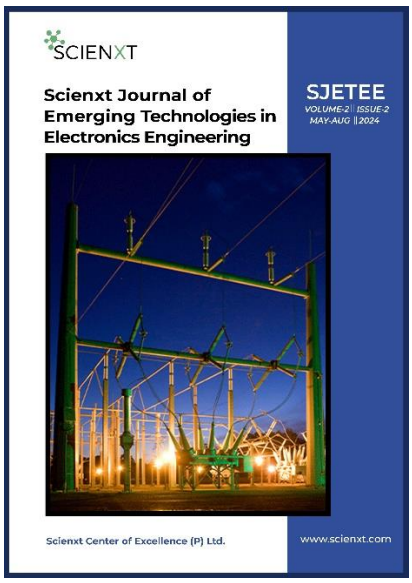

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Investigating wireless connectivity: developments in 6G technology

[*1]Sarika Rai, [2]Saurabh Singh Rathour, [3]Tarun Kumar, [4]Himanshu Kumar Singh, [5]Ashish Kumar

[*1,2.3,4,5]Department of Electronics and Communication, Bhopal Institute of Technology and Science, (BITS), Bhopal, 462045 M.P. India.

**Corresponding Author: Sarika Rai*
Email: rai91sr09@gmail.com

Abstract:

Wireless communication involves the transmission of data between two or more points without physical connections. Mobile wireless communication has been in use for many years, and with the increasing need for mobile services, successive iterations of network technology have been introduced over time. These distances can vary from short, such as those used for television remote control, to far-reaching distances used in deep-space radio communications. A wireless network enables devices to maintain connectivity without the need for physical cables, allowing them to move freely. Access points amplify Wi-Fi signals, extending the network's reach so that devices can remain connected even when distant from the router. The goal of wireless technology is to deliver high-quality, dependable communication, with each new generation of services marking significant advancements in this pursuit. From the early stages of 1G to the current 5G network technology, we've witnessed remarkable progress. However, while many countries are adopting 5G, only a few are actively developing the next generation: 6G.The latest iteration is 5G, although it's currently only adopted by select countries. 5G is a robust and high-speed wireless communication network that largely meets users' requirements. However, the quest for enhanced capabilities persists. The 6G technology will be much faster than the previous generations. This paper explores the evolution of technologies, their benefits, and the fulfillment of user demands with the introduction of the next generation of mobile networks: 6G and even beyond, envisioning the future with 7G.

Keywords:

5G, 6G, Handoff, Time Division Multiple Access, Code Division Multiple Access, GSM, smart antenna.

1. Introduction:

Wireless communication has sparked a revolutionary transformation in the realm of mobile communication. With a rising demand for mobile and wireless communication in recent years, wireless technology facilitates seamless data transfer across significant distances without the need for intermediaries. Mobile communication has evolved through various generations, from the foundational 0G to the latest 4G technology, and now heralds the advent of 5G.

This innovation has propelled the field into a new era of advancement. Initially, the introduction of 3G brought about enhanced internet experiences, paving the way for subsequent enhancements. With a clear recognition of the need for superior communication networks, the emergence of 5G promised seamless wireless communication devoid of limitations, marking a significant leap in wireless technology. Within the framework of 5G systems, each cell phone is allocated a permanent "IP address" and a "care of address," ensuring uninterrupted connectivity. As we look forward, anticipation mounts for the arrival of 6G. Present-day mobile devices boast an array of features, characterized by compact designs, ample memory, high-speed capabilities, and energy efficiency. Technologies such as Bluetooth have become ubiquitous. 6G wireless cell phone communication networks are poised to meet global standards, providing coverage on par with systems developed by industry leaders. The incorporation of satellites will be instrumental in achieving this widespread coverage. It is evident that mobile communication undergoes upgrades approximately every 8 to 10 years. The advent of 6G technology offers vast opportunities for innovative research and development. 6G is poised to operate with ultra-high-speed data networks, providing extensive coverage for all networks. This paper aims to explore how 6G technology will contribute to future advancements.

