

# 6G: THE PARADIGM FOR FUTURE WIRELESS COMMUNICATIONS



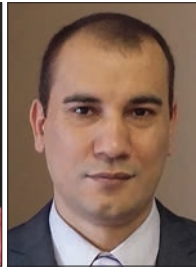
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While 5G research is maturing toward a global standard, the focus has now shifted toward the development of beyond 5G solutions. Wireless data traffic is estimated to reach 4394 EB by 2030 (Source: International Telecommunication Union), and the number of connected devices might surge beyond 50 billion. 5G will be unable to provide adequate support for various applications that depend on this huge data generated from massively interconnected devices. Many future data-intensive applications and services like pervasive edge intelligence, holographic rendering, high-precision manufacturing, ultra-massive machine-type communications, and virtual/augmented reality (VR/AR)-based gaming are expected to demand higher bit rates (terabits per second) and lower latency (less than 1 ms). Here, 6G is expected to extend 5G capabilities to higher levels where millions of connected devices and applications could operate seamlessly with trust, low latency, and high bandwidth. Research in 6G has already begun and is expected to gain momentum very soon. Industries and academia have allocated enormous funds and other resources for 6G research and development. The main focus is expected to be in the deployment of 6G-enabled massive Internet of Things (IoT), interoperability issues, system architectures, energy-efficient technologies, and application of artificial intelligence and other novel techniques to improve network performance, security, and privacy.

After a careful review process, nine outstanding papers were selected for this Special Issue. The first article, “AI-Based Cloud-Edge-Device Collaboration in 6G Space-Air-Ground Integrated Power IoT” written by Wang *et al.*, demonstrates implementation of a hybrid and hierarchical cloud-edge-device collaboration architecture to adapt to different scenarios and domains. The work also suggests a queue-aware offloading algorithm to facilitate decision making optimization under incomplete information.

The second article, “Integrating Terrestrial and Satellite Multi-beam Systems toward 6G: Techniques and Challenges for Interference Mitigation” written by Peng *et al.*, provides a systematic overview of efficient interference mitigation technologies focusing on two NOMA-enabled joint beamforming and resource allocation schemes to increase the minimal data rate. A future integrated scenario is also presented to validate the effectiveness of the proposed schemes.

The next article, “A Novel Wireless Resource Management for the 6G-Enabled High-Density Internet of Things” written by Shen *et al.*, proposes a novel wireless resource management technique for 6G network enabled high-density IoT services. Their experimental results demonstrate that the speed of the platform based on this solution is significantly faster than that of

the traditional platform, and it is especially suitable for wireless resource management in 6G-enabled high-density IoT.

The fourth article, “Intelligence-endogenous Networks: Innovative Network Paradigm for 6G” written by Zhou *et al.*, puts forward the concept of the intelligence endogenous network (IEN), which basically aims to introduce knowledge graph and artificial intelligence technologies into networks to characterize and apply the network’s multi-dimensional subjective and objective knowledge. They further introduce the basic concepts, goals, and meanings of IEN, together with its key theories and technologies.

The fifth article, “Toward Federated-Learning-Enabled Visible Light Communication in 6G Systems” written by Muhaidat *et al.*, demonstrates a detailed review of the literature on the application of federated learning (FL) in visible light communication (VLC) networks. Their work also includes a thorough overview on the main design aspects of FL-based VLC systems. Toward the end, the authors highlight some potential future research directions of FL that are envisioned to substantially enhance the performance and robustness of VLC systems.

The next article, “Quantum-Enabled 6G Wireless Networks: Opportunities and Challenges” written by Wang *et al.*, highlights a technology-driven and visionary description and exploration on how quantum information technology (QIT) can be leveraged for future 6G wireless networks. For instance, QIT can be leveraged to solve challenging wireless resource optimization problems in 6G systems. However, QIT is facing many challenges such as availability of quantum hardware and integration of QIT with ICT for 6G networks.

The seventh article, “A Prototype of Reconfigurable Intelligent Surface with Continuous Control of the Reflection Phase” written by Di Renzo *et al.*, delineates a prototype of the reconfigurable intelligent surface (RIS) that offers the capability of controlling the phase shifts. The work also includes characterization of its properties with the aid of full-wave simulations and through experimental measurements.

The penultimate article, “Satellite Based Computing Networks with Federated Learning” written by Chen *et al.*, proposes the application of FL in low Earth orbit (LEO)-based satellite communication networks. Having reviewed the state-of-the-art LEO-based SatCom and related machine learning (ML) techniques, the analysis of four possible ways of combining ML with satellite networks is carried out followed by their evaluation by simulations, which reveal that FL-based computing networks improve the performance of communication overheads and latency.

Finally, the last article, “Toward Zero-Touch Management and Orchestration of Massive Deployment of Network Slices in 6G” written by Ksentini, proposes a novel framework featuring

a distributed and AI-driven management and orchestration system for massive deployment of network slices in 6G. It is worth noting that the proposed framework is compliant with both European Telecommunications Standards Institute standards focusing on autonomous and intelligent network management and orchestration: zero touch service management (ZSM) and experimental networked intelligence (ENI). This implies that their proposed work will be leveraged to enable autonomous as well as scalable management and orchestration of network slices and their dedicated resources.

In conclusion, the Editors would like to thank all authors who submitted manuscripts to this Special Issue. The Editors wish to thank the reviewers who helped to review all of the papers in a very short timescale. We would like, in particular, to thank the Editor-in-Chief, Yi Qian, for his support to organize this Special Issue. Last but not least, it is our hope that the readers will enjoy these articles.

## BIOGRAPHIES

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