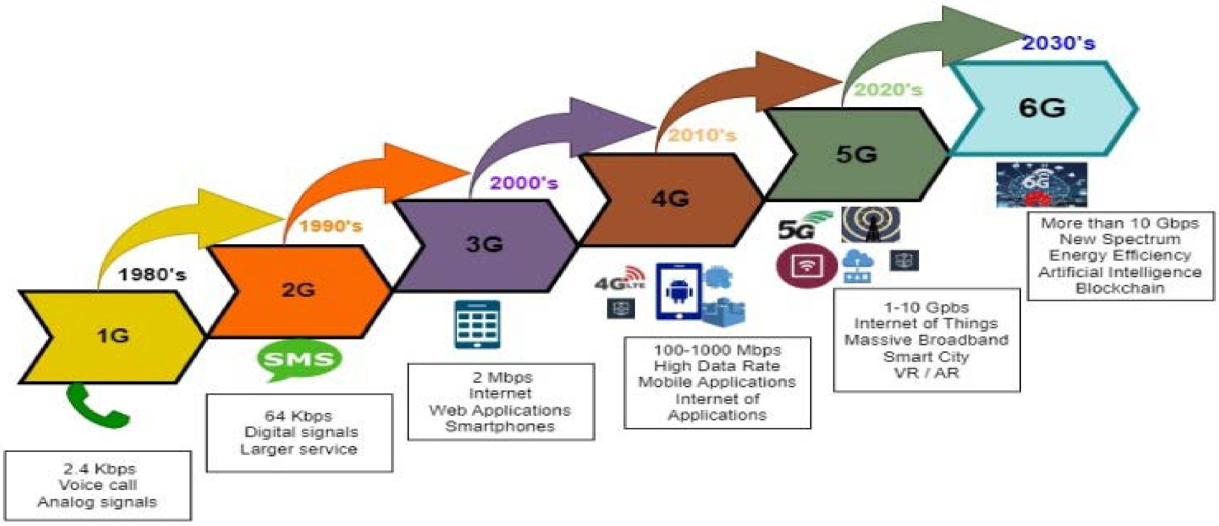

Figure 1. Transition of Mobile Technology from 1G to 6G

6G will enable cutting-edge technologies like holographic communications, powerful artificial intelligence, and seamless connectivity in challenging environments. It will also enable even higher data speed and less latency. Another vital element of 6G networks is enhanced high data transmission [3]. Together with other state-of-the-art techniques, massive and terahertz integration will enable 6G to deliver seamless connectivity even in underserved and remote areas. This will bridge the technological gap by enabling global access to high-speed internet and digital services. 6G will employ AI-powered security systems, complex encryption algorithms, and block chain technology to offer robust defence against online threats. In order to safeguard user information and ensure a secure message exchange, data delivery, and security, privacy-preserving techniques will also be included. 6G has the potential to completely transform the landscape of global connection in the future and to enable a plethora of new technologies and applications [4].

1.1. Innovations in Wireless Technology: Navigating 5G

The Fifth generation (5G) communication is already being deployed commercially, providing users with new services, improved user experiences, and a myriad of creative opportunities in a variety of industries. 5G, the most recent version of mobile network technology, provides faster data rates, lower latency, and more capacity than its predecessors. Some of the most recent innovations in 5G technologies include:

(i) Network slicing: 5G employs the creation network slices of many virtual sliced network layers by operators within a single physical network infrastructure. As a result, network resources can be customized to meet the particular needs of different services and applications.

(ii) Massive MIMO (Multiple-Input Multiple-Output): 5G employs this technology, which boosts spectral efficiency and network capacity by sending and receiving data utilizing an enormous number of antennas.

(iii) Beam formation: 5G networks use advanced beam forming techniques to focus signal transmission in specific directions, increasing signal intensity and coverage. Increased Data Rates: 5G and subsequent technologies are built to provide increased data rates, enabling users to upload and download data more quickly.

(iv) Reduced Latency: One of the primary features of 5G and later is its capacity to decrease latency, enabling nearly instantaneous response and communication for real time applications such as augmented reality, autonomous vehicles, and gaming.

(v) Enhanced Capacity: The technology is designed to manage multiple connected devices simultaneously in order to support the growing Internet of Things (IoT) ecosystem.

(vi) Better Spectrum Efficiency: 5G and subsequent technologies employ state-of-the-art techniques to more effectively utilize the radio frequency spectrum that is accessible [4-5].

