Tremplin Recherche ESIEE - IMT Nord Europe - PUC Rio, Brazil

Title: *Sustainable wireless communications via backscattering and energy harvesting*

Research lab: LIGM, MMSID team

Supervisor:
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National collaboration:
- Dr. Anne Savard, **IMT Nord Europe**

International collaboration:
- Prof. Rodrigo C. De Lamare, **PUC-Rio,** Rio de Janeiro, Brazil

Context: The energy consumption of the Information and communication technologies (ICT) sector - the backbone of our modern and digital society - has become a global and major issue. In this context, backscattering communications have attracted a lot of attention thanks to their ability to shape the wireless environment to increase network capacity in a sustainable manner [1-5]. Backscattering, as opposed to classical relaying, does not introduce additional electromagnetic waves, having thus zero added electromagnetic field exposure, and relies on low-cost and low-energy consumption devices (no RF active components), which can either send information by riding on the ambient RF signals or harvest their energy for operations. In our prior work, we have derived the fundamental rate regions achievable in a multi-user non-orthogonal multiple access (NOMA) network assisted by a backscatter device and then optimized its energy efficiency under minimum quality of service constraints [3]. We have also investigated multiple backscatter devices assuming that they do not send any information, but are in full cooperative mode [4,5].

Objectives: In this *tremplin recherche*, the main goal is to explicitly consider and optimize the harvesting capabilities of the backscattering device.
OBJ-1. Perform a literature review on backscatter-enhanced communication networks with energy harvesting capabilities, with a focus on resource optimization works.
OBJ-2. Investigate the resource optimization problem to maximize the energy-efficiency of a backscatter-enhanced multi-user communication under joint quality of service constraint and energy harvesting consideration. Derive efficient algorithms to solve the problem.

Requirements: The candidate should have a working knowledge on convex optimization (e.g., IGI 3013), and basic computer literacy skills (Python, MATLAB). Notions of wireless communications and machine learning are a definite plus.

Student level: Master 2 or E5
Potential ESIEE tracks: *Informatique, Datascience et intelligence artificielle, Systèmes embarqués, Systèmes électroniques intelligents, Génie industriel, Énergie, Artifcial Intelligence and Cybersecurity*

Possibility to continue with a 6-month PFE (Master 2 - level internship) at LIGM lab or IMT Nord Europe (funded by the PEPR 5G *Réseaux du Futur* project). The international mobility will depend on other available scholarships and funding.

References

[1] N. Van Huynh, D. T. Hoang, X. Lu, D. Niyato, P. Wang, and D. I. Kim, "Ambient backscatter communications: A contemporary survey" IEEE Commun. Surveys Tuts., vol. 20, no. 4, pp. 2889–2922, 2018.

[2] E.C. Strinati, et al., D-T. Phan-Huy, et al., "Reconfigurable, intelligent, and sustainable wireless environments for 6G smart connectivity", IEEE Communications Magazine, 2021, vol. 59, no 10, p. 99-105.

[3] H. El Hassani, **A. Savard, E.V. Belmega,** and **R. de Lamare**, "Multi-user downlink NOMA systems aided by an ambient backscatter device: achievable rate region and energy-efficiency maximization", IEEE Transactions on Green Communications and Networking, Mar. 2023.

[4] H. El Hassani, **A. Savard, E.V. Belmega,** and **R. de Lamare**, "Energy efficient solutions in two-user downlink NOMA systems aided by ambient backscattering", IEEE Globecom, Rio de Janeiro, Brazil, Dec. 2022.

[5] H. El Hassani, **A. Savard, E.V. Belmega,** and **R. de Lamare**, "Energy-efficient cooperative backscattering closed-form solution for NOMA", IEEE Globecom, Madrid, Spain, Dec. 2021.