2. 6G technologies:

At the forefront of technological advancement, 6G internet utilizes a fusion of state-of-the-art radio and fiber optics technology, enabling connectivity via line of sight. This liberates us from the constraints imposed by copper cables and distance limitations from the exchange, ensuring unparalleled speed and reliability.How does 6G compare to traditional broadband? Unlike traditional broadband, 6G enjoys the advantage of establishing an entirely novel network infused with the latest cutting-edge technology. By circumventing the constraints of legacy systems, 6G Air Fiber introduces a revolutionary wireless solution, leveraging military-

developed technology to communicate with unmanned aerial vehicles in critical scenarios. Now accessible to businesses, 6G provides faster, more secure, and cost-effective broadband connectivity.

Introducing WISDOM – Wireless Innovative System for Dynamic Operating Mega communications. Envisioned as the 6th generation with exceptional data rates and Quality of Service (QoS), and the 7th generation with space roaming capabilities. This paper delves into the specifications of future generations and the latest technologies slated for deployment in forthcoming wireless mobile communication networks. However, mindful of India's widespread populace, certain future generation technologies will be integrated with 2G and 2.5G to ensure broad access to internet and multimedia services, while also enabling operators to optimize revenues with minimal additional expenditure on existing mobile communication networks.

3. 6G Mobile communication system:

The 6G mobile system, designed for global coverage, will seamlessly integrate the existing 5G wireless mobile system with satellite networks. These satellite networks comprise telecommunication satellites for voice, data, internet, and video broadcasting; Earth imaging satellites for weather and environmental information collection; and navigation satellites for global positional system (GPS) services. The four countries behind the development of these satellite systems are as follows: the GPS by the USA, the COMPASS system developed by China, the Galileo system by the EU, and the GLONASS system developed by Russia. Looking ahead, the anticipation for the future lies in 6G technology. Present-day cell phones have become marvels of compactness, boasting high memory, high-speed capabilities, and low power consumption. Technologies like Bluetooth have become commonplace, akin to child's play. The vision for 6G wireless cell phone communication networks is to establish world-class standards, providing comprehensive coverage across the globe, much like the global positioning systems devised by various countries.

6G technology represents the next frontier in wireless communication standards, currently in the developmental stage to bolster cellular networks. As the successor to 5G, it promises significantly enhanced speeds and capabilities. Much like its predecessors, 6G networks are anticipated to function as broadband cellular networks, wherein the service area is subdivided into smaller cells. Companies such as Nokia, Ericsson, Huawei, Samsung, LG, Apple, and

Xiaomi, alongside countries like India, China, Japan, and Singapore, are actively involved in its development.6G networks are projected to exhibit even greater diversity than their 5G counterparts, accommodating applications beyond conventional mobile use cases. These may include virtual and augmented reality (AR/VR), seamless instant communication, pervasive intelligence, and the Internet of Things (IoT). In the domain of 6G technology, the seamless transition and roaming between satellite systems present notable challenges. These systems operate under distinct standards, adding complexity to the handoff process. Given that 6G spans across four different standards, achieving smooth handoff and roaming capabilities between these networks stands as a pressing issue awaiting resolution.

The development of 6G is geared towards expanding the adoption of 5G use cases on a large scale, achieved through optimizations and cost reductions, particularly within enterprise settings. With an expected latency of one microsecond or even sub-microsecond, 6G mobile technology aims to facilitate near-instantaneous communication. The upcoming 6th generation (6G) wireless mobile communication networks aim to integrate satellite technologies to achieve global coverage. Looking even further ahead, the task of the 7th generation (7G) wireless mobile communication networks will be to unify these disparate systems, fostering greater connectivity and cohesion in the global communication landscape

