Offer #2024-08015

PhD Position F/M Analyzing full life cycle of IoT based 5G solutions for smart agriculture

**Contract type:** Fixed-term contract  
**Level of qualifications required:** Graduate degree or equivalent  
**Function:** PhD Position

**About the research centre or Inria department**

The Inria University of Lille centre, created in 2008, employs 360 people including 305 scientists in 15 research teams. Recognised for its strong involvement in the socio-economic development of the Hauts-de-France region, the Inria University of Lille centre pursues a close relationship with large companies and SMEs. By promoting synergies between researchers and industrialists, Inria participates in the transfer of skills and expertise in digital technologies and provides access to the best European and international research for the benefit of innovation and companies, particularly in the region. For more than 10 years, the Inria University of Lille centre has been located at the heart of Lille's university and scientific ecosystem, as well as at the heart of FrenchTech, with a technology showroom based on Avenue de Bretagne in Lille, on the Euratechnologies site of economic excellence dedicated to information and communication technologies (ICT).

**Context**

Internet of Things (IoT) technologies, combined with Artificial Intelligence (AI), autonomy, and connectivity, are propelling the phenomena of smart agriculture. AI-powered IoT systems can support agriculture by helping farmers save precious resources such as water, and reduce employed workforce thus increasing resource efficiency. Wireless sensor networks (WSNs) can provide monitoring systems capable of automatically assessing the physical conditions of plants, soil, crop and farm animals. Therefore, smart agriculture is a powerful ally that can make agriculture practices more efficient, accurate, and controlled.

The impact of digital pollution on the planet has grown strongly in the last few years (Shift Project report [1]). Therefore, deploying IoT products and AI solutions in agriculture need to be conducted in a responsible manner in order to be energy efficient and to minimize digital pollution. Energy Efficiency in IoT-based agriculture is a new research field [2] [5] [11] [12].

Although software and communication protocols aim to reduce the energy consumption of infrastructures and that the data collected could allow for a reduced environmental impact thanks to this accurate monitoring, the manufacturing, the usage and the end of life of the devices themselves, of their battery and the full infrastructure they use (e.g., 5G core network) also consumes energy and generate environmental impacts. There is thus a tremendous need for a study of the global environmental cost including all aspects of the IoT in smart agricultural systems [6] against the environmental gain it brings. This global environmental cost should encompass the full lifecycle of the devices (sensors) from their design to their end of life for different agricultural applications and services. We will study such a systemic view, enriched by measurements on real platforms. This study will allow the life cycle analysis of 5G-based IoT solutions for smart agriculture and could allow some comparisons with other networking technologies. To this aim, we will first enumerate all different phases of this life cycle and identify all related components (e.g., the individual sensors but also each part of the infrastructure), flows and inter-dependencies. From it, each phase will be weighted to assess its environmental cost and gain, alone and in its position in the chain. The evaluation of the energy consumption will be done through experimental measurements when possible and combined with manufacturers specs.

This position is funded in the framework of the PEPR 5G Networks of the Future - Just Enough Networks (NoF-JEN). It is a collaboration between the Inria AVALON team in Lyon, the Inria FUN team and AIVANCITY (engineering school in IA and computer science) located in Paris. It will be co-supervised by Doreid Ammar, Laurent Lefevre and Nathalie Mitton.

**Assignment**

This research proposal aims, on one hand, to deeply explore resources (energy, bandwidth, memory, computing) usage efficiency for such systems and, on the other hand, to propose AI-powered frugal solutions. More precisely, the potential of software intelligence (like AI) in controlling and reducing the extensive hardware infrastructures used in smart farming and agriculture [8] will be studied.
Furthermore, the optimization of the overall environmental footprint over all lifecycle of WSNs systems will be investigated, including manufacturing, transportation and end of life (eg recycling, degradation, etc). This is the approach that will be explored in this research project, by proposing software and energy-efficient systems in smart agriculture, and limited AI and resources models and solutions as some substitutes to classical IoT smart infrastructures.

