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Editorial

5G and Beyond: Technologies and Communications

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1. Introduction

The rapid evolution of fifth-generation (5G) and beyond-fifth-generation (B5G) wireless technologies is transforming the way societies connect, communicate, and interact with digital services. These technologies support a wide range of emerging applications, including immersive virtual reality, Internet of Things (IoT) systems, autonomous vehicles, smart healthcare, remote surgery, intelligent transportation, industrial automation, and mission-critical communication services. The progression toward sixth-generation (6G) networks further expands these possibilities by targeting ultra-high data rates, ultra-low latency, enhanced reliability, massive connectivity, and intelligent network control.

As communication systems move toward higher frequency bands, denser deployment scenarios, and increasingly software-defined and data-driven infrastructures, several technical challenges remain. These include reliable millimetre-wave and terahertz propagation, energy-efficient network operation, hardware complexity, secure communication, accurate localisation, dynamic resource allocation, and scalable edge computing. Addressing these challenges requires innovations across multiple layers of the communication ecosystem, from antenna design and radio propagation to artificial intelligence, reconfigurable intelligent surfaces, and network optimisation.

This Special Issue, entitled "5G and Beyond: Technologies and Communications", brings together recent research contributions addressing these opportunities and challenges. The published articles collectively highlight important developments in wireless propagation, intelligent surfaces, edge-node placement, indoor localisation, antenna manufacturing, energy harvesting, and secure communication systems.

2. An Overview of Published Articles

Recent advancements in 5G and beyond communication technologies have focused on improving network performance, coverage, energy efficiency, localisation accuracy, and infrastructure optimisation.

The first study in this Special Issue proposes a placement method for 5G edge nodes based on the hotspot distribution of mobile users. By clustering user trajectories and extracting hotspot features such as user density and duration time, the authors formulate an optimisation model to improve high-load utilisation and reduce core network bandwidth consumption. Their results demonstrate the value of mobility-aware edge-node deployment for reducing latency and improving resource utilisation in 5G networks [1].

The second contribution investigates a hybrid reconfigurable intelligent surface (RIS) approach for reducing power loss and enhancing coverage in 6G networks. The proposed hybrid RIS decision-making algorithm dynamically configures RIS elements according

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to user location information, enabling more efficient signal reflection and transmission. The study reports substantial improvements in signal power loss, delay, channel gain, and system efficiency compared with conventional STAR-RIS and base-station handover approaches, highlighting the importance of intelligent and adaptive radio environments in future networks [2].

Indoor propagation at millimetre-wave frequencies is examined in the third contribution through extensive simulations of 5G indoor channels. This work investigates omnidirectional and directional propagation characteristics across 28 GHz, 39 GHz, 60 GHz, and 73 GHz bands under line-of-sight and non-line-of-sight conditions. By analysing path loss exponents, delay spread, cluster behaviour, and ray characteristics, the study provides useful insights for indoor channel planning and network design at high-frequency bands [3].

In the area of antenna design and fabrication, the fourth article explores the feasibility of using fused deposition modelling for manufacturing dielectric resonator antenna arrays for millimetre-wave 5G applications. The study demonstrates that low-cost 3D printing can support flexible antenna development, while also showing that dimensional accuracy, surface roughness, and fabrication precision remain important constraints, particularly at higher millimetre-wave frequencies. This contribution illustrates the potential of additive manufacturing for rapid prototyping and accessible production of antenna structures for modern wireless systems [4].

Artificial intelligence is addressed in the fifth article through a study on 6G indoor localisation using deep learning with attention mechanisms. The authors use channel state information with convolutional neural networks and investigate self-attention and channel-attention mechanisms to improve positioning accuracy and robustness. Their findings indicate that attention-enhanced deep learning can significantly reduce localisation error, supporting the development of accurate indoor positioning systems for IoT and future 6G applications [5].

Secure and energy-efficient IoT communication is investigated in the sixth study, which focuses on quantum particle swarm optimisation-based secured intelligent reflecting surface-assisted wireless-powered IoT networks. The authors combine intelligent reflecting surfaces, energy harvesting, friendly jamming, and physical layer security to maximise secrecy throughput. By jointly optimising IRS phase shifts and time allocation using quantum particle swarm optimisation and bisection methods, the proposed approach achieves notable performance improvements over baseline schemes, demonstrating the potential of IRS-assisted designs for secure and efficient wireless-powered IoT systems [6].

These studies collectively highlight the breadth of current research in 5G and beyond communications. They address complementary aspects of future networks, including physical-layer propagation, intelligent radio environments, AI-driven localisation, additive antenna manufacturing, secure wireless-powered IoT systems, and edge-computing infrastructure. Together, they contribute to the development of more adaptive, efficient, secure, and intelligent communication systems.

3. Conclusions

The articles published in this Special Issue demonstrate significant progress in the development of 5G and beyond communication technologies. The contributions span multiple research directions, including millimetre-wave propagation modelling, reconfigurable intelligent surfaces, 3D-printed antenna arrays, AI-assisted indoor localisation, mobile hotspot-based edge-node placement, and secure IRS-assisted wireless-powered IoT networks.

By exploring these areas, the Special Issue highlights how future wireless systems will rely not only on higher data rates and expanded spectrum access, but also on intelligent

optimisation, adaptive environments, sustainable infrastructure, accurate positioning, and secure connectivity. The collected works show that the successful realisation of 6G and beyond networks will require close integration of communication theory, hardware innovation, artificial intelligence, edge computing, and security-aware system design.

Overall, these research efforts provide valuable insights into the technologies and challenges shaping next-generation wireless communications. Future research should continue to focus on scalable real-world deployment, cross-layer optimisation, energy-aware networking, trustworthy AI, robust security mechanisms, and sustainable communication architectures.

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