1.2. Importance of 6G

The current global implementation of 5G connectivity technology is not accelerating enough to alter the number of IoT devices. There are three primary use cases identified for 5G by the 3GPP, which is currently developing the standard use cases are enhanced mobile broad band (eMBB), massive machine type communication (mMTC), and ultra-reliable and low latency communication (URLLC). However, 6G research is still in its beginning stages, with experts and scholars from around the globe examining and assessing potential technologies, details, and uses for 6G networks. Important problems highlighted in the ITU Journal 2023 "Sights set on 6G" newsletter are as follows,

1. Security powered by AI in 5G and beyond
2. 5G network virtualization, orchestration, slicing, fog, and edge platforms.
3. The metaphysical realm: Networking, computation, and communication.
4. AI and machine learning solutions for networks in the future, including 5G.
5. Intellient technology for distributed systems and n etworking in the future [6].

The goal is to present a future vision for 6G systems, including possible uses, emerging trends, and disruptive technology. It seeks to offer suggestions and a road plan for switching from the present 5G systems to the next 6G systems. The essay aims to provide insights into the path of 6G development and the potential services it could enable by highlighting the breakthroughs and future technologies. Therefore, research serves as motivation to address these worldwide concerns. According to the concept, commonplace items like cars, appliances, and even cities would be networked and able to speak with one another in the future.

Many facets of human existence may become more automated, efficient, and convenient as a result of this connectedness. Considering that 6G features and real deployment might change as technology advances. In the upcoming years, ongoing research, industry partnerships, and standardization initiatives will define the development of 6G. Examine 5G through the perspective of the Internet of Things, in 2020, it is anticipated that there will be 64.2 zeta bytes of data produced, captured, copied, and consumed worldwide, according to a recent ITU assessment. After five more years of growth, it is predicted that the total amount of data created globally will exceed 180 zeta bytes in 2025. In 2020, the amount of data generated and duplicated reached a record high. 15 gigabytes (GB) of data were used monthly on average by smart phone users worldwide in 2022.

The source predicts that by 2030, this would increase by almost four times, reaching 46 GB per smart phone each month globally. After five more years of growth, it is predicted that the total amount of data created globally will exceed 180 zeta bytes in 2025. In 2019, services and apps become feasible with the widespread deployment of 5G networks [6]. However, as 5G networks and apps develop, they will face more problems and challenges. Although 5G networks may be able to address some of these problems, it may be more difficult to address others in order to fully understand the network's limitations. These problems and challenges will be a key source of creativity and inspiration for the 6G design, including coverage of networks and infrastructure implementation.

This article is organized as section 1 gives introduction to innovations in wireless technology 5G and beyond 5G, importance of 6G with technical aspects, research motivation toward 6G. Section 2 explores literature review study. Section 3 Objective of the article, Section 4 describes research method and data study selection. Section 5 defines Result Findings and Discussions, outlines research gaps of most recent articles, the paradigm shift from 5G to 6G demands, key performance indicators, 6G use case scenarios, key technologies, finally Conclusion section defines the overall objective of this article.

2. Literature Review

The paper emphasizes 6G will be to align with the specific performance requirements of IoE applications, which means the system should be capable to handle the massive data generated by billions of connected devices, support real-time communication with ultra-low latency and provide reliable connectivity in challenging environments [7].

The article describes the privacy of data composed by personal IoT in the perspective of 5G and future networks pose significant breakthroughs. In this article, the authors have recognized five-six key areas that enforce the protection of IoT devices on advanced networks. The purpose is to present a summary of the existing state of future research opportunities to progress the safety of data composed by these devices. The paper AI is recognized as key potentials for the next generation of 6G cellular system, and ensures protection is a critical contemplation to realize the full potential of 6G [8].

AI-enabled security solutions can provide intelligent and robust protection against evolving threats. This manuscript aims to propose an indication of the opportunities and challenges associated with incorporating intelligent security and privacy provisions into 6G systems. It also defines hopeful research directions by analyzing the challenges of AI-based security prerequisite and suggesting potentials.

In this paper which provides a collaborated survey on 6G technology, also discuss the function of technology and statistical information for industries to investigate the new research directions. Paper is presented technology of edge intelligence, block chain as the technologies that can mould next level IoT networks. Authors described in research milestones of 6G networks, risks involved with security and performance issues [9].

3. Objectives

As mobile traffic and subscriptions continue to rise at an exponential rate, it begs the question: do we need 6G? The answer is a resounding yes. With disruptive new services and apps emerging every day, it's become increasingly clear that next-generation systems must be developed to accommodate them. To achieve this, the mobile communication society must continuously strive to improve network efficiencies, particularly in operations, cost, energy, and spectrum. This review article provides a comprehensive qualitative and quantitative survey of studies, identifying the technologies and methodologies used, as well as the most significant contributions. By filling in the gaps, we can modernize mobile communication and unlock its full potential.