**Main activities**

In this perspective, this research project aims at:

1. modeling and developing innovative, frugal, energy and resource efficient systems capable of increasing farmers’ competitiveness, resource efficiency, animal well-being, preventing plant and farm animal diseases and reducing strenuousness by means of IoT and AI. These systems collect measurable parameters, such as temperature, humidity, soil moisture, farm animal activities using the IoT components. The collected data is then cleaned and used in the learning process in order to build intelligent models capable of helping farmers in their daily tasks. For instance, AI can help by automatically assessing the health and threat status of farm animals, tackling plant diseases, providing a judicious use of water resources, and much more. Such AI-powered environments require some features that need to be explored such as energy efficiency due to some limited available energy budget, resilience, large scale communications, end to end orchestration of data streams and services, etc.

2. design a dynamic WSNs which optimizes the overall environmental footprint of such a system over its all lifecycle. The data collected from Wireless sensor networks can be sent over different communication technologies (e.g., LoRa, SigFox, LTE, NB-IoT, 5G, etc.), potentially combining them to achieve the best energy efficiency possible for a given type of applications without jeopardizing the expected performances. For instance, for small monitoring delay-tolerant data, LoRa can be selected. But when the amount of data is huge or the application requires high throughput and/or bounded delays and jitters (e.g., video, images, etc.), 5G communications might be the only option.

3. embracing digital frugality to the developed solution by exploring, once more, the use of AI to limit the number of digital components that are usually deployed massively in traditional IoT infrastructures. This phase ensures a good compromise between the number of electronics deployed and the performance of the AI models.

The main goals of this project are:

- Provide an overview of the current AI and IoT technologies deployed in smart agriculture with a focus on communication technologies and protocols, the generation and analysis of data, AI models and IoT architectures.
- Design an energy efficient IoT architecture consisting of physical objects, network and application layer. The physical objects (sensors and actuators) sense and collect relevant data. The network layer communicates the data to a gateway (or proxy server) to the internet (cloud) by means of communication protocols. Finally, the application layer stores and provides access to the processed data.
- Define the IoT setup and computing techniques (e.g., fog and edge computing) and make use of an efficient data flow strategy (sensing, communication/transfer, storage, processing, analytics, and actuation and display).
- Explore and develop some frugal machine learning and deep learning algorithms able to deal with multiple data flows generated by the IoT systems (from energy, multimedia, CPU, network sensors).
- Design a sustainable, autonomous, and energy efficient AI-powered IoT systems for organic agriculture.
- Explore the need to reduce IoT hardware infrastructures by partially (or totally) substituting them by software frugal AI systems and study its impact on the performance of the deployed AI models.
- Simulate and design federation of AI-powered organic agriculture systems for large scale energy efficient use of resources (coordination, service sharing, load balancing, etc.).

**Skills**

- Knowledge in wireless networks (technologies, routing protocols, etc) and edge computing
- Skills in Simulation tools and development
- Skills in C/C++ and python
- English speaking
- Autonomy and curiosity
- Open minded
- Team working
- Capacity to write English reports and papers
- Sense of organization, autonomy, rigor

**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 and flexible organization of working hours
- Professional equipment available (videoconferencing, loan of computer equipment, etc.)
- Social, cultural and sports events and activities
General Information

- **Theme/Domain**: Networks and Telecommunications
  System & Networks (BAP E)
- **Town/city**: Villeneuve d'Ascq ou Lyon
- **Inria Center**: Centre Inria de l'Université de Lille
- **Starting date**: 2024-10-01
- **Duration of contract**: 3 years
- **Deadline to apply**: 2024-09-02

Contacts

- **Inria Team**: FUN
- **PhD Supervisor**: Mitton Nathalie / Nathalie.Mitton@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 are looking for a candidate that owns a Master in computer science, who is creative in proposing solutions and capable of critical analysis of results. We demand the student:

1. to be curious and interested in new technologies
2. to have appetite for environment concerns
3. to have a strong background in IoT and wireless sensor networks
4. to have excellent skills in scripting and programming (e.g., python, C/C++, Java) as well as previous experience with simulation tools
5. to be fluent in spoken and written English with strong communication and presentation skills
6. Experience with energy-efficient data collection, resource management for wireless networks is considered a plus

**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

Please send us your CV and cover letter.

**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.