Internship: NOMA Resource Allocation for Massive Machine Type Communications (mMTC)

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Department: Algorithms, Analysis & Augmented Intelligence Research (AAAIR)
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Position: Summer research internship (2-3 months)

Context

The non-orthogonal multiple access (NOMA) [1] is a promising technology to increase the spectral efficiency and enable massive connectivity in 5G and future networks. Multiple access schemes adopted by 1G-4G cellular systems are all orthogonal in the sense that users are allocated orthogonal resources in frequency, time and/or code domains. These schemes aim to avoid or alleviate mutual interference among the users by dividing the radio resource into interference-free pieces. On the contrary, NOMA multiplexes several users on the same resource (e.g., frequency sub-carrier), thus achieving higher spectral efficiency in turn of larger decoding complexity. The basic principles of NOMA are signal superposition at the transmitter and successive interference cancellation (SIC) at the receiver. NOMA has been identified as a key technique in 5G to enable massive machine type communications (mMTC) [2]. Some work has been done in the context of Narrowband Internet of Things (NB-IoT) [3] in terms of connectivity and throughput optimization [4,5].

Objective

The aim of this project is to develop new resource allocation algorithms to maximize the number of connected devices in a NOMA narrowband-IoT system subject to devices' power constraints and QoS requirements. Prior work [4] and [5] only propose simple heuristics to tackle this problem. Therefore, the goal of this project is to develop algorithms with performance guarantees (optimal or approximation).

The intern will be introduced to optimization techniques - dynamic programming, convex programming and combinatorial knapsack problems [6] useful for this project [7-8]. The intern will finalize its training by describing the work in a technical report. It is the objective to submit suitable technical contributions as future proposals and to summarize the most relevant results in a research paper, which can be submitted to a distinguished research conference or journal. It can also be considered as a preliminary work for a PhD program.

Tasks

- Review the state-of-the-art
- Design optimization method and schemes
- Implement new algorithms and performance simulations (e.g., using Matlab or Python)

Criteria skills

- Understanding mathematical optimization, combinatorial problems
- Algorithms performance and complexity analysis
- Programming: intermediate level in Matlab, Python or similar
- Interests in radio resource management is a definite plus
- Language: fluent English, we are in a multi-culture multi-language work environment

References

[1] Z. Ding, X. Lei, G. Karagiannidis, R. Schober, J. Yuan and V. Bhargava, "A Survey on non-orthogonal multiple access for 5G networks: Research challenges and future trends," IEEE JSAC, 2017.

[2] M. Shirvanimoghaddam, M. Dohler and S. J. Johnson, "Massive Non-Orthogonal Multiple Access for Cellular IoT: Potentials and Limitations," in IEEE Communications Magazine, vol. 55, no. 9, pp. 55-61, Sept. 2017.

[3] Ericsson, "NB-IoT: a sustainable technology for connecting billions of devices," Ericsson, Tech. Rep., April 2016.

[4] A. E. Mostafa, Y. Zhou and V. W. S. Wong, "Connectivity maximization for narrowband IoT systems with NOMA," in IEEE International Conference on Communications (ICC), 2017.

[5] W. Chen, H. Zhang, H. Ji, and X. Li, "Joint QoS-Aware Downlink and Resource Allocation for Throughput Maximization in Narrow-Band IoT with NOMA," in International Conference on Communications and Networking in China, 2018.

[6] H. Kellerer, U. Pferschy, and D. Pisinger, Knapsack problems, Springer, 2011.

[7] L. Salaun, M. Coupechoux, and C. S. Chen, "Weighted Sum-Rate Maximization in Multi-Carrier NOMA with Cellular Power Constraint," IEEE International Conference on Computer Communications (INFOCOM), 29 April 2019.

[8] Y. Fu, L. Salaun, C. W. Sung, and C. S. Chen, "Subcarrier and Power Allocation for the Downlink of Multicarrier NOMA Systems," IEEE Transactions on Vehicular Technology (TVT), 2018.