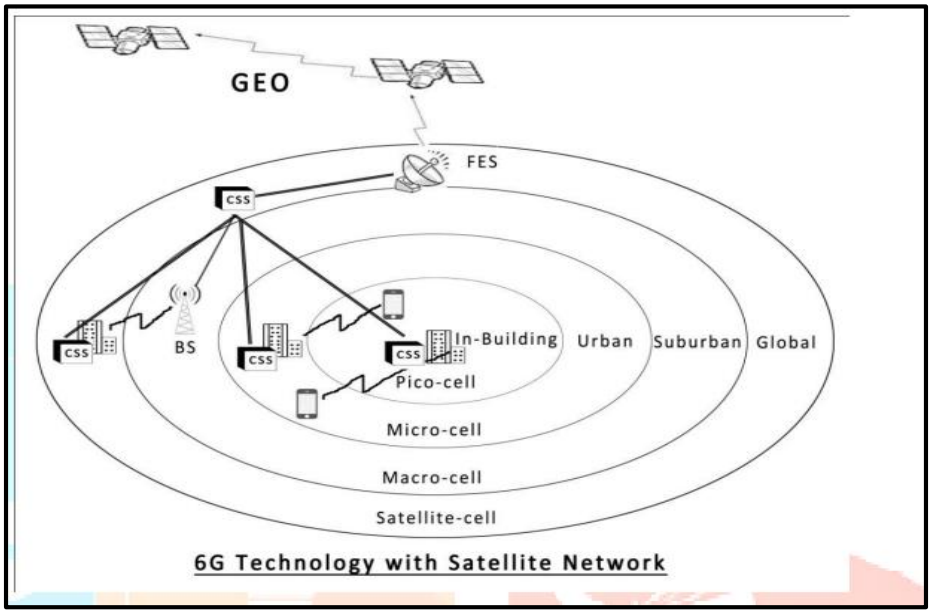

Figure.

3.1. Handover (or handoff):

It occurs when a mobile user moves from one coverage area or cell to another while in the midst of a call, necessitating the transfer of the call to the new cell's base station. Handoffs

incur costs, making it imperative to minimize unnecessary handoffs. Poorly executed or unreliable handoff procedures can diminish the overall quality and reliability of the system.

Table.

Generation	*Started at*	*Technology*	*Data rates*	*Main network*	*Handover*	*Sub Generation*
1G	1980	Analog wireless	2kbps	PSTN	Horizontal	1G only
2G	1991	Digital wireless, GPRS, EDGE	10 kbps to 500 kbps	PSTN, GSM, CDMA	Horizontal	2.5 G, 2.75G
3G	2001	Board band IP tech	400 kbps to 30 mbps	Packet, GSM, WCDMA	Horizontal and Vertical	3.5G, 3.75G
4G	2008	LTE, wi-max	200 kbps to 1 gbps	Internet	Horizontal and Vertical	4G only
5G	Will start by 2020	IPv4	Higher than 1 gbps	Internet	Horizontal and Vertical	5G till now

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4. Comparison of 5G and 6G technologies:

The advent of 6G technology marks a new era in the evolution of wireless communications, building upon the foundation laid by 5G. While 5G has already deepened the way we connect and interact with the digital world, 6G promises to take this transformation to an entirely new level. Here are the key differences we can surmise:

4.1. Speed:

The 6G network is anticipated to be 100 times faster than 5G, facilitating significantly accelerated data transmission rates.

4.2. Latency:

6G targets sub-millisecond latency, substantially lower than the 1 ms latency of 5G, enabling near-instantaneous communication for time-critical applications.

4.3. Frequency bands:

6G is poised to leverage higher frequency bands, such as terahertz waves, capable of carrying more data, thus offering enhanced bandwidth and capacity.

4.4. Network intelligence:

6G will heavily integrate artificial intelligence into network operations, enhancing functionalities like predictive maintenance, automated network optimization, and intelligent resource allocation.

4.5. Advanced applications:

6G is anticipated to unlock more sophisticated applications, including high-fidelity holographic communications, immersive augmented and virtual reality experiences, and seamless IoT connectivity.

4.6. Global coverage:

By integrating satellite and terrestrial networks, 6G could provide truly global coverage, extending connectivity to remote and previously inaccessible regions.

4.7. Energy efficiency:

With technological advancements, 6G networks are projected to be more energy-efficient than 5G, crucial for sustainable development and operation.

4.8. Device connectivity:

6G will broaden the scope and scale of device connectivity, supporting the Internet of Everything (IoE), where virtually every device is intelligently interconnected.

4.9. Reliability and security:

Enhanced reliability and security features are expected in 6G to meet the escalating demands for secure and resilient communication, particularly in critical applications.

4.10. New architectures:

6G may introduce novel network architectures, including decentralized and user-centric designs, offering more adaptable and efficient network management.

5. Advancing technologies for 6G development:

6G mobile technologies will be built upon the foundation established by 5G, with several existing innovations poised for further enhancement:

5.1. Millimeter:

Wave Technologies: Leveraging frequencies higher in the spectrum enables broader spectrum utilization and the potential for wider channel bandwidths. Given the substantial data speeds and bandwidth demands of 6G, millimeter-wave technologies will undergo further development, potentially extending into the Terahertz spectrum region.

