


Chapter 1


Advancing towards 6G Innovations, Challenges and Future Prospects

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ABSTRACT

The development of wireless communication advances toward 6G, enabling high-speed data sharing and robust networking. Future 6G networks will use terahertz (THz) bands for continuous performance. AI, quantum communication, blockchain, and digital twins will optimize efficiency and security. 6G will modernize digital infrastructure, supporting smart cities, self-driving transport, XR programs, and IoE.

DOI: 10.4018/979-8-3373-2220-9.ch001

However, challenges include high costs, radio wave safety, and energy efficiency. Research must focus on THz-based hardware, AI-network orchestration, and edge computing. Key directions include AI-driven networks, satellite-ground systems, and eco-friendly protocols. Power-saving solutions like IRS and RIM enhance signal propagation. Quantum communication and blockchain ensure security and reliability. Global research will drive 6G as a foundation for intelligent, hyper-connected systems, uniting demographics in industrial and social transformation. This study explores 6G advancements, future wireless techniques, and anticipated solutions.

1. INTRODUCTION

6G is the next generation of mobile technology, anticipated as ultra-fast, low-latency, and extremely reliable wireless communications. After improving data rates by a large margin, 6G is aimed at going beyond it. It will enable real-time immersive experiences with virtual and augmented reality systems by transferring data beyond 1 Terabit Per Second (TBPS). Self-optimizing performance will be driven by AI-based autonomous networks, (Akyildiz, Kak, & Nie, 2020). The development and upgradation of cellular technology through 1G to 5G has been, until now, focused on improving speed, connectivity, and reliability. 6G is likely to cause breakthroughs with quantum computing, Terahertz (THz) communication, and ultra-low-latency networking. Expected to come into play by 2030, 6G will cause paradigm shifts in interactions between the digital and human worlds, autonomous operations, and real-time holographic communications. Substantial thought needs to go into research and development, both in technical and regulatory domains, in order to achieve such a vision, (Haung et al., 2019) (Imoize et al., 2021).

1.1 Definition and Significance of 6G

The upcoming mobile network generation known as 6g or sixth generation represents a major wireless communication leap while forecasted to expand data exchange rates much beyond what 5G offers. One terabit (TBPS) provides the foundation for 6G as it enables facilitated communication which allows seamless interconnection of equipment with people. Advanced techniques including THz Communication and Artificial Intelligence (AI), Edge Computing and Quantum Computing will be fully integrated to form self-adjusting networks which provide dynamic user and application service customization. 6G serves to establish basic yet efficient interconnections between humans and machines and environmental

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