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EDITORIAL

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Potential of sixth-generation technologies for emerging future wireless networks

1 | INTRODUCTION

All new fifth-generation (5G) mobile technology is expected to be operational by 2020. This time, it is therefore crucial to know the direction of research and developments enabling 5G technology. The opportunities and challenges of 5G rapidly gain a lot of attention. Therefore, 5G is currently attracting extensive research interest from both industry and academia. With the task of rolling out 5G technology just getting started, work is already beginning on a sixth-generation (6G) standard. In March of 2019, a global 6G Summit event was held in Finland. The first of its kind, the event strives to initiate the process of establishing and agreeing upon a global 6G standard for the technology even at this early stage. What would 6G technology involve, who is working on it, and what are we likely to see from the technology is the open questions. There are four research areas in 6G, wireless connectivity, devices and circuit technology, distributed computing, and services and applications. The project brings together researchers, ICT companies and businesses that want to exploit opportunities that the new wireless technology will enable.

2 | THEMES OF THIS SPECIAL ISSUE

This special issue on "Potential of 6G Technologies for Emerging Future Wireless Networks" is intended to provide representative papers in the current state-of-the-art in the field of 5G mobile technology systems. The ultimate objective is to bring together well-focused, top quality research contributions, providing to the general wireless networks community an opportunity to get an overall view of research results, projects, surveying works and industrial experiences that are dealing with theory and applications within the theme of Potential of 6G Technologies for Emerging Future Wireless Networks. We welcomed both theoretical contributions as well as papers describing interesting applications. Papers were invited for this special issue considering aspects of this problem, including:

- Terahertz communications and sensing
- Mobile edge networking and computing
- Massive millimeter wave (mmWave) technologies
- Terahertz (THz) and quantum nanodevices and circuits
- 6G applications such as robotics, UAVs, autonomous vehicles
- Machine learning
- Communication foundations
- 6G testbeds
- New security concepts / New network architectures

It was able to attract multiple submissions in total. Each submission has been reviewed by at least three reviewers on the basis of theoretical originality, technical quality, relevance, originality, significance, and clarity. Following a rigorous review and selection process, we finally selected five articles. These articles present novel research in Potential of 6G Technologies for Emerging Future Wireless Networks.

3 | MODELS, PERFORMANCE IMPROVEMENT, AND APPLICATIONS

Nonorthogonal multiple access (NOMA) is an attractive candidate for 6G networks to support ultra-massive machine-type communications (umMTC). Power domain NOMA (PD-NOMA) is the simplest type of NOMA, which assigns a different power level to each user. Power allocation in PD-NOMA can be classified into fixed/dynamic power allocation (FPA/DPA). FPA is simple, but DPA is more suitable for the mobile environment than FPA. However, finding optimum power per each user in DPA is extremely complex. Fortunately, many DPA strategic design methods were introduced in the literature as simple suboptimal solutions of DPA. Therefore, DPA strategic design methods and FPA techniques are simple approaches to implement PD-NOMA in 6G and beyond. In the literature, no previous work had compared the performances of all DPA strategic design methods, nor FPA techniques, to ease the selection of a simple strategy for PD-NOMA in 6G. The contribution by Mounir et al "On the selection of power allocation strategy in power domain non-orthogonal multiple access (PD-NOMA) for 6G and beyond" compares performances of all DPA strategic design methods as well as FPA techniques, in terms of sum-rate capacity, fairness, and bit error rate (BER).[1] Results showed that the best DPA strategic design method and the best FPA technique have comparable performance.

In this article, a new transmission method named enhanced orthogonal frequency division multiplexing (E-OFDM) is proposed to increase the spectral efficiency (SE) of the OFDM. The proposed method conveys information bits not only by the M-ary symbols but also by the multiple different constellation sets. In the contribution by Acar "Orthogonal frequency division multiplexing with index modulation by using multiple constellation sets," authors build the subblocks by splitting the whole OFDM into pieces.[2] Then, the authors use different constellation sets in each subblock and the authors assign the extra bits to them to increase the SE of the OFDM systems. Consequently, at the same modulation level, the proposed method has higher SE than the conventional OFDM system. The simulation results also show that the proposed method achieves better BER performance than the conventional OFDM system with tolerable complexity. For example, the proposed method with a subblock size 2 doubles the SE of the conventional OFDM method with BPSK modulation, and also it has approximately 1.6 dB better BER performance than the conventional OFDM at BER = 10^{-4}. New constellation designs and receiver algorithm for the detection of additional bits are also presented.

