

INTERNATIONAL RELATIONS



INTERNSHIP SUBJECT

2883 - Downlink Communication in Satellite - Internet of Things

This work will occur in the Inria Agora research team in Lyon, within the framework of the DORSAL-IoT Associated Team between Inria Agora, Universidad de Chile, and Pontificia Universidad Católica de Chile. The internship student will be supervised by Dr. Oana Iova (Inria Agora) and work closely with Dr. Miguel Gutiérrez Gaitán (Pontificia Universidad Católica de Chile).

Keywords: LoRa, LoRaWAN, Internet of Things (IoT), Low-Power Wide Area Networks (LPWAN), satellite communication, Medium Access Control (MAC).

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 [1] to transmit data directly to satellites, even without ground infrastructure [2]. 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.

Assignment

While uplink communication (from end devices to satellites) has been successfully demonstrated in multiple deployments, downlink communication (from satellites to end devices) remains a challenge in DtS-IoT due to intermittent satellite visibility, strict receive window timing, and limited onboard resources [3]. Today's downlink mechanism in LoRaWAN can only handle terrestrial communication and is not adapted for satellite environments. This internship aims to propose a downlink scheduling mechanism that minimizes the number of transmissions to end devices with overlapping reception windows and coverage. The proposed solution needs to select the best LEO satellite for each packet transmission, while accounting for the high-latency, low data rate, cross-linked, and multi-hop LEO communication.

The student will have to:

- Familiarize with the LoRa, LR-FHSS, and LoRaWAN technologies.
- Study the latest state-of-the-art in DtS-IoT communication and downlink IoT scheduling.
- Propose a scheduling mechanism for downlink packets in DtS-IoT that will respect the delay constraints.
- Familiarize itself with the FLoRaSat (performance evaluation simulator for DtS-IoT developed in the Inria Agora team) [4] to implement the proposed scheduling mechanism for evaluation.
- Perform performance evaluation campaigns within case study scenarios using the newly implemented channel model, incorporating LEO satellites and ground nodes. Analyze the collected data, draw insights from the findings, and compile a report.

Bibliography:

[1] LoRa Alliance, LoRaWAN 1.1 Specification, 2017.

[2] J. A. Fraire, O. Iova, and F. Valois, Space-Terrestrial Integrated Internet of Things: Challenges and Opportunities, in IEEE Communications Magazine, vol. 60, no. 12, pp. 64-70, 2022.

[3] C. Christelle, A. Guitton, O. Iova, and F. Valois, The Impact of Downlink Scheduling Policy on the Capacity of LoRaWAN, in IEEE Global Communications Conference (GLOBECOM), 2024.

[4] FLoRaSat simulator: <https://gitlab.inria.fr/fraire/florasat>

Required Skills

We encourage applications from students pursuing a Computer Science or Computer Engineering degree. Practical proficiency with programming languages (C/C++ and Python) is desirable. A solid understanding of mathematics and wireless networking is also preferred. Applicants must have fluency in English; proficiency in French is not a prerequisite but would be advantageous. We are seeking candidates who are empathetic, proactive, and self-motivated.

General Information

- **Research Theme :** Networks and Telecommunications
- **Locality :** Villeurbanne
- **Level :** Master
- **Period :** 2nd March 2026 -> 29th May 2026 (3 months)

 *These are approximative dates. Please contact the training supervisor to know the precise period.*

- **Deadline to apply :** 1st July 2025 (midnight)

Contacts

- **Training Supervisor :** Oana-teodora Iova / oana.iova@inria.fr
- **Team Manager :** Herve Rivano / herve.rivano@inria.fr

More information

- **Inria Team :** AGORA
- **Inria Center :** Centre Inria de Lyon