4. Research Method and Data Study Selection

A comprehensive search was conducted in order to compile the most recent papers, articles, white papers, and reports from the ITU that were published between 2019 to 2024. These materials were gathered from digital repositories like IEEE Xplore, Science Direct, Springer, and Scopus and even white papers and magazines like 5G IA, 6G-ANA,Vivo 6G, 5G & 6G Evolution, and Samsung Newsroom. This paper conducted and studied a total of 79 papers as part of its data collection and study selection. Final selection of 47 articles in total. **Figure 2** shows year wise data collection of 6G articles and study selection for last 5 years (2019-2024).

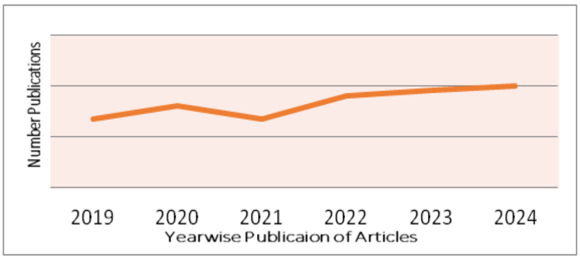

Figure 2. Graph of Exploratory Research on Data Collection and Study Selection

The 5G generation, is capable of connecting to the World Wide Web of Things. It is now possible to accomplish communication between people and objects as well as between objects and people. But 5G still has a lot of obstacles to overcome. International business, intellectual, and principles groups have started researching 6G communication technologies in response to these issues. A number of survey papers and white papers have been released with the intention of defining 6G in terms of specifications, use cases, important technologies, etc. Despite the fact that ITU-R has started research on the 6G idea and that an agreement on what 6G will be by mid-2023 is anticipated, there are still many unanswered questions in the relevant global talks, so there is a need of 6G wireless network [10]. This paper portrays an extensive overview of the 6G perception, Use cases, Key technologies to deploy the 6G.

5. Results and Discussion

The use of promising technologies such massive MIMO, artificial intelligence (AI), transmission at high frequencies (THz), and extensive satellite constellations has enabled the network to transform into an additional potent and better meets the demands of existing approaches. Hence this paper outline the summary of surveyed papers, future gap has identified and their major offerings have been figured out in the **Table 1**.

As a findings, the main contribution of this study which classifies these technology usages which affects with their Key Performance Indicators (KPI) along with what are the contributions as well as the major research gaps which can useful for bridging the next generation networks. Based on these key insights its figure out the 6G demands for implementing and research directions with the major areas which help the researchers to work on them.

Table 1. Classification and summary of recent survey on 6G, technologies, KPI and research gaps

Ref.ID	Technology Used & Key Performance Indicator (KPI)	Major Contributions	Year	Future work and Research Gap
[7]	Satellite Communication and terrestrial networks KPI: Broadband, High reliable Connectivity.	Phase 2 5G PPP project called "SaT5G." It describes the project's idea, goals, research pillars, and chosen application cases and scenarios for satellite communications placement in the context of 5G.	2019	Research gap may involve identifying areas within the integration of satellite and terrestrial networks for 5G where there is limited existing research or where further exploration is needed.
[8]	AI and ML Communication KPI: Transfer rates, network coverage, latency,	The paper's discuss about large-dimensional and autonomous network architecture, integration of various network types (space, air, ground, and underwater), and the role of Machine learning in autonomous networks contributes to the understanding of the potential advancements in network.	2019	The document provides a comprehensive vision of 6G networks and discusses various promising technologies, there may be gaps in comparison with the existing state of research and expansion in these areas.
[9]	Network Slicing, Intelligent Reflecting Surfaces KPI: Bandwidth ,Global coverage, latency,	This paper presents a survey on resource allocation techniques for the co-existence of eMBB and URLLC services in 6G wireless networks.	2019	The research gap addressed in this paper is the detailed survey on the co-existence of eMBB and URLLC in 6G, specifically focusing on resource allocation techniques and their implementation challenges.
[11]	AI Communication and Internet of Things KPI: high-speed communication technology using LTE.	NTT started the first global mobile network service and fascinating to see the progress of mobile communication systems from 1G to 5G and the anticipated impact of 5G and 6G on future industry and society.	2020	There is a need to integrate AI with the original phase of technology and enable the integration of innovative network entity in the context of 6G, which may necessitate further research and growth in AI technologies.
[12]	Terahertz (THz) frequency band, novel antenna technologies, KPI: high-speed communication technology using LTE.	Samsung provides in the white paper is to convince the needs for 6G and technologies aim to address the challenges and limitations of current communication systems and pave the way for advanced services and capabilities, which are truly immersive extended reality (XR), hi-fi cellular phone hologram.	2020	While the white paper outlines the vision for 6G and the technologies to be employed, it does not specifically any identified research gaps.
[13]	Integrated Sensing and Communication KPI: Ubiquitous Networking	The Next Generation Mobile Networks (NGMN) Alliance provides insights into the key drivers and vision for the development of 6G networks.	2021	The document may provide a high-level vision for 6G networks without exploring a diverse range of future scenarios and potential use cases.
[14]	AI Communication, Virtual Reality KPI: Network Security	The European viewpoint on the implementation of 6G networks is reflected in the 5G Infrastructure Association. Highlighted the importance of artificial intelligence and 6G will be able to connect digital and physical worlds, virtual and real worlds.	2021	Research gaps could arise if the perspectives of other relevant stakeholders, such as end-users, regulatory bodies, or environmental groups, are not adequately considered.

