Optimized Performance and Transmission Techniques for Next Generation Satellite Communication Networks

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Context:

With the rise of Internet-of-Things (IoT) applications and the need for massive connectivity, future 6G networks should meet the demands for the global access to high-speed Internet [1]. One of the envisaged solutions consists in deploying non-terrestrial networks such as networks of satellites or microsatellites in the low Earth orbit (LEO). Such satellites have a much lower manufacturing and launch costs than the traditional satellites, such as those placed in the geostationary orbit. Such very high-throughput satellite (VHTS) networks will be able to meet the future substantial data traffic requirements [1,2]. The specificity of these satellites (or microsatellites) is that they have limited capacities and resources (energy, computing, etc.). However, they are more flexible in terms of resource management, such as power and bandwidth allocation. Another particularity of such networks is the irregular distribution of users (on the Ground) and the variability of connections and, therefore, the data traffic over time. This calls for energy efficient and high-speed connectivity solutions for inter-satellite and satellite-to-ground links. In particular, the use of laser communications or free-space optics (FSO) technology promises high rate and secure data transmission over very large distances [3].

For transmission links to users, radio frequency links are used with a multi-beam approach in order to minimize interference. Figure 1 illustrates an example of satellite links with an FSO backbone [4]. Also, Fig.2 shows the FSO links between the LEO microsatellites for a Starlink type constellation, for example [5].

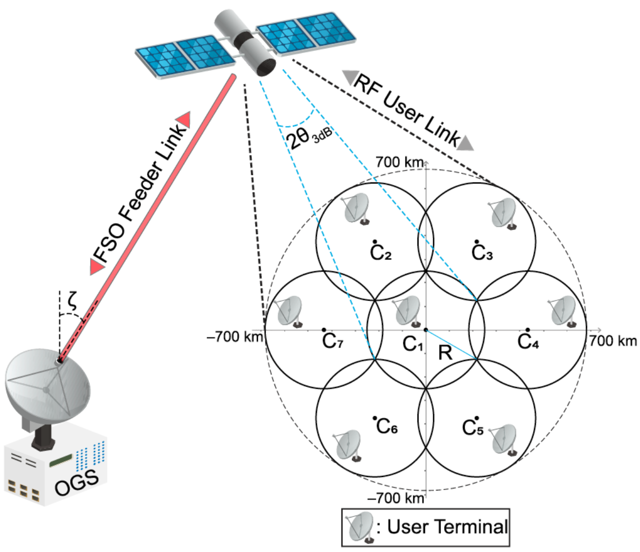

Fig.1. Architecture of a multi-beam satellite network with an FSO backbone connection [4].

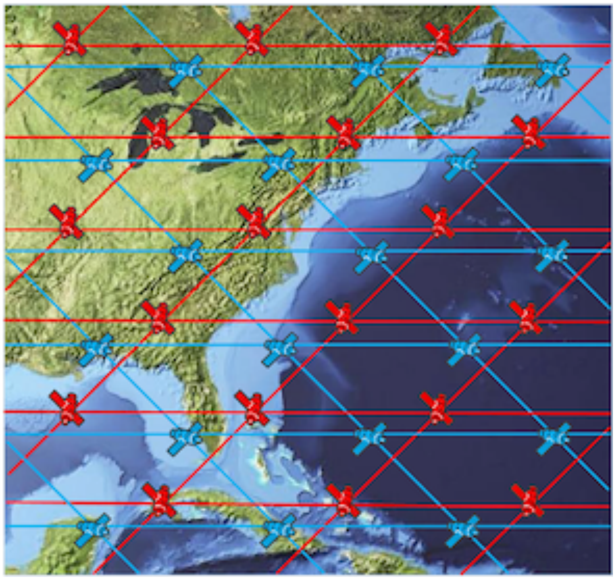

Fig.2 : Intersatellite FSO links in a LEO constellation ensuring a universal coverage [5].

Thesis objectives:

In practice, the establishment of such links is associated with several challenges in terms of **(a)** link availability/reliability and **(b)** resource management at the satellite. Indeed, the irregular distribution of users (on the Ground) and the variability of data traffic during the day appeal for the design of efficient architectures with flexible resource allocation according to the requested traffic [6].

(a) The first objective is to propose advanced transmission techniques to establish high-speed communication links with high-reliability between microsatellites or between a microsatellite and a Ground station [7]. These solutions must in particular take into account the atmospheric channel and the vibrations of the payloads, which can cause significant pointing errors (i.e., misalignment between the transmitter and the receiver) [4]. This first step includes the modeling of optical communication channels and will be carried out in collaboration with the University of Edinburgh.

(b) In a second step, machine learning-based mechanisms will be designed for performing automated resource allocation in order to increase the capacity of satellite-Earth links [8-9]. This will exploit the flexibility of microsatellites in terms of resource management, such as power and bandwidth allocation.

Collaborations

This PhD thesis will be carried out in close collaboration with researchers of the Universities of Edinburgh (Scotland) and Alto (Finland) with planned short-term stays in the partner research labs. It will also benefit from an international collaboration network on space communications within the framework of the COST Action CA19111 NEWFOCUS, coordinated by the Fresnel Institute, as well as with regular exchanges with our industrial partners.

Required Skills :

A solid background in signal processing is an important asset. An experience or training in optics and/or digital communications is also very welcome. The candidate **must** have a very good English language proficiency (oral and written expression) and be keen for short-term stays in partner laboratories.

References:

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