## PFE/M2R: Routing and Scheduling in LoRa satellite constellation

Internship place :	LIG (Laboratoire	Duration:	From february
	Informatique de Grenoble)		~6 months
Supervised by:	Olivier ALPHAND		
	(Drakkar) and Didier		
	DONSEZ (Erods)		
Profile:	M2 student + $3^{rd}$ year	Contact :	Stipend: ~550€/month for
	Engineer	alphand@imag.fr	35h/week (see simulateur service
			public)

<u>Keywords</u> : cubesat, new space, satellite constellation, LoRa, networking, routing, MAC scheduling <u>Context</u> :

In the <u>ThingSat</u> project, LIG lab has an ongoing mission aboard the cubesat STORK-1 (<u>https://www.n2yo.com/satellite/?s=51087</u>) in orbit since January 2022. This internship aims to prepare future ThingSat missions by studying the use of Low Earth Orbit (LEO) satellite constellation to transfer data from/to IoT (Internet of Things) devices located in areas where terrestrial connectivity is not existing. Such projects are possible because of two recent revolutions: the cubesat revolution (miniaturized satellite) in space and the LPWAN revolution (Low-power and Long-Range IoT network) on Earth. And, now for a few years, the convergence between satellite and IoT is accelerating.

One of the most widespread terrestrial IoT technology is currently LoRa which is cheap, low-power and long range. And there are great expectations from this technology in the satellite context. The typical scenario is :

- to bring connectivity to thousands of LoRa end-devices on ground
- through a partial constellation of 16 LEO satellites (acting as LoRa gateways in the sky) with intersatellite links
- by routing the packets among the satellites in order to reach their destination (a cloud server centralizing all the data for instance).

Why do we need routing and several satellites ? The fact is that LEO satellite only has a 1000-km diameter footprint and, at a 500-km altitude circular orbit, a satellite is only visible during 5 min over a geographical area for one pass we can have up to 4 passes per day on the same area).

To give you a rough idea, Figure 1 and Figure 2 at the end of the document gives respectively (i) an example of a satellite constellation and (ii) the main characteristics of a LEO satellite in such networks

## **Internship** :

In this internship, we especially want to focus on the study of the routing protocol and its interaction with scheduling algorithms. We need to be able to schedule the emission of IoT devices on ground so that they do not overlap which would lead to collisions. For that purpose, we will use a network simulator FLORASAT<sup>1</sup> [1] that integrates

- propagators results like STK<sup>2</sup> to determine the position of satellites
- routing protocols based on Contact Graph Routing (CGR) dedicated to partial constellation of satellites
- as well as an implementation of the LoRa physical and link layers

You will

- do the state of the art of scheduling algorithms and particularities of such SatIoT (Satellite for IoT) networks [2-3]
- get familiar with FloRaSat [1] and other additional tools like STK
- do a proposal to enhance scheduling
- and evaluate it

Expected skills : C++/C, TCP/IP networking, git, ...

## How to apply :\_

Send an email to alphand@imag.fr and didier.donsez@univ-grenoble-alpes.fr with your CV, a short text describing your motivation, and the M1 academic transcript (or 2nd year engineering school).

[1] Fraire, Juan A., et al. "Simulating LoRa-Based Direct-to-Satellite IoT Networks with FLoRaSat." 2022 IEEE 23rd International Symposium on a World of Wireless, Mobile and Multimedia Networks (WoWMoM). IEEE, 2022.

[2] J. A. Fraire, O. De Jonckère, and S. C. Burleigh, "Routing in the Space Internet: A contact graph routing tutorial," *Journal of Network and Computer Applications*, vol. 174, p. 102884, Jan. 2021

[3] Afhamisis, Mohammad, and Maria Rita Palattella. "SALSA: A Scheduling Algorithm for LoRa to LEO Satellites." IEEE Access 10 (2022)

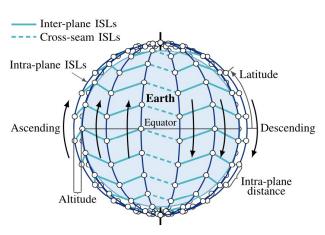


FIGURE 2. Diagram of a Walker star LEO constellation with the established intra- and inter-plane (including cross-seam) ISLs.



Figure 1: (a) full constellation, (b) partial constellation

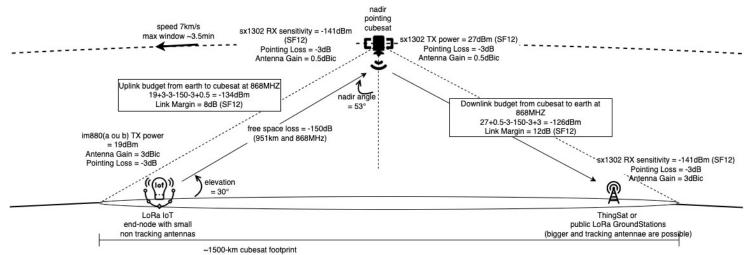


Figure 2 : typical orbital and communication characteristics of a LEO SatIoT satellite