[15]	Immersive and AI Communication KPI: Ubiquitous Network	The paper outlines key objectives, challenges, and opportunities for 6G technology. It likely discusses various aspects of 6G networks, including technological advancements, policy considerations, research priorities, and potential use cases.	2021	The research gaps identified in this paper would require a comprehensive and inclusive approach to analyzing the vision for the 6G network ecosystem, incorporating diverse stakeholder perspectives, interdisciplinary considerations, and future scenarios into the discussion.
[16]	AI security, Block Chain, THz Communication KPI: Low latency High reliable communication.	This defines promising techniques mentioned, such as Ai security, THz communications, MIMO, multiplexing, laser communications and Visible light, quantum communications and computing, block chain, all have the potential to significantly contribute to the development of 6G.	2021	Research gaps exist in the development of energy-efficient 6G networks, considering the high-power requirements of some advanced techniques such as THz communications and quantum computing.
[27]	Cloud IoT, massive MIMO, Block Chain, KPI: Broadband, Low latency High reliable communication	The paper discusses Internet of Things (IoT), cloud Security aspects, mobile ultra-broadband, and AI possibilities were proposed as three 6G features. Reliable data connectivity is crucial for the increasingly intelligent, automated, and ubiquitous digital world.	2022	Research gaps identified in this paper is 5G wireless networks are being deployed but may not fully meet future connectivity demands. Cloud radio access is not be explored much.
[28]	Advanced mobile communication systems KPI: Full spectrum, wide coverage, large dimension, convergence.	Paper outlines the 6G vision of 3GPP society's improvement at 2030 and identifies better appliance scenarios for mobile communication, which are essential for shaping the future of mobile networks. Additionally, the proposed consistent mobile network design and the features of the 6G network provide valuable insights for the design and implementation.	2022	The research gap here is related to the specific technological and architectural challenges that need to be develop for 6G mobile networks. Identifying and addressing these gaps will be critical for advancing the research and development of 6G technology.
[29]	Massive MIMO, Sub THz, human-thing intelligence. KPI: High data rates, increased reliability, Coverage	Paper describes offshore 5G virtual MIMO (Multiple Input Multiple Output) paradigm presents a promising solution to address these challenges. By leveraging 5G technology and virtual MIMO, maritime vessels can benefit from improved.	2022	The research gap of this paper is regulatory and policy implications of deploying 5G virtual MIMO systems in maritime environments is a crucial area for further research.
[30]	Reconfigurable intelligent surfaces (RIS KPI: Physical Layer Security	The research paper discusses the task of reconfigurable intelligent surfaces (RIS) in enhancing the security of wireless networks. It covers various aspects of Physical Layer Security (PLS), including performance metrics, applicability in different wireless networks, and applications in the 6G scenario. The paper analyzes the performance of RIS-assisted systems and discusses challenges and potential applications of RIS in improving the secrecy performance, energy efficiency, and reliability of wireless communication systems.	2023	The research gap here lies in the need for further exploration of reconfigurable intelligent surfaces (RIS) in wireless communication systems.. Additionally, there is a need for more research on the accurate acquisition of Channel State Information (CSI) for RIS and the exploration of future research directions for PLS in wireless networks.
[31]	Multi user, THz, mmWave , Orthogonal frequency multiplexing technique. KPI:Channel estimation	Author proposes a comprehensive 6G idea in requisites of application, market, and business expectations, emphasized the technological convergence using orthogonal frequency multiplexing.	2023	The paper present the insights into the gaps in current knowledge and the need for additional research in this area.

