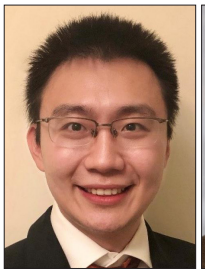
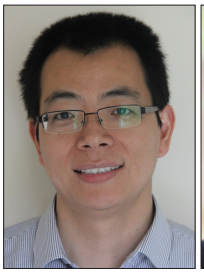
Next Generation Multiple Access for 6G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With the standardization of 5G systems, research focus is slowly shifting towards potential designs, use cases, and performance targets for 6G systems. To meet the escalating data demands of mobile devices and to deal with the deluge of data, as well as the high-rate connectivity required by bandwidth-thirsty applications (e.g., space-air-ground-integrated-networks (SAGINs), augmented reality (AR), and virtual reality (VR), etc.), 6G networks are expected to provide substantial breakthroughs beyond the previous five generations. These breakthroughs include the following:

- A ten-fold larger connectivity density compared to 5G.
- A peak data rate of one terabit per second.
- One hundred times higher energy efficiency than that of 5G.

Thus, to support the aforementioned services and applications, novel next-generation multiple access (NGMA) schemes have to go beyond merely combining existing schemes and incorporate innovative concepts, such as massive non-orthogonal multiple access (NOMA) and advanced space division multiple access.

Compared to the traditional multiple access (MA) technologies, novel NGMA aims to intelligently accommodate multiple users in the allotted resource blocks, such as time slots, frequency bands, and spreading codes, in the most effective manner. NGMA schemes can achieve higher bandwidth efficiency and higher connectivity by supporting multiple users in the allotted resource blocks, including time slots, frequency bands, spreading codes, and power levels. Thus, NGMA can improve the 6G network performance in terms of massive connectivity, energy efficiency, and low latency. However, the investigation of NGMA is still in a nascent stage, and extensive research efforts have to be devoted to several key aspects, as discussed next. First, new MA schemes, such as NOMA, are capable of achieving higher bandwidth efficiency and higher connectivity compared with conventional MA schemes. Second, it is important to understand the interplay of NGMA with emerging technologies, such as reconfigurable metasurfaces, multi-access edge computing, and integrated sensing and communications, just to name a few. Third, to facilitate the intelligent applications in 6G, NGMA schemes must embrace intelligence. Recent advances in artificial intelligence/machine learning and big data can provide promising approaches to tackle new challenges in intelligent NGMA.

This Special Issue (SI) aims to pave the way for the development of novel NGMA schemes for future wireless networks. This SI received 24 submissions- most of which were of high-quality, allowing us to select an excellent set of articles. However, given the tight publication schedule and the limited space, we unfortunately had to reject many high-quality articles. After a rigorous review process, we accepted six papers (acceptance rate of less than 25 percent). This has naturally resulted in an excellent collection of contributed articles covering many aspects of NGMA.

The article,"Realizing 6G: The Operational Goals, Enabling Technologies of Future Networks and Value-Oriented Intelligent Multi-Dimensional Multiple Access," by Wang *et al.* presents and analyzes different perspectives of the future 6G networks, including the 6G operational goals, key performance indicators, and value-oriented multi-dimensional technologies.

The article, "Grant-Free NOMA-OTFS Paradigm: Enabling Efficient Ubiquitous Access for LEO Satellite Internet-of-Things," by Gao *et al.* provides a comprehensive overview of the state-of-the-art multiple access schemes, investigated the limitations in the context of low-Earth-orbit satellites (LEO-SATs), and proposed a novel NGMA scheme for simplifying the connection procedure with reduced access latency and enhanced Doppler-robustness.

The article, "Massive Unsourced Random Access for NGMA: Architectures, Opportunities, and Challenges," by Che *et al.* compares existing random access schemes and unsourced random access (URA) for 6G systems. URA is considered as a promising multi-access technology for NGMA. In this article, the applications of URA are summarized as user-specific and user-independent scenarios.

The article, "Joint Design of Beam Hopping and Multiple Access Based on Cognitive Radio for Integrated Satellite-Terrestrial Network" by Li *et al.* analyzes the integrated satellite-terrestrial communication network (ISTCN) and jointly designs beam hopping and adaptive dynamic multiple access by integrating promising beam hopping, cognitive radio, and nonorthogonal multiple access technologies.

The article, "Multimedia Semantic Communications: Representation, Encoding and Transmission," by Duan *et al.* discusses key technologies for semantic communications, which involve semantic representation, semantic encoding and decoding, and transmission of semantic information by using NOMA.

The article, "Index Modulation Multiple Access for 6G Communications: Principles, Applications, and Challenges," by Wen *et al.* introduces index modulation multiple access (IMMA) schemes with their pros and cons and investigated the promising potential of IMMA in important application scenarios of 6G communications, such as vehicular networks, RIS aided networks, cooperative networks, and secure networks. At last, the challenges and opportunities of IMMA are discussed.

As a prestigious magazine focusing on global networking systems and technologies, IEEE Network is a perfect venue for publishing such a timely SI on next generation multiple access in 6G. We truly believe that our SI covers a number of emerging topics which are of interest to the readership of IEEE Network. We trust that this SI will provide useful insights and inspire further research in this exciting field.

Acknowledgment

As Guest Editors, we would like to take this opportunity to thank our authors and reviewers for their efforts in preparing, submitting, and reviewing these high-quality papers. Additionally, we want to extend our thanks to the Editor-in-Chief of IEEE Network for their support and valuable advice; and to the Publication Coordinators for their tremendous efforts.

Biographies

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