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EDITORIAL

IEEE ACCESS SPECIAL SECTION EDITORIAL: COMPLEX NETWORK ANALYSIS AND ENGINEERING IN 5G AND BEYOND TOWARD 6G

Modern telecommunication networks represent a large-scale construction and deployment effort, with renovations occurring almost continuously over the course of decades. The resulting networks consist of numerous dimensions, each following its own trajectory of development, commingled into a complex ecosystem. Typical attributes used to characterize networks (e.g., interference, coverage, throughput, robustness, and cost) fail to fully capture a key feature of future wireless networks, namely the degree of organization. This is increasingly important when we consider the trajectory of the evolution of 5G and beyond networks with respect to densification, heterogeneity, and distributed and self-organizing decision-making.

This Special Section highlights such issues including how a self-organizing and highly dynamic environment can be treated as a complex system, whether complex systems science detects and exploits emergent properties of these kinds of networks, and whether it offers any new insights that can be used in their design and deployment. A complex system can be defined as a network formed by a large number of elements, which adopt simple actions in a distributed fashion, giving rise to complex system-wide patterns and behaviors; with appropriate design and management, the interaction of elements in this manner enables aggregate capability far exceeding the capabilities of the individual system components. This view resonates with the trends emerging in wireless networks.

Several complex systems science perspectives are indeed beginning to emerge as possible solutions to provide the necessary means to redefine the general understanding of telecommunication networks. For example, network science and its application to communication networks are drawing more and more interest due to the increasing heterogeneity and density of networks. As another example, chaos theory has been shown to enable the creation of fast and light yet efficient and reliable security protocols; these methods are starting to be implemented in network communication and IoT.

This Special Section focuses on the application of systems and complexity science to 5G and beyond wireless communication systems, as well as MANET and IoT-based systems. In particular, the Special Section aims at answering questions such as whether future mobile networks and systems built upon them can be treated as complex systems while seeking to uncover insights that can be gleaned from this treatment, e.g., whether stable and desirable operating points emerge out of local configuration and optimization actions.

We received a very good response for the Special Section. We sincerely thank all the authors for their contributions. After a careful and detailed review process, seven articles have been accepted for publication in the Special Section, which highlight very interesting aspects about the application of Complex Systems Science in the area of Communications and Networking in 5G and beyond.

We invited one excellent article by Sergiou *et al.*, "Complex systems: A communication networks perspective towards 6G," which aims to reveal the models of complex networks that may apply when modeling 5G and 6G mobile communication networks. Furthermore, the authors expect to encourage the collaboration between complex systems and networking theorists toward meeting the challenging demands of 5G networks and beyond.

The next two articles focus on different aspects related to dynamics and mobility in future complex networks. In the article "Key challenges, drivers and solutions for mobility management in 5G networks: A survey," by Shayea *et al.*, the authors aim to provide an overview of mobility management in 5G networks, highlighting the main challenges facing user mobility, as well as future research directions on mobility management in 5G networks and beyond.

In the article "Digital twin for metasurface reflector management in 6G terahertz communications," by Pengnoo *et al.*, the authors propose a terahertz signal guidance system where a Digital Twin is used to model, predict, and control the signal propagation characteristics of an indoor space.

The next two articles tackle the very important area of complex networks' topology. In the article "An analytic latency model for a next-hop data-ferrying swarm on random geometric graphs," by Fraser *et al.*, the authors discuss a data-driven approach to ferrying data between graph components of a disconnected network and describe the development of a mathematical model of such a next-hop ferrying swarm.

In the article "A compression-based multi-objective evolutionary algorithm for community detection in social networks," by Liu *et al.*, the authors propose an algorithm for community detection where the network is first compressed to a much smaller scale by exploring network topologies. Subsequently, a local information based genetic operator is proposed to speed up the convergence and improve the accuracy of the algorithm.

In the article "Multi-agent deep learning for multi-channel access in slotted wireless networks," by Mennes *et al.*, the important area of multiagent modeling and deep learning in future networks is discussed. The authors present a deep neural network approach that can predict spectrum occupation of unknown neighboring networks in the near-future by using online supervised learning in a multi-agent setting.

In the article "Resource allocation for hybrid visible light communications (VLC)-WiFi networks," by Yang *et al.*, the authors examine another key aspect of complex systems in the context of future networks, i.e., heterogeneity within the system. The authors propose a distributed joint resource management system model for Hybrid Visible Light Communications (VLC)–WiFi networks, allocating the bandwidth among the users with maximum fairness.

We would like to thank our reviewers who provided timely and detailed reviews to help us complete the review process for the Special Section in time. Finally, we appreciate the support of the IEEE Access Editor-in-Chief and staff members for their guidance and cooperation.

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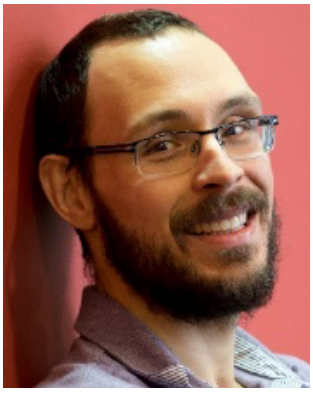

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