[32] [33]	Multi cell, Orthogonal frequency multiplexing technique. KPI: Physical layer security , Channel estimation	In these articles, the primary research projects for the creating sophisticated interference management methods, investigating multicell OTFS schemes that are optimized, and tackling the difficulties and unresolved research topics related to physical layer design, multicell OTFS systems.	2023	The both authors also recommend more study and research into the coexistence of OTFS-based radar sensing and communication systems.
[35]	sub-THz and THz frequency bands KPI: Low reliable latency, Spectrum capacity	The document focuses on research in the URLLC, sub-THz and THz frequency bands, which are part of the radio spectrum. These frequency bands have potential for wideband channels and future applications such as 5G wireless communications, cell phones, autonomous vehicles, and smart devices.	2024	This gap has limited the utilization of the spectrum between ~100 GHz and ~10 THz. The document highlights that although modern hardware have been finishing the THz gap, but still significant challenges pertaining to physical limitations, properties of materials, integrated code sign of system components, measurement of THz.
[36]	extremely large-scale multiple-input-multiple-output (XL-MIMO) wireless systems KPI: High data rates, increased reliability, and enhanced coverage	This article provides a broad analysis of research on XL-MIMO wireless systems, which is considered a potentially pivotal enabling technology for 6G of wireless mobile networks. The article introduces four XL-MIMO hardware architectures and discusses their characteristics and interrelationships. It also highlights the opportunities and challenges associated with XL-MIMO technology.	2024	The article defines research gaps, on general XL-MIMO technology, elaboration for practical implementation, and exploration of low-complexity signal processing schemes. This article, has prospective future research directions for XL-MIMO technology include AI-aided resource allocation schemes, Energy efficiency and green communication, Semantic communications, Test beds and experimental evaluation can be better implemented.
[44]	millimetre wave, MIMO KPI: High data rates, increased reliability, and enhanced coverage	This article provides innovative method that solves the zero-forcing algorithm by converting it into an optimization problem and doing away with the difficult matrix inverse operation. This is achieved by employing the conjugate gradient method. The main points of the study, such as the issue raised, the suggested fix, and the simulation's outcomes, are summarized in this article.	2024	There exist a research gap still need to reduce hardware cost and power consumption of millimetre-wave large-scale antenna systems.
[45]	Block chain, cyber twin KPI: Quantum security	The paper's goal is to clarify the revolutionary role that 6G wireless networks play in smart energy grid management (SEGM) and to open the door for an intelligent and sustainable energy grid management future. The technologies that are studied for their potential to change the monitoring, control, and optimization of energy grids include block chain, cyber twin, and Sixth Generation (6G) wireless networks. These technologies are listed in the abstract.	2024	The shortage of exhaustive study or comprehension of how block chain, cyber twin, and 6G wireless networks might be successfully combined and used to bring the revolutionary advances in smart energy grid management may be the research gap in this case. By shedding light on the possible benefits and real-world applications of combining these technologies for energy grid management, the study may aim to close this knowledge gap.
[47]	Software Defined Network, Machine type communication KPI: Ubiquitous Network, less delay,	Three main use cases are covered in this paper: eMBB, URLLC, and mMTC. It also proposes an architecture for network slicing in SDN for 5G networks.	2024	In addition, it addresses the difficulties and makes recommendations for future lines of inquiry for network slicing in the context of 5G.

5.1. Paradigm Shift to 6G

Although 6G expertise research and development are still in their early stages, information is already available. The **figure 4** shows the new directions for adapting intelligent communication system. however, based on industry trends and conversations, this manuscript might provide some broad projections for 6G networks such as:

(i) Faster data rates: 6G is expected to provide data rates that are likely to be close to terabits per second (Tbps) speeds, which are far faster than those of its predecessors. This will enhance real-time applications and enable ultra-high definition content to broadcast and download more fast.

(ii) Ultra-low latency: 6G promises to drastically cut latency, with goals of achieving sub-millisecond latency. This incredibly fast response time will be necessary for applications like augmented and virtual reality, remote surgery, and driverless cars.

(iii) Much more device connectivity: It is anticipated that 6G would make it possible for device connectivity to rise significantly. As IoT devices spread throughout high-tech towns and metropolitan areas, 6G networks will need to handle billions of continuously linked devices [17], [34].

(iv) Enhanced energy efficiency: 6G networks are expected to consume the least amount of energy as compared to its predecessors, which will solve the growing environmental problems associated with increased data use. Energy-saving techniques like dynamic spectrum sharing and sophisticated power management must be used [18], [37].

(v) Spectral efficiency: It is the maximum amount of data that can be transferred over a specific bandwidth or frequency range is referred to as spectrum efficiency in 6G. It's a crucial indicator of how well wireless communication technologies are working. The spectral efficiency of 5G can vary based on the particular technology and deployment, although in real-world situations, it typically falls between 3 and 4 bits/s/Hz. As with 6G, precise spectral efficiency numbers might not be easily accessible because the technology being developed and hasn't been standardized or implemented extensively. But compared to 5G, 6G is anticipated to provide far improved spectral efficiency, maybe as high as 100 bits/s/Hz in some envisioned use scenario, Spectral efficiency can be calculated as,

$$SE = NK(1-DS)\log 2(1+1I) \text{ Bits/Hz/Cell}\ldots.(1)$$

where base stations (BS) correspond with NK single-antenna user equipments (UEs) at same time. S is the symbol transmitted per frame, with D being pilot transmission symbols. I denotes the interference [3].

