



**Offer #2025-08563**

## **M2 Internship - AI-based proactive scheduling for IoT data streams**

**Contract type :** Internship agreement

**Level of qualifications required :** Master's or equivalent

**Fonction :** Internship Research

### **Context**

The MIMOVE team at Inria Paris undertakes research enabling next-generation distributed systems, from their conception and design to their runtime support, focusing on middleware and data. MIMOVE has longstanding expertise in mobile and service-oriented computing, semantic technologies, interoperability, system emergence and evolution, and edge/fog computing. We work on these topics through many national and international collaborations with academia and industry, including large-scale software development of real-world systems. MIMOVE's research results impact various application domains; we focus in particular on the application areas of IoT and smart cities.

The selected candidate will be supervised by Maroua Bahri ([maroua.bahri@lip6.fr](mailto:maroua.bahri@lip6.fr)) and Nikolaos Georgantas ([nikolaos.georgantas@inria.fr](mailto:nikolaos.georgantas@inria.fr)).

### **Assignment**

Data Stream Processing and Analytics (DSPA) applications are widely used to process unbounded data streams generated online at different rates from multiple geographically distributed data sources, such as mobile IoT devices, sensors, etc. These data streams require to be processed with low latency guarantees to extract valuable information in a timely manner via a series of continuous operators that constitute a DSPA application.

The edge-fog-cloud continuum deployment approach enables benefits from both lower network delays and balanced bandwidth usage and resources along the continuum. To this end, it requires deciding which part of the DSPA application to deploy on each of the layers in order to ensure the trade-off between the aforementioned advantages. Several deployment solutions have been proposed in the literature that statically identify (near) optimal deployment schemes of DSPA applications which are typically long-running with varying workloads conditions over time [1,2]. To keep consistent Quality of Service (QoS) levels (e.g., latency, energy, network constraints) in the face of such varying conditions, the static deployment scheme may no longer be sufficient. This requires a solution for triggering and calculating dynamically a new deployment scheme from the current deployed DSPA application in order to continuously ensure the required QoS levels [3,4]. Actually, dynamic deployment should be triggered at the right time: triggering it too late will violate the QoS requirements while triggering it too early will impose unnecessary load on the edge-fog-cloud resources and may result in a solution that diverges from the (near) optimal solution.

### **Main activities**

The internship focuses on enhancing DSPA applications through predictive methods for proactive triggering and optimized scheduling mechanisms across the edge-fog-cloud continuum to maintain consistent QoS requirements. The proactive approaches will leverage AI-based methods over historical and real-time system and application metrics data to forecast operator and execution environment changes, enabling dynamic adaptation of operator scheduling [5].

Key objectives include: design of an intelligent triggering strategy to initiate dynamic redeployment, predictive scheduling for proactive adjustments to operator deployments, and validation of the proposed scheduling method to ensure QoS metrics. This work aims to ensure optimal resource usage and performance in highly dynamic environments while maintaining a balance between proactive adjustments and minimal disruption to operations.

#### **References:**

[1] P. Ntumba, N. Georgantas, and V. Christophides, "Efficient scheduling of streaming operators for IoT edge analytics" in FMEC, 2021.

[2] P. Ntumba, N. Georgantas, V. Christophides, "Scheduling Continuous Operators for IoT edge Analytics with Time Constraints" SMARTCOMP 2022: 78-85.

[3] P. Ntumba, N. Georgantas, V. Christophides. "Adaptive Scheduling of Continuous Operators for IoT Edge Analytics". Future Gener. Comput. Syst. 158: 277-293 (2024).

[4] H. Arkian, "Resource management for data stream processing in geo-distributed environments," Ph.D. dissertation, Université de Rennes 1, 2021.

[5] Z. Zhong, M. Xu, M. A. Rodriguez, C. Xu, and R. Buyya, "Machine learning-based orchestration of containers: A taxonomy and future directions," ACM Computing Surveys (CSUR), 2022.

## Skills

- Master level research internship (M2) or equivalent (stage de fin d'études ingénieur).
- Sound knowledge of machine learning, distributed systems, and edge-fog-cloud computing.
- Software development skills: Python and Java.
- Good level of spoken and written English which is our working language. French is not required.

## 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
- Access to vocational training
- Social security coverage

## General Information

- **Theme/Domain** : Distributed Systems and middleware System & Networks (BAP E)
- **Town/city** : Paris
- **Inria Center** : [Centre Inria de Paris](#)
- **Starting date** : 2025-03-01
- **Duration of contract** : 6 months
- **Deadline to apply** : 2025-02-16

## Contacts

- **Inria Team** : [MIMOVE](#)
- **Recruiter** :  
Georgantas Nikolaos / [Nikolaos.Georgantas@inria.fr](mailto:Nikolaos.Georgantas@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.

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## Instruction to apply

### 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.