

Advanced 5G and Beyond Networks

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The evolution of mobile and wireless communication systems has entered a decisive phase. While 5G networks are still being deployed, optimized, and integrated into real-world infrastructures, research and development are already moving toward Beyond 5G and 6G networks. These emerging systems are expected to support substantially higher data rates, ultra-low latency, massive connectivity, enhanced reliability, and intelligent network operation. They will also serve as the foundation for demanding applications such as extended reality, tactile Internet, smart cities, autonomous systems, industrial automation, drone networks, and integrated terrestrial and non-terrestrial communication.

This Special Issue, “Advanced 5G and Beyond Networks”, brings together eight papers that reflect the breadth of current research in this area. The contributions address both fundamental enabling technologies and application-oriented challenges, including mmWave MIMO channel estimation, machine learning for security, drone jamming detection, digital twins for mobile ad hoc networks, quantum communication protocols, tactile Internet requirements, and machine-learning-assisted 6G optimization. Together, these papers illustrate the multidisciplinary nature of future network research, where wireless communication, artificial intelligence, cybersecurity, edge intelligence, distributed systems, and emerging computing paradigms increasingly converge.

One major theme of this Special Issue is the design of efficient communication techniques for high-capacity and low-latency wireless systems. Sujatha and Kumaravelu [1] propose a hybrid GOMP–ROMP algorithm for sparse channel estimation in mmWave hybrid MIMO systems. By combining the group-selection efficiency of generalized orthogonal matching pursuit (GOMP) with the regularization mechanism of regularized orthogonal matching pursuit (ROMP), the proposed approach aims to reduce computational complexity while maintaining estimation accuracy. Their results indicate that such algorithms can contribute to real-time channel estimation in massive MIMO scenarios, which is essential for practical 5G and 6G deployments.

Security and resilience form another central focus of the issue. Kalodanis, Papapavlou, and Feretzakis [2] examine machine-learning-based approaches for adaptive intrusion detection and prevention in 5G and future 6G networks. Their work highlights how architectural flexibility, device heterogeneity, and large-scale connectivity expand the attack surface of modern wireless systems, while also showing how intelligent detection methods can support adaptive security. In a related contribution, Moubayed [3] presents an exploratory data analysis and deep-learning pipeline for intrusion detection in softwarized 5G networks, demonstrating the potential of data-driven methods for identifying and classifying attacks in complex network environments.

The security of emerging application domains is also addressed through the work of Cibecchini, Chiti, and Pierucci [4], who propose a lightweight AI-based approach for drone jamming detection. As unmanned aerial vehicles become increasingly integrated into future 6G-enabled ecosystems, their exposure to availability attacks such as jamming becomes a critical concern. The proposed unsupervised machine-learning solution, based



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on Isolation Forest and enhanced through a Majority Rule module, shows how edge-compatible intelligence can improve the robustness of drone communications against disruptive attacks.

Another contribution explores the management and monitoring of dynamic network environments. Jesús-Azabal et al. [5] present a connection-aware digital twin for 5G mobile ad hoc networks. Their work addresses the challenge of representing and monitoring highly variable network topologies, particularly when some nodes may lack direct 5G connectivity. By providing a live virtual representation of the physical network and estimating its performance under changing conditions, the proposed digital twin approach points toward more adaptive and context-aware management of future mobile infrastructures.

The Special Issue also includes contributions that look beyond conventional communication paradigms. Andronikos et al. [6] introduce a GHZ-based protocol for the Dining Information Brokers Problem, proposing an entanglement-based quantum protocol for anonymous, untraceable, and massively parallel information exchange. Although conceptual in nature, this work reflects the growing relevance of quantum communication ideas in the broader discussion of future secure and distributed networking systems.

Two review papers provide broader perspectives on the requirements and enabling technologies of future networks. Chaudhari [7] reviews the role of 6G in enabling the Tactile Internet, focusing on application characteristics, performance requirements, and design considerations for use cases such as remote surgery, autonomous vehicles, industrial automation, brain-machine interfaces, telepresence, and holography. Okere and Balyan [8] examine the intersection of 6G enabling technologies and machine learning from a performance optimization perspective, discussing technologies such as digital twins, intelligent reflecting surfaces, visible light communication, quantum computing, blockchain, UAVs, and non-orthogonal multiple access. These review contributions help position the research articles within the wider trajectory toward intelligent, high-performance, and application-aware 6G systems.

Taken together, the eight papers in this Special Issue show that the transition from 5G to Beyond 5G and 6G is not merely a matter of increasing bandwidth or reducing latency. It involves a deeper transformation of network architectures, control mechanisms, security models, and application ecosystems. Future wireless networks will need to be intelligent, secure, energy-efficient, resilient, and capable of supporting diverse services with widely varying requirements. The contributions collected here offer valuable insights into these challenges and provide directions for continued research in communication technologies, machine learning, cybersecurity, distributed systems, and emerging network applications.

We would like to thank all authors for their valuable contributions to this Special Issue. We are also grateful to the reviewers for their careful evaluations and constructive feedback, and to the editorial team of Future Internet for their support throughout the editorial process. We hope that this collection will be useful to researchers, practitioners, and students working on the evolution of 5G, Beyond 5G, and future 6G networks.

Conflicts of Interest: The author declares no conflict of interest.

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