5.2. Massive MIMO (multiple input multiple output):

While MIMO is prevalent in various applications such as LTE and Wi-Fi, advancements in antenna sizes and spacing facilitate the realization of a large number of antennas on a single equipment, enhancing spatial multiplexing and throughput.

5.3. Dense networks:

The reduction in cell size enables more efficient spectrum utilization across the network. Techniques ensuring seamless operation of small cells within the macro-network and deploying femtocells are essential for maximizing network effectiveness.

5.4. Emerging technologies for 6G advancement:

In the pursuit of 6G innovation, numerous novel technologies are poised to make their mark. Some of the notable contenders include:

5.4.1. Future PHY / MAC:

a) Waveforms: A key focus area lies in exploring new waveforms for wireless communications. While OFDM has been highly effective in 4G and 5G, there's interest in novel waveforms offering enhanced performance.

b) Multiple Access Schemes: Various new access schemes are under investigation to cater to the evolving needs of 6G technology.

c) Modulation: While PSK and QAM have delivered exceptional spectral efficiency and capacity, alternatives like APSK are being explored for their potential advantages in specific scenarios.

5.4.2. Duplex methods:

The evolution of 6G wireless communications brings forth several candidate forms of duplexing. While current systems predominantly use Frequency Division Duplex (FDD) or Time Division Duplex (TDD), 6G explores flexible duplexing options, where allocated time or frequencies can adjust based on directional load. Additionally, concepts like division-free duplex or single-channel full duplex present opportunities for simultaneous transmission and reception on the same channel.

6. Challenges of 6G technology:

Enumerating the disadvantages of 6G technology presents a challenge today, as it is still in the developmental stage. However, like any innovation, 6G technology is expected to have its share of drawbacks:

6.1. Complexity:

The intricacy of 6G technology may pose a barrier to its adoption. Learning to navigate and utilize this advanced technology may prove challenging for many individuals, requiring significant time and effort to grasp its intricacies.

6.2. Costly investment:

Implementing 6G networks with their promised high-speed capabilities and extensive coverage entails substantial investment. Consumers may find the cost of adopting this technology prohibitive compared to previous generations.

6.3. Privacy concerns:

There are apprehensions regarding the privacy and security implications of 6G technology. Questions arise about the vulnerability of these networks to surveillance by governments or unauthorized parties.

6.4. Compatibility challenges:

Compatibility issues may arise with older devices, potentially rendering them incompatible with 6G technology. This could present a hurdle for consumers who wish to upgrade but are hindered by the compatibility limitations of their existing devices.

6.5. Health implications:

The high-frequency radiations associated with 6G technology raise concerns about potential health impacts. Prolonged exposure to these radiations may lead to health issues such as headaches, dizziness, nausea, and vision problems.

6.6. Societal impact:

The widespread adoption of 6G technology may lead to increased mobile phone usage, particularly among children and individuals. Excessive screen time and reliance on mobile devices for entertainment could negatively impact cognitive development, foster sedentary lifestyles, and encourage harmful habits, thereby affecting overall well-being.

7. Conclusion and future work:

In conclusion, while the existing wireless technologies (1G to 4G) have satisfactorily met the needs of users, the modern era demands unprecedented speed and efficiency across all domains. Hence, the exploration of the next-generation wireless network, 6G, is underway. Envisioned as a solution to meet the demands of both present and future generations, 6G holds the promise of fulfilling diverse user requirements. 6G network technology emerges as a novel and promising advancement poised to significantly benefit businesses, educational institutions, and governmental bodies in the future.The lightning-fast speed of 6G not only promises enhanced efficiency but also addresses communication challenges even in the most remote areas.

Further exploration and deployment of this technology are crucial to gain deeper insights into its pros and cons. With more scientific evidence and widespread implementation, a clearer understanding of its potential benefits and limitations will emerge.

Looking ahead, the envisioned 7G holds the potential to be the pinnacle of mobile communication technology. However, several pressing issues require further research and resolution. These include addressing challenges related to seamless mobile communication during international travel, considering the movement and orbit of satellites, and establishing standards and protocols for cellular-to-satellite and satellite-to-satellite communication systems.

The realization of the 7G dream hinges upon the meticulous definition of standards and protocols. It is conceivable that subsequent generations, such as 7.5G, may emerge to bridge existing gaps and push the boundaries of technological innovation even further. Therefore, the journey towards the future of wireless communication continues, with each step paving the way for greater connectivity, efficiency, and advancements yet to be realized.

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