PEPR 5G JEN - Post-doctoral candidate position

Sustainable wireless communications: low-energy, low-cost and zero added electromagnetic waves

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Collaborators: Rodrigo C. de Lamare (PUC-Rio, Rio de Janeiro, Brazil and Univ. of York, UK), Dinh-Thuy Phan Huy (Orange Chatillon)

1. Scientific context and objectives

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, jointly with **reconfigurable intelligent surfaces** (RIS), **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 [1-3,8,9]. 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 [4]. We have also investigated multiple backscatter devices assuming that they do not send any information, but are in full cooperative mode [5,6].

In this project, the main goal is to move towards multiple separate or joined backscattering devices, which form reflective intelligent surfaces (RIS), that can transmit their own information while enhancing the ambient wireless communications. Also, we will explicitly consider in our new models, and optimize, the harvesting capabilities of the backscattering/RIS devices. Thus, our main objectives are:

OBJ1. Derive the fundamental achievable Shannon rates in multi-user, multi-backscatter/RIS networks via **information theory**;
OBJ2. Develop efficient algorithms that jointly tune the transmit strategy (input covariance matrices, power allocation over the users and carriers) and the backscattering/RIS strategy (reflection coefficients, energy harvesting) via **machine learning** and optimization.

Two types of contributions are targeted within the two objectives: i) *fundamental:* derivation of information theoretical achievable Shannon rates when they are not readily available; ii) *algorithmic:* design of efficient optimization algorithms to tune the transmission strategies jointly with that of the backscattering/RIS devices. The obtained results will be published in top-tier international journals (IEEE Trans. on Wireless Commun, IEEE Trans. on Signal Processing, IEEE Trans. on Green Commun. and Networking) and international conferences (IEEE ICC, IEEE GLOBECOM, etc).

2. Research environment and opportunities

a. Funding, duration, salary

The **18 month post-doctoral** research project is funded within the **PEPR 5G** project on the *"Development of advanced technologies for 5G and future networks"* and within the JEN scope - *"Just Enough Networks".*

The candidate will receive a gross salary depending on their prior experience: for example a candidate having less than 3 years of experience after the PhD diploma will receive around 2875 euros gross per month. The postdoc duration can be further extended beyond the 18 months.

The PEPR 5G project budget includes further research related expenses such as: participation to international conferences, short mobilities, publication fees, laptop, etc.

b. *Advising team*

The hired candidate will be jointly advised by **E.V. Belmega** (UGE, ESIEE Paris) and **A. Savard** (IMT Nord Europe) and will collaborate with **Rodrigo C. de Lamare** (PUC-Rio, Rio de Janeiro, Brazil and Univ. of York, UK), who together combine the necessary expertise in information theory, wireless communications, MIMO systems, cooperative (relay, backscattering) networks, optimization and machine learning necessary to ensure the project's success.
Potential collaboration: **Dinh-Thuy Phan Huy** (Orange Chatillon) will be able to provide inputs regarding practical aspects of backscattering and RIS. Together with E.V. Belmega, she has co-Guest Edited the SI on IoT networks IEEE IoT Magazine, Dec. 2022 [7].

c. International collaborations

The advising team has fostered world-wide collaborations with researchers from prestigious universities, such as: PUC-Rio, Rio de Janeiro and Univ. São Paulo, Brazil; VirginiaTech and Princeton University, USA; University of Pisa, Italy; University of Oulu, Finland, etc. The candidate will have the opportunity to visit and collaborate with prestigious experts on backscattering and intelligent reflective surfaces for wireless communications.
In particular, as mentioned above the candidate will work with **Rodrigo C. De Lamare** and his research group at PUC-Rio, Rio de Janeiro, Brazil.

d. Main affiliation and campus

LIGM lab / ESIEE Paris (UGE)
The postdoc candidate will be affiliated to the *Laboratoire d'Informatique Gaspard Monge (LIGM)* research laboratory located on the Champs-sur-Marne Campus in the **Greater Paris** area, France (at 25 minutes by public transportation to **center Paris**, France).

The LIGM lab is conducting both theoretical and applied computer science, robotics, telecommunications, etc. LIGM is a mixed research unit (UMR 8049) of the Université Gustave Eiffel, CNRS and Ecole des Ponts ParisTech. LIGM is part of the LabEx (laboratory of excellence) at the interface between computer science and mathematics: "Bézout – Models and algorithms: from the discrete to the continuous" (http://labex-bezout.fr/).

Through the CNRS (the French National Center for Scientific Research) tutelle, the LIGM lab has access to all CNRS digital, admin and management, and other resources (Jean Zay supercomputer).

Through the tutelle of the Université Gustave Eiffel, first, the project team has access to the I-Site FUTURE "Inventing Cities of Tomorrow" (http://www.future-isite.fr/), offering regularly funding opportunities for mobility, etc.

In particular, the postdoc candidate will be assigned to **ESIEE Paris** (as E.V. Belmega), which is a member of the Université Gustave Eiffel and a **French Grande Ecole** of electrical engineering and computer science. This implies full access to IEEE Xplore and other online libraries, access to office spaces, workspaces, printing facilities, server clusters, VR laboratory, a microsystem cleanroom, an electronics equipment library 4.0 by Texas Instrument, local funding of small equipment, etc.

IMT Nord Europe
Secondary to LIGM lab and ESIEE Paris, the postdoc candidate will also be affiliated to the IMT Nord Europe, Lille (at 1h30 from center Paris by TGV).

IMT Nord Europe is a school under the supervision of the Ministry of the Economy and Finance, and is part of the Institut Mines Télécom. IMT Nord Europe has three main missions: to train responsible engineers capable of solving the major problems of the 21st century; to conduct research leading to high value-added innovations; to support the development of territories, in particular by facilitating innovation and business start-ups. Its objective is to train the engineers of tomorrow, mastering both digital technologies and industrial know-how.

The research activities related to this project will be performed within the Centre for Digital Systems of IMT Nord Europe. This center covers a wide range of applications related to constrained systems (IoT, Digital communications, Robotics), interactions between humans and the digital world, and complex systems through the lens of artificial intelligence and automation.

3. How to apply?

a. *Applicant requirements*

The applicants should hold a PhD degree (BAC+8) and have a strong background in either electrical engineering (with a focus on telecommunications and/or signal processing) or applied mathematics. A good English level in writing, reading and speaking is also required. Finally, having a strong mathematical background (analysis, probability and statistics, optimization, machine learning, etc.) and/or computer literacy skills (Python, C++, MatLab, etc.) is a definite plus.

b. Applications: will be received via the **online application form** below until the position is suitably filled.
NB: no applications will be received via email.

The application dossier should include: a short motivation letter (1 page max), an academic oriented CV (5 pages max), the PhD diploma (or proof of), the academic track records for the M.Sc. and B.Sc. (post-BAC) including rankings, Master diploma or equivalent, and two relevant reference letters.

Online application form: https://forms.gle/aukMHT3pzk4M4EjcA

Contact: anne.savard@imt-nord-europe.fr

c. Starting date: as soon as possible for a duration of 18 months, which can be further extended.

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.

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