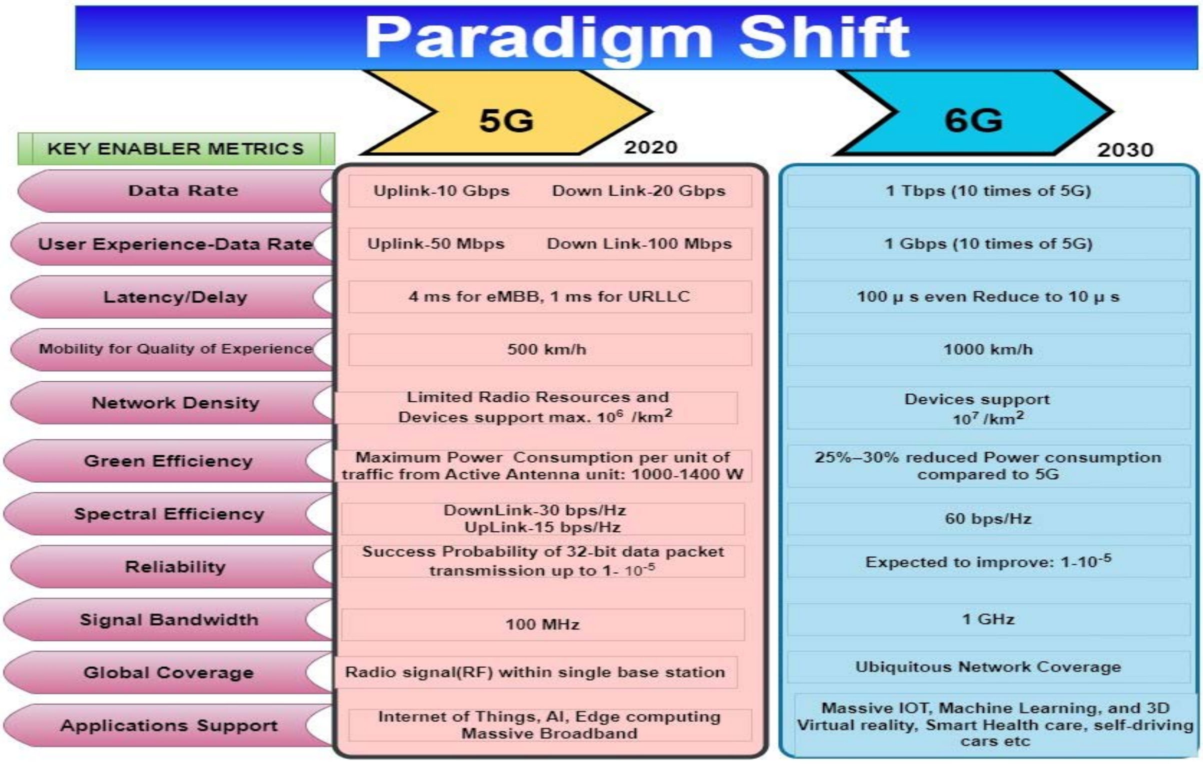

Figure 4. Paradigm shift from 5G towards 6G

5.2. Key Performance Indicators (KPI)

The prospective for transformative applications that are beyond smart phones are presented by next-generation wireless networks. Researchers will gain from a new spectrum of 5G use cases and applications that combine Internet of Things (IoT), intelligent edge, and connectivity technologies from gamers to governments. The evolving nature of communication is embodied by 5G wireless technology. 5G, which is built for maximum speed and capacity, will allow new applications and use cases that extend well beyond smart phones and have the ability to significantly increase the quantity of data that can be transmitted. 6G System will provide extensive competency with 5G, as considering minimal requirements based on IMT 2020 report on 5G & KPI applied to find new key enablers for 6G in 2030 [18], [38] as shown in **Figure 5.(a) and 5.(b)**.

