Offer #2025-08828

Post-Doctoral Research Visit F/M Downlink Optimization for Robust Direct-to-Satellite LoRaWAN

Contract type : Fixed-term contract

Level of qualifications required : PhD or equivalent

Fonction : Post-Doctoral Research Visit

Level of experience : From 3 to 5 years

About the research centre or Inria department

The Inria research centre in Lyon is the 9th Inria research centre, formally created in January 2022. It brings together approximately 320 people in 19 research teams and research support services.

Its staff are distributed in Villeurbanne, Lyon Gerland, and Saint-Etienne.

The Lyon centre is active in the fields of software, distributed and high-performance computing, embedded systems, quantum computing and privacy in the digital world, but also in digital health and computational biology.

Context

About the centre

The postdoctoral position at Inria's AGORA research group, located at the La Doua Campus in Lyon, offers a unique opportunity to collaborate with esteemed experts such as Dr. Juan Fraire, Dr. Oana Iova, and Prof. Hervé Rivano. The appointee will

use advanced software tools like FloRaSat, an Omnet++-based DtS-IoT simulator, enhancing their expertise in space communication systems and wireless sensor networks. This role is enriched by AGORA's strong international and academic-industrial collaborations. This position is a gateway to cutting-edge research and professional growth in IoT, space networking, and Internet technologies in general.

Context

Every year, Inria’s International Relations Department (DRI) has a few postdoctoral positions to support Inria's international collaborations. The postdoctoral contract will have a duration of 12 to 24 months. The default start date is November 1st, 2025, and not later than January 1st, 2026. One of the Inria Centres in France will recruit the postdoctoral fellow. Still, it is recommended that the time be shared between France and the partner country, in this case, the Universidade Federal de Santa Catarina in Brazil. Please note that the postdoctoral fellow has to start his/her contract in France and that the visits must respect Inria rules for missions.

Eligibility Conditions

Candidates for postdoctoral positions are recruited after the end of their Ph.D. or after a first post-doctoral period: for the candidates who obtained their PhD in the Northern hemisphere, the date of the Ph.D. defense shall be later than September 1, 2022; in the Southern hemisphere, later than April 1, 2022. To encourage mobility, the postdoctoral position must occur in a scientific environment that is genuinely different from the Ph.D. (and, if applicable, from the position held since the Ph.D.); particular attention is thus paid to French or international candidates who obtained their doctorate abroad.

Assignment

Context

The emerging paradigm of Direct-to-Satellite Internet of Things (DtS-IoT) represents a significant advancement in linking terrestrial Low-Power Wide Area Network (LPWAN) technologies with Low-Earth Orbit (LEO) satellites. Through this new paradigm, IoT devices communicate using well-established terrestrial technologies such as LoRaWAN to transmit data directly to satellites, even without ground infrastructure. DtS-IoT enables efficient and seamless connectivity for global-scale applications such as international asset tracking, cross-border environmental monitoring, and global data collection and distribution. DtS-IoT also facilitates the development of applications in remote regions that would otherwise be challenging to cover with low-cost terrestrial IoT connectivity, like oceanic monitoring and remote agriculture.

While LPWAN technologies such as LoRaWAN suit DtS-IoT connectivity, existing prototypes and validations have predominantly emphasized data uplink

communication (from end devices to satellites); however, downlink communication (from satellites to end devices) is of the utmost importance for ensuring robust data communication and user access to all the deployed end devices. This includes acknowledging successfully received uplink data. Data flows from the Internet to ground devices through the LEO satellite network in these cases. Additionally, the downlink channel enables the LoRaWAN network and application servers to utilize a control channel to remotely configure end devices and operate actuators via the DtS-IoT network. This postdoc is focused on proposing and testing efficient downlink techniques within the DtS-IoT landscape, utilizing LEO satellite networks, and addressing the constraints of IoT communications in space.

Assignment

In the DtS-IoT context, the unique challenges associated with LoRaWAN's downlink are multi-faceted. On the one hand, they involve the challenging selection of suitable downlinking gateways (situated onboard the LEO satellites) that minimize the number of transmissions to end devices with overlapping reception windows and coverage. On the other hand, once a LEO satellite is selected, intricate scheduling follows for each downlink packet to be forwarded across high-latency, low data rate, cross-linked, and multi-hop LEO networks to multiple LoRaWAN devices.

Addressing these challenges requires developing specialized and customized solutions across several layers of the DtS-IoT network stack, physical layer models, MAC algorithms, network optimization, and satellite scheduling methods. The proposed solutions could be based on offline and online optimization and machine learning approaches to schedule downlink messages to prevent overlap, assure optimal channel conditions, and ensure seamless, reliable, and efficient communication between remote IoT devices and the space core network connected to the Internet.

Collaboration

Dr. Juan Fraire and Dr. Oana Iova actively collaborate with Prof. Richard Demo Souza from Universidade Federal de Santa Catarina (UFSC) in Brazil on the topic of Direct-to-Satellite Internet of Things convergence, also supported by a STIC AmSud project recently acquired by Inria and UFSC.

References

- Fraire, Juan A., Oana Iova, and Fabrice Valois. "Space-terrestrial integrated Internet of Things: Challenges and opportunities." IEEE Communications Magazine 60, no. 12 (2022): 64-70.
- Fraire, Juan A., Pablo Madoery, Mehdi Ait Mesbah, Oana Iova, and Fabrice Valois. "Simulating lora-based direct-to-satellite IoT networks with FloraSat." In 2022 IEEE 23rd International Symposium on a World of Wireless, Mobile and Multimedia Networks (WoWMoM), pp. 464-470. IEEE, 2022.
- Tondo, Felipe Augusto, Jean Michel de Souza Sant'Ana, Samuel Montejo-Sánchez, Onel Luis Alcaraz López, Sandra Céspedes, and Richard Demo Souza. "Non-Orthogonal Multiple-Access Strategies for Direct-to-Satellite IoT Networks." arXiv preprint arXiv:2409.02748 (2024).