The 5G network development trends (eg, more cells, larger and distributed antenna arrays, higher frequency spectrum) and new technologies are driving beyond 5G (B5G) and even 6G research together. In the existing works, performance analysis is based on typical users, but no user is typical, because of spatial correlation in the scheduling of transmission points (TPs) caused by overlapping conflict between the different transmission point groups (TPGs). Using stochastic geometry, the contribution by Chen et al "Spatial correlation modeling and ergodic capacity analysis of networks with overlapping conflict" analyzes ergodic capacity of entire network by deriving the semiclosed form expression of area spectral efficiency (ASE), where Matérn-like model is proposed to capture the spatial correlation of overlapping conflict.[3] Specifically, the serving probability of TP is lower to avoid intense overlapping conflict in heavily overlapping region, thanks to Matérn-like model requires that only one TP with best channel condition be in serving within the same TPG. In addition, considering different serving probabilities of TPs, user performance is nonindependent, thus ASE could more accurately characterize the overall level of user performance by traversing nonindependent user performance. Simulation and analytical results show that ASE considering spatial correlation can more accurately fit the overall performance of networks with overlapping conflict.

Mm-Wave communication ushers next-gen communication to new heights guaranteeing higher speed and throughput. Enabling device-to-device (D2D) communication in next-gen wireless communication is a Herculean task. This is due to introduction of path loss attenuation by various environmental factors which deteriorates the signal. The contribution by Sarma et al "Power control scheme for device-to-device communication using uplink channel in 5G mm-Wave network" aims to minimize the effect of interference for quality reception of signals for D2D communication and to increase system throughput.[4] Thus, a power control scheme is proposed in underlay mode for uplink channel in mm-Wave band. Here, D2D communication takes place through two modes namely, general mode and mm-Wave mode. In presence of large number of proximity D2D users and increasing path loss attenuation, it switches to mm-Wave mode for communication. The formulated problem is converted to semiconvex form by expressing it into exponential form in Laplace domain. Their final objective is to maximize the energy efficiency (EE) of the proposed system under certain constraints. To reduce complexity of the problem, feasible regions of transmission power are introduced, that is, least and upper bounds which will ensure that power is maintained within a limit guaranteeing better throughput for D2D users. Enhanced EE and outage probability values also depict better performance of proposed system.

Finally, fairness index (FI) shows that the proposed scheme yields better performance for the D2D users to communicate in the mm-Wave band. A detailed comparison of FI for the proposed scheme is also done with other existing methods to prove the adequate performance of the proposed method. Simulation results also prove the efficacy of the proposed scheme.

Current network technologies evolve toward the 6G of mobile communications systems. To achieve the performance requirements of high data rate, low latency, and massive connection, full-duplex (FD) wireless communication is one possible solution to provide high throughput and channel utilization. However, it is difficult to do so for legacy communication nodes. A distributed fairness-aware FD dual-hop link scheduling algorithm, named weighted full duplex (W-FD), is proposed in the contribution by Guan et al "A fairness-aware distributed dual-hop heterogeneous half and full-duplex link scheduling for 6G network" to achieve the efficient node selection and dynamic relay probing.[5] The scheduling weight that considered traffic load, mutual interference, and response interval is employed to ensure link load balance. A node with a higher scheduling weight in the neighborhood is selected as the link establishment object to build a FD link. Better than conventional half-duplex link scheduling, W-FD reduces link scheduling interval and ensures the access opportunities for legacy nodes. Simulation result shows that throughput and delay performance are improved. Compared with the existed FD link scheduling, W-FD could better reflect the fairness of scheduling in multinodes and asymmetric-packets networks, and ensure the throughput and delay performance.

4 | CONCLUSIONS

The articles presented in this special issue provide insights in fields related to Potential of 6G Technologies for Emerging Future Wireless Networks, including models, performance evaluation and improvements, and application developments. We wish the readers can benefit from insights of these papers, and contribute to these rapidly growing areas. We also hope that this special issue would shed light on major developments in the area of *Emerging Telecommunications Technologies* and attract attention by the scientific community to pursue further investigations leading to the rapid implementation of these technologies.

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Gwanggil Jeon[1]
Valerio Bellandi[2]
Abdellah Chehri[3]
Marcelo Keese Albertini[4]

[1]*Department of Embedded Systems Engineering, Incheon National University, Incheon, South Korea*
[2]*Department of Computer Science, Università degli Studi di Milano, Milan, Italy*
[3]*Department of Applied Sciences, Université du Québec à Chicoutimi, Chicoutimi, Québec, Canada*
[4]*Faculdade de Computação, Universidade Federal de Uberlândia, Uberlândia, Brazil*

Correspondence
Gwanggil Jeon, Department of Embedded Systems Engineering, Incheon National University, Incheon, South Korea.
Email: gjeon@inu.ac.kr

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