

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

Research Project Short Title as Submitted to CEFIPRA: “AI Enabled IRS Assisted Beam forming and Beam Tracking for 6G Communication Systems”

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Reference Number of the Job Offer: IFI_CEF_25_07

Project description

- **Keywords:** Reconfigurable intelligent surface, Millimeter wave communications, Channel estimation, Deep learning, Channel modelling
- **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 **hybrid precoding** techniques for RIS-based mmWave systems and integrated **non-orthogonal multiple access (NOMA)** to enhance spectral efficiency. Additionally, hybrid beamforming strategies for multiuser mmWave communications have been investigated, along with the joint optimization of RIS reflection coefficients and hybrid precoding/combining at both the base station (BS) and user equipment (UE). Moreover, studies have examined the impact of **double RIS** configurations in improving spectrum efficiency for multiuser networks at mmWave frequencies. Despite these advancements, one of the critical challenges remains **channel acquisition** for RIS-assisted systems. To address this, deep learning-based signal processing techniques have been developed to facilitate efficient channel estimation with minimal training overhead.

- **Abstract of the Research Project:** Modern wireless communication systems rely heavily on multiple antennas and their corresponding signal processing to achieve optimal performance, in terms of spectral efficiency and multiple access management. As 5G and 6G networks emerge, beamforming and beam management become increasingly complex due to factors such as user mobility, a higher number of antennas, and the adoption of elevated frequencies. Artificial intelligence, specifically machine learning, offers a valuable solution to mitigate this complexity and minimize the overhead associated with beam management and selection, all while maintaining system performance. Despite growing interest in AI-assisted beamforming, beam management, and selection, a comprehensive collection of datasets and benchmarks remains scarce. On the other hand, smart radio environments are of great interest in the future wireless networks, where the wireless environments can be tuned favorable for propagation with the help of reconfigurable intelligent reflecting surfaces (RIS). In this project, we investigate and leverage the smart wireless environments and beamforming with RIS and beam management with the aid of AI and machine learning. Furthermore, identifying the most-suitable algorithm for a given scenario remains an open question. Hence, the PhD thesis aims to address the following: i) Challenges in beamforming and beam management that can be aided with sophisticated AI techniques. ii) Investigation of the techniques suitable for beamforming and management, iii) Composition of relevant data sets, modelling and simulation, iv) Suitable numerical simulations and demonstrations to validate the algorithms.

- **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 RIS in the next generation mmWave communication systems. Specifically, the objectives of the proposal are summarized as:
 - Incorporating practical channel conditions and hardware limitations in the simulation of RIS-assisted mmWave communication systems.
 - Amendable AI techniques for RIS-assisted beamforming, beam tracking and beam management in 6G systems.
 - Detailed study of 3D geometry stochastic channel modelling and beam patterns of mmWave communications, and their extension to encompass IRS and
 - Learning with limited datasets available by introducing suitable probabilistic models and new data set generation with 3D channel profiling.

The proposal aims to employ machine learning techniques and to develop an adaptive machine learning framework to solve the power optimization problems with transmission rate constraints.
- **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 beamforming, spatial multiplexing and coding techniques for mmWave bands, work environment setup, code development in MATLAB and analysis of SoA algorithms performance.
 - T0+6-T0+18 Beam forming, beam training and steering the beams, algorithms and code development in MATLAB.
 - T0+12-T0+24 Data set generation and collection for various beam training design codebooks, channel models, and time varying statistical parameters, valorization of first results in Conferences
 - T0+18-T0+30 IRS placement, distributed deployment, optimization of phase shifts, power allocation strategies, redaction of a paper review
 - T0+24-T0+36 Redaction of PhD thesis, redaction of a journal paper.

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: 01/09/2025
- 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. Two letters of recommendation: one from any Indian institution and one from the French institution planned to host the candidate –mandatory- (max 2 pages)
- vi. All should be submitted within 1 pdf file of no more than 10 pages.

Applications should be submitted to the following email address: msi@ifindia.in mentioning the reference number of the Job offer clearly.

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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 1790 euros for PhD
- Travel allowance
- University fee
- Carte de séjour fee
- Campus France management fee
- Registration to the French social security scheme

Selection process:

Selection is made by a dedicated selection committee of at least 4 persons. Decisions will be transmitted by the Embassy of France to CEFIPRA. **No consideration will be given for candidates with no recommendation letter from the French institution.**

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