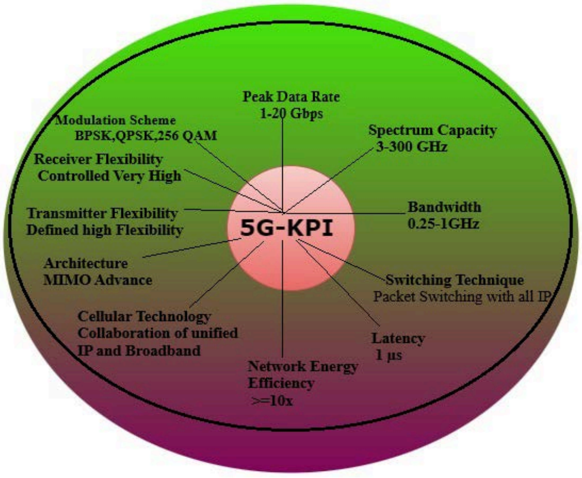

Figure 5 (a). KPI of 5G

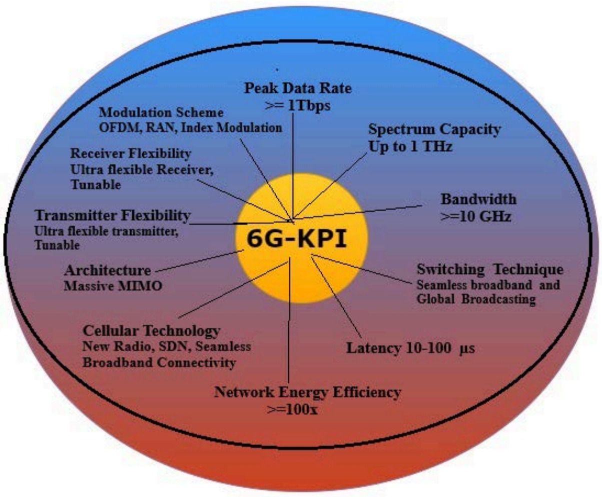

Figure 5 (b). KPI of 6G

5.3. 6G Use case Scenarios

6G use case scenarios are precise examples that exemplify the prospective applications and benefits of 6G technology. These scenarios demonstrate how 6G can be leveraged to address various challenges and meet the needs of different industries and sectors. The case scenarios for 6G technology may include ultra-reliable low-latency communication (URLLC), immersive extended reality (XR) experiences, intelligent transportation systems [19]. As per IMT report (International Mobile Telecommunication) in 2020 predicted that extensive use case scenarios showcase the diverse range of applications and capabilities that 6G technology aims to enable which shown in **Figure 6.**

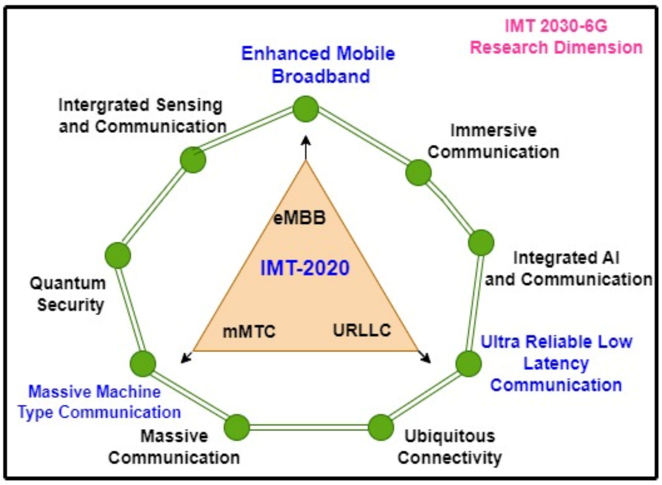

Figure 6: Use case Scenarios of 6G at 2030

5.4. Key Technologies

6G technology has the potential to completely transform networking and communication in several of respects. These are but a handful of the advantages that 6G technology may offer opportunities and use cases as research and development continue major ones can be listed as,

(i) **Sub-Terahertz communication and sensing:** Sub-frequencies are electromagnetic wave frequencies that fall between 100 GHz and 1 THz. Sub-THz waves allow for high-resolution imaging and can pass through a variety of materials, such as plastics and fabrics. As a result, they can be applied to security screening, medical imaging, and non-destructive testing. By interacting with molecular vibrations and rotational states, sub-THz waves analyze different materials using spectroscopy [20],[39].

Figure 7 shows 6G introduces 1 THz, frequencies range from 100 GHz to 10 THz.

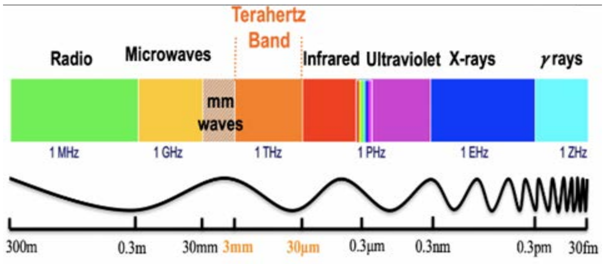

Figure 7: 6G introduces 1THz band

(ii) **New waveforms and multiple access:** 6G employs many approaches, such as the waveform known as Orthogonal Time Frequency Space which can improve performance in high-mobility contexts like networks for unmanned aerial vehicles (UAVs) or vehicular communication. It utilizes the delay-Doppler domain to reduce the effects of time-varying channels, enhance spectral efficiency, and increase resilience to multipath fading. By lowering out-of-band emissions, Filtered-OFDM, also known as F-OFDM, is an adaption of Orthogonal Frequency-Division Multiplexing (OFDM) that increases spectral effectiveness. It achieves interference management while balancing spectral efficiency [21],[40].

