



PFE/M2R: Routing and Scheduling in LoRa satellite constellation

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

Keywords : cubesat, new space, satellite constellation, LoRa, networking, routing, MAC scheduling

Context :

In the [ThingSat](#) project, LIG lab has an ongoing mission aboard the cubesat STORK-1 (<https://www.n2yo.com/satellite/?s=51087>) 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 inter-satellite 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 FLORASAT¹ [1] that integrates

- propagators results like STK² 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

¹<https://gitlab.inria.fr/jfraire/florasat>

²<https://www.agi.com/products/stk>

