Job offer – PhD in Wireless Communications
(*For non-French scientists only*)

Research Project Short Title as Submitted to CEFIPRA: STAR-RIS Assisted Beam forming and Beam Tracking for 6G Communication Systems
Principal Investigator contact: "Charlotte Langlais, IMT Atlantique, Nantes charlotte.langlais@imt-atlantique.fr"
Reference Number of the Job Offer: IFI_CEF_26_06

Project description

- **Keywords :** Simultaneously Transmitting and Reflecting Reconfigurable Intelligent Surface, Millimeter wave communications, Hardware impairments, 3D geometric Channel Modeling

- **Context : Millimeter wave (mmWave) communications** have emerged as a promising technology to meet the immense data rate required for future wireless networks by utilizing higher frequency bands. However, due to the extreme path loss, mmWave communications require costly and outrageous energy-consuming transceiver architectures, which is highly impractical. In this context, an energy-efficient **reconfigurable intelligent surfaces (RIS) based mmWave communication network** was established over the conventional power-hungry phased array-based transceiver architecture, even by considering blockage of line-of-sight link. RIS-assisted wireless communication attracted wider attention due to its lightweight, and low-cost deployment.

  In this context, researchers have explored **beamforming** techniques for RIS-based mmWave systems to compensate for the double path loss introduced by the RIS. Additionally, hybrid beamforming strategies need the joint optimization of RIS reflection coefficients (passive beamforming) and precoding/combining at both the base station (BS) and user equipment (UE) (active beamforming).

  Despite these advantages, conventional RIS is limited by its ability to only reflect signals, effectively serving users within a half-space and creating 'blind zones' on the opposite side of the surface. To overcome this spatial constraint, **Simultaneously Transmitting And Reflecting Reconfigurable Intelligent Surfaces (STAR-RIS)** have recently emerged as a more versatile paradigm. Unlike traditional reflective RIS, STAR-RIS elements can simultaneously support both signal transmission and reflection, thereby enabling **full-space coverage**. This dual-functionality introduces new degrees of freedom for **beamforming** and necessitates more sophisticated **beam tracking** algorithms, as the system must now dynamically manage interference and alignment for users located on both sides of the surface. Consequently, optimizing the STAR-RIS coefficients alongside the BS/UE precoders becomes essential to unlocking the full potential of ubiquitous 6G connectivity

- **Abstract of the Research Project :**

  Millimeter-wave communications are pivotal for achieving the high data rates envisioned for 6G networks. However, severe path loss and sensitivity to blockages necessitate energy-intensive transceiver architectures. While conventional Reconfigurable Intelligent Surfaces (RIS) offer a low-cost solution by reflecting signals, they are limited by 180° half-space coverage, creating significant dead zones. This research proposes the integration of Simultaneously Transmitting And Reflecting Reconfigurable Intelligent Surfaces (STAR-RIS) to overcome these spatial constraints. By enabling a 360° full-space coverage through the simultaneous manipulation of transmission and reflection coefficients, STAR-RIS provides a transformative paradigm for Smart Radio Environments, ensuring seamless connectivity for users regardless of their location relative to the surface.

  The primary objective of this project is to develop advanced beamforming and beam tracking strategies tailored for STAR-RIS assisted mmWave systems. We will first establish a rigorous 3D geometric stochastic channel model that incorporates practical hardware limitations and non-ideal phase-shift behaviors. Based on this framework, we will design joint

optimization algorithms to align active precoding at the base station with the passive STAR-RIS coefficients. Furthermore, we will investigate dynamic beam tracking protocols to maintain high-gain links for mobile users transitioning between reflection and transmission zones. The anticipated results aim to demonstrate significantly enhanced spectral efficiency, robust mobility management, and superior coverage reliability, establishing STAR-RIS as a cornerstone technology for the next generation of wireless communication systems.

