UNLOCKING 5G SPECTRUM POTENTIAL FOR INTELLIGENT IOT: OPPORTUNITIES, CHALLENGES, AND SOLUTIONS


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The Internet of Things (IoT), one of the hottest trends in technology, is transforming our future by interconnecting everything; humans, vehicles, appliances, utilities, infrastructures, street lights, etc., through intelligent connections. For deploying the realization of IoT by 2020, Fifth Generation (5G) wireless communication networks are considered as an essential unifying fabric that will connect billions of devices in some of the fastest, most reliable and most efficient ways possible, whose impact will be revolutionary, reshaping industries and transforming our world. Therefore, 5G is currently attracting extensive research interest from both industry and academia. It is widely agreed that in contrast to 4G, 5G should achieve 1000 times system throughput, 10 times spectral efficiency, higher data rates (i.e., the peak data rate of 20 Gb/s and the user experienced rate of 1Gb/s), 25 times average cell throughput, less than 1 ms in end-to-end (E2E) latency, and 100 times higher connectivity density. Among those requirements, the 1000-fold increase in system capacity becomes the most important and maybe the most challenging for 5G systems.

To cope with such challenges, spectrum efficiency through utilization of free and less crowded spectrum resources has been considered as a promising complementary solution by providing flexible and maximal spectrum usage to support the ultra-capacity foreseen by 5G and beyond. Already some technologies have been evolving, such as Long Term Evolution Unlicensed/Licensed-Assisted Access (LTE-U/LAA) that has increased the spectrum efficiency of the Wireless Fidelity (Wi-Fi) band through coexistence technology. The practice of extremely high frequency millimeter wave has been already proposed for broadband access and backhaul/fronthaul networks for fast 5G speeds, whereas on the other hand, utilization of the very low frequency band, sub 1-GHz spectrum, is aimed for the IoT to enable sensor-to-cloud applications.

Although these technological advances are expected to help the forecasted demand on the 5G environment, these technologies have not been fully tested to benchmark performance. There are many challenges that need to be resolved, such as network coexistence among different radio access technologies, resource sharing and access with legacy devices, Quality of Experience (QoE) for users in the unlicensed band, environmental and propagation issues, and power and cost issues.

The main objective of this Feature Topic (FT) is to present technical challenges and the latest results related to spectrum management techniques in 5G. In this FT, we present seven articles that have been accepted after a rigorous peer review process.

The first contribution, co-authored by Nadeem Javaid *et al.*, entitled "Intelligence in IoT Based 5G Networks: Opportunities and Challenges," discusses the need for Artificial Intelligence (AI) in IoT based 5G networks. The authors discuss different enhancements that the future 5G network provides such as the impact of intelligence in the context of dynamic spectrum management, structuring of the huge data, integration of heterogeneous devices, ultra densification of devices, interoperability, and battery dissipation.

The next article, entitled "Spectrum Management Scheme in Fog IoT Networks," co-authored by Ning Yang *et al.*, presents a network architecture for networks-fog-based IoT systems to share the unlicensed spectrum. A joint channel access algorithm and spectrum allocation scheme for unlicensed spectrum management is proposed to improve the system's performance and capacity.

Spectrum efficiency is an important feature and requirement of 5G. The usage of unmanned aerial vehicles (UAVs) to provide high-speed wireless communications is expected to play a vital role in 5G. Therefore, Hamed Hellaoui *et al.*, in their article entitled "Aerial Control System for Spectrum Efficiency in UAV to Cellular Communications," discuss the issue of spectrum degradation due to frequent UAV control and management messages and emphasiz the requirements for efficient UAV planning.

In the article entitled "From IoT to 5G I-IoT: The Next Generation IoT-Based Intelligent Algorithms and 5G Technologies," Dan Wang *et al.* propose a 5G Intelligent IoT (5G I-IoT) as the Internet-connected framework utilizing next generation communication techniques to transmit and process data. The proposed framework processes big data intelligently, and improves channel utilizations.

The next article, entitled "Dynamic Spectrum Management Through Resource Virtualization with M2M Communications," co-authored by Abdallah Moubayed *et al.*, presents a dynamic spectrum management scheme through resource virtualization with Machine to Machine (M2M) communications using an LTE Advanced cellular network.

Non Orthogonal Multiple Access (NOMA) has been introduced to achieve high data rates in 5G networks. In the article entilted "Fractional-Time Exploitation for Serving IoT Users with Guaranteed QoS by 5G Spectrum," Nasir Ali *et al.*, introduce a fractional-time based approach to ensure guaranteed user throughput without any security compromise.

In the last article, entitled "LWA in 5G: State-of-the-Art Architecture, Opportunities, and Research Challenges," R. Bajracharya *et al.* propose LTE Wireless Local Area Network (LTE-WLAN) Aggregation (LWA) as a promising candidate to effectively aggregate LTE and WLAN at the link layer. LWA offers operators with capacity increases and a peak throughput experience for users.

BIOGRAPHIES

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