(iii) **Ultra-massive MIMO:** With the help of a very high quantity of antennas at the base station, ultra-massive MIMO (Multiple Input, Multiple Output) technology is able to serve many users at once. Wireless communication systems' capacity and spectral efficiency could be greatly increased using this technique. Ultra Massive MIMO is an active subject of explore and improvement for 6G wireless communication networks. Because massive array topologies can effectively support a large number of antennas, scientists are looking into new array designs and topologies. Looking at innovative antenna configurations such hybrid analog digital arrays, distributed antenna arrays, and complex antenna selection methods [22],[41] as Shown in **Figure 8**.

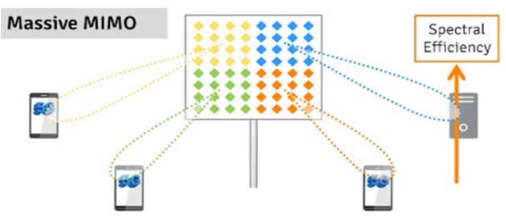

Figure 8: Massive MIMO and Beam forming in 6G

(iv) **Quantum Communication:** Quantum communication involves Using quantum phenomena to send and receive data securely across large distances is known as quantum communication. Quantum communication may be crucial to the secure and dependable operation of future wireless networks in the context of 6G [23],[42-43].

(v) **Visible Light Communication:** A method called Light Communication (VLC) employs visible light with a wavelength between 400 and 800 THz (780–375 nm). It's an optical technique that transmits data using light-emitting diodes (LEDs). 6G technology, which promises fast data transfer, low latency, and secure connection, may include VLC [24],[25],[37]. It is used to distribute over high-speed wireless networks indoors in places like offices and hospitals. The benefit of VLC is that it can coexist with current RF (radio-frequency)-based wireless technologies and is impervious to electromagnetic interference. VLC has the potential to enhance current wireless communication methods and increase wireless network capacity in 6G.

(vi) **Intelligent Reflecting Surfaces (IRS):** A technology that has drawn interest as a possible part of 6G wireless communication systems is called Reflecting Surfaces (IRS). To improve wireless communication, IRS is made up of passive reflecting components that can be placed throughout the surroundings. It is to maximize the signal capacity at the receiver; these components have the ability to modify the amplitude and phase of the incoming electromagnetic waves. **Figure 9** shows the simple architecture of IRS in 6G implementation.

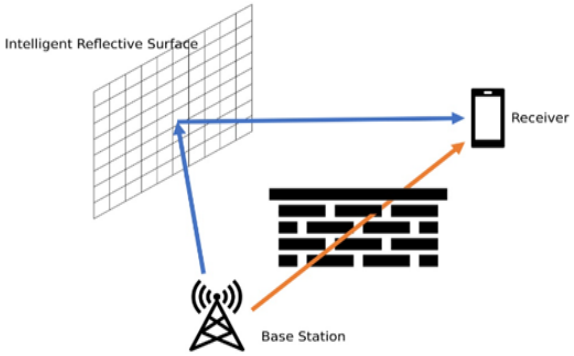

Figure 9: 6G Intelligent Reflecting Surfaces (IRS)

IRS can be utilized in 6G wireless networks to reduce interference, boost spectral efficiency, and enhance coverage. IRS has the facility to recover the overall concert of the wireless communication system by manipulating the surfaces' reflection qualities intelligently [26],[38],[46].

Conclusion

This article analysis the groundwork for additional investigation and overall standardization of 6G research topics that are anticipated ,the mobile wireless networks and communication technologies would significantly develop with the switch from 5G to 6G technology. It attempts to meet the growing need for greater data rates, lower latency, and wider network coverage. In order to address these needs and make new services and applications possible, the article highlights how crucial intelligent communication is. Additionally, it compares 5G and 6G, describes the use cases and enablers for adopting intelligent communication beyond 5G, and addresses research gaps related to infrastructure deployment, network densification, spectrum limitations, and security risks, use cases, key driver Technologies. Overall article includes the importance of 6G wireless communication and its network model, as well as the focus on research goals including IoT, AI, big data management, wireless mobile networks, and advanced network architecture. This article shows 6G new perspectives mainly focus on 1. Proliferation of wide applications and business support. 2. Sustainability and Social responsibility.3.Integrated secure connectivity. 4. Ecosystem Safety and collaborative convince, which can reshape the direction of wireless communication i.e. 6G in the future by 2030.

Conflicts of Interest

"The authors have no conflicts of interest to declare that are relevant to the content of this article".

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