- **Scientific Objectives of the Project :**

The proposed approach is to address the crucial aspects in the beamforming and beam management in the 6G systems. In particular, the proposal aims to integrate STAR-RIS in the next generation mmWave communication systems. Specifically, the objectives of the proposal are summarized as:

- **Modeling under Realistic Constraints**: To develop a comprehensive simulation framework for STAR-RIS-assisted mmWave systems that incorporates non-ideal hardware effects. This includes modeling phase-shift errors, amplitude-phase coupling, and the hardware limitations such as practical reflection models.
- **Optimization of Beam Management Architectures**: To design and evaluate advanced 360° beamforming, beam tracking, and beam management protocols. This objective focuses on the joint optimization of active precoding at the Base Station and passive transmission/reflection coefficients at the STAR-RIS.
- **Advanced Stochastic Channel Modeling**: To conduct a rigorous study of 3D geometric stochastic channel models**,** specifically tailored for STAR-RIS. This involves extending existing mmWave channel models to account for the unique spherical wave propagation, near-field effects, and the distinct beam patterns generated by the simultaneous transmission and reflection properties of the surface.

- **Methodology and Timeline of the Project**

The detailed list of research activities which will be carried out and the corresponding timeline are discussed below.

- **T0-T0+12** State of the art: Study of existing hybrid beamforming for conventional RIS, study of existing 3D geometric (deterministic or stochastic) channel model incorporating STAR-RIS, work environment setup, code development in MATLAB and analysis of state-of-the-art algorithms performance.
- **T0+6-T0+18** Integrating phase-shift errors and hardware impairments into the simulation environment, Design of joint optimization algorithms for the BS active precoder and the STAR-RIS passive coefficients, advanced beam tracking strategies, valorization of first results in Conferences.
- **T0+12-T0+24** Developing algorithms to track users moving between the "Reflection" and "Transmission" zones, redaction of a paper review.
- **T0+18-T0+30** Robust Beamforming under Uncertainty (partial channel state information, information of location only), Multi-STAR-RIS scenarios, redaction of a journal paper
- **T0+30-T0+36** Redaction of PhD thesis.

Candidate profile

- Candidates can be all nationalities except French. In case of double nationality (French and another one), the candidate is not eligible. In the context of CEFIPRA, Indian candidates are preferred
- Applicants for PhD must have a master's degree (or be in the process of obtaining one) or have a University degree equivalent to a European Master's (5-year duration) to be eligible at the time of the deadline of the call
- No competences in French language is required
- Candidate competences: software development, mathematical analysis
- Candidate know-how: digital communications, wireless communications.
- Expected starting date: 01/07/2026
- Expected duration: 36 months

How to candidate ?

Documents to be provided :

i. A cover letter (reasons for the candidature, professional project …) max 2 pages
ii. A copy of the master's degree or a proof of the program followed (and expected date of end) OR A copy of the PhD degree or a proof of the PhD program followed (and expected date of defense) max 1 page
iii. A copy of results for previous scholarship (max 3 pages)
iv. International curriculum vitae (max 2 pages)
v. One letter of recommendation from any Indian institution –mandatory- (max 2 pages)
vi. All should be submitted within 1 pdf file of no more than 10 pages.

Applications must be submitted through this Google Form selecting the appropriate reference number for the job offer.

Research Project Title : STAR-RIS Assisted Beam forming and Beam Tracking for 6G Communication Systems

Candidates are requested to contact the French scientific principal investigator of the project before submission. A recommendation letter from the scientific principal investigator is mandatory.

Benefits:

- Monthly allowance of 1870 euros for PhD
- Travel allowance
- University fee
- Carte de séjour fee
- Campus France management fee
- Registration to the French social security scheme

Selection process:

The final selection is made by a dedicated selection committee of scientific experts after a pre-selection phase by the French principal investigator. Decisions will be transmitted by the Embassy of France to CEFIPRA.

Criteria for applicants' selection:

Academic excellence

- Excellence of the Academic background, Academic records, Honors, Letters of support, Participation to international research projects, exchange programmes and conferences.

Motivation and qualities

- Academic maturity: appropriation of the thesis project (stakes and contexts)
- Quality of the presentation (oral expression, skills for synthesis, English level)
- Maturity of the professional project: capacity to project her/himself within five years in terms of career development.

About CEFIPRA:
Indo-French Center for the Promotion of Advanced Research (CEFIPRA/IFCPAR) is an Indian body which promotes scientific cooperation between France and India in advanced fields of Science and Technology. It is supported by the Department of Science and Technology, Government of India and the Ministry of Europe and Foreign Affairs of the French government