- Ron, Dara, Chan-Jae Lee, Kisong Lee, Hyun-Ho Choi, and Jung-Ryun Lee. "Performance analysis and optimization of downlink transmission in LoRaWAN class B mode." IEEE Internet of Things Journal 7, no. 8 (2020): 7836-7847.
- Abboud, Samira, Nancy El Rachkidy, Alexandre Guitton, and Haidar Safa. "Gateway selection for downlink communication in LoRaWAN." In 2019 IEEE Wireless Communications and Networking Conference (WCNC), pp. 1-6. IEEE, 2019.

Main activities

1. **Comprehensive Literature Review**

- Survey state-of-the-art techniques in DtS-IoT, LoRaWAN downlink mechanisms, satellite scheduling, and network optimization methods.
- Identify current limitations and research gaps specific to downlink performance and scalability.

2. **Model Development**

- Explore energy-aware, latency-constrained, and multi-hop-aware strategies for robust downlink delivery.
- Design and implement simulation, analytical, optimization (exact or heuristic), and/or machine learning models to address gateway selection and downlink scheduling in DtS-IoT systems.

3. **Definition of Performance Metrics and Tooling**

- Define relevant performance indicators (e.g., delivery ratio, delay, energy consumption, fairness) for downlink communication in realistic satellite scenarios.
- Develop and implement the software tools to evaluate these metrics through simulation or analytical frameworks.

4. **Simulation Campaigns and Data Analysis**

- Execute large-scale simulation campaigns using realistic satellite constellation configurations.
- Collect, organize, and analyze the resulting data to evaluate the proposed downlink strategies under diverse traffic and coverage conditions.

5. **Dissemination of Results**

- Write detailed technical reports and documentation describing the developed methods, tools, and findings.
- Prepare and submit high-quality papers to international conferences and journals in satellite communications, IoT, and networking (e.g., IEEE ICC, GLOBECOM, TCOM, CN, IoTJ).

Skills

The ideal candidate for this postdoctoral position holds a PhD in Computer Science, Electrical or Telecommunications Engineering, or a related field, with a solid foundation in wireless networking, satellite communications, or LPWAN technologies such as LoRaWAN. Proficiency in programming—particularly in Python and C++—is expected, along with experience in simulation environments (e.g., OMNeT++, NS-3) or in developing optimization and machine learning models. A firm grasp of mathematical modeling, performance evaluation, and network protocol design is highly desirable. Fluency in English is essential for effective collaboration and dissemination, while knowledge of French or Portuguese is advantageous but not required. The candidate should demonstrate a proactive, self-driven attitude and the ability to work independently and as part of an international, interdisciplinary team.

Benefits package

- Subsidized meals
- Partial reimbursement of public transport costs
- Leave: 7 weeks of annual leave + 10 extra days off due to RTT (statutory reduction in working hours) + possibility of exceptional leave (sick children, moving home, etc.)
- Possibility of teleworking (90 days / year) and flexible organization of working hours Social, cultural and sports events and activities
- Access to vocational training
- Social security coverage under conditions

Remuneration

2788 € gross salary / month

General Information

- **Theme/Domain :** Networks and Telecommunications
  System & Networks (BAP E)
- **Town/city :** Villeurbanne
- **Inria Center :** Centre Inria de Lyon
- **Starting date :** 2025-11-01
- **Duration of contract :** 2 years
- **Deadline to apply :** 2025-05-18

Contacts

- **Inria Team :** AGORA
- **Recruiter :**
  Fraire Juan Andres / juan.fraire@inria.fr

About Inria

Inria is the French national research institute dedicated to digital science and technology. It employs 2,600 people. Its 200 agile project teams, generally run jointly with academic partners, include more than 3,500 scientists and engineers working to meet the challenges of digital technology, often at the interface with other disciplines. The Institute also employs numerous talents in over forty different professions. 900 research support staff contribute to the preparation and development of scientific and entrepreneurial projects that have a worldwide impact.

The keys to success

We seek a highly motivated and technically skilled postdoctoral researcher with a strong interest in emerging paradigms at the intersection of satellite communications and the Internet of Things (IoT). The ideal candidate will demonstrate intellectual curiosity, creativity, and a drive to tackle complex, multi-layered challenges in space-based networking. A solid foundation in wireless communications or computer networks, combined with hands-on experience in programming and performance evaluation, is essential. The candidate should be comfortable working in interdisciplinary and international teams and show strong initiative, adaptability, and scientific rigor. Excellent written and oral communication skills are essential for engaging collaborators and disseminating results.

Warning : you must enter your e-mail address in order to save your application to Inria. Applications must be submitted online on the Inria website. Processing of applications sent from other channels is not guaranteed.

Instruction to apply

Applications must be submitted online via the Inria website. Processing of applications submitted via other channels is not guaranteed.

Defence Security :
This position is likely to be situated in a restricted area (ZRR), as defined in Decree

No. 2011-1425 relating to the protection of national scientific and technical potential (PPST).Authorisation to enter an area is granted by the director of the unit, following a favourable Ministerial decision, as defined in the decree of 3 July 2012 relating to the PPST. An unfavourable Ministerial decision in respect of a position situated in a ZRR would result in the cancellation of the appointment.

Recruitment Policy :
As part of its diversity policy, all Inria positions are accessible to people with disabilities.