SCHEDULING ALGORITHM FOR A GROUND STATION NETWORK DEDICATED TO SMALL SATELLITES

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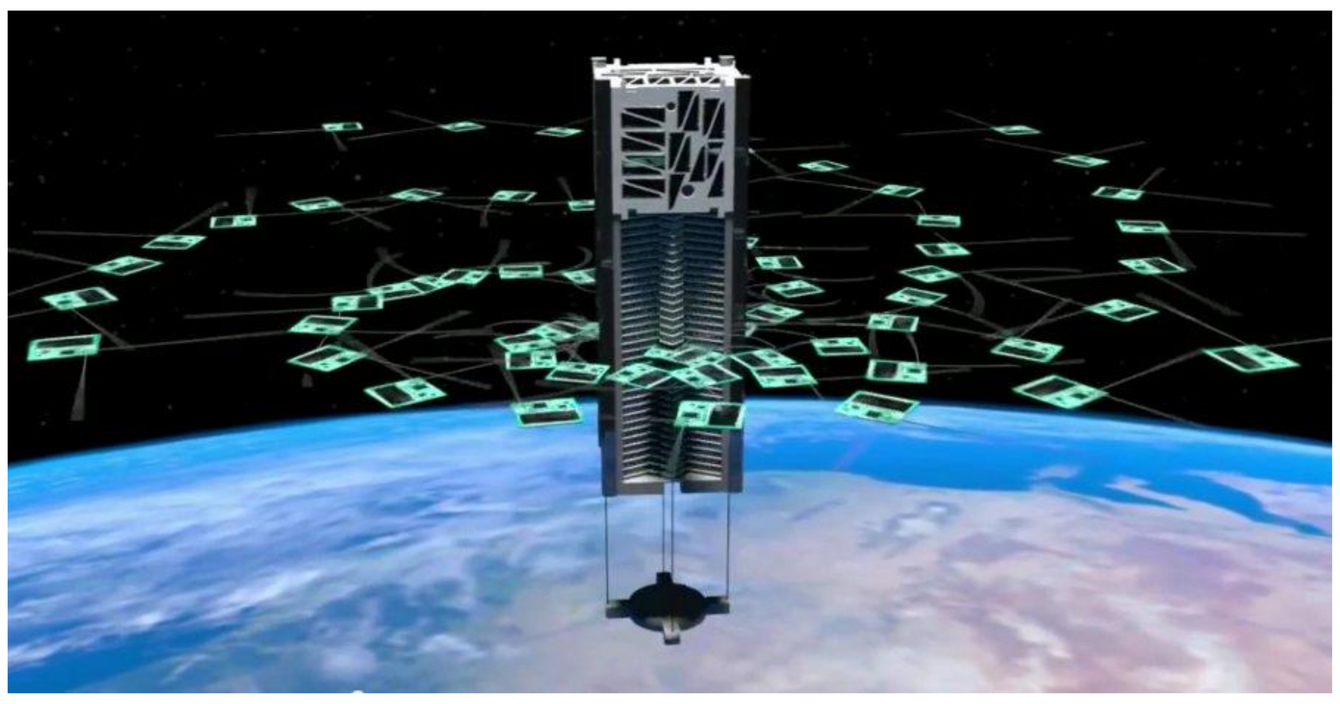
MOTIVATION

Current small satellites developers face the challenges of complex communication systems and the restrictions of inadequate ground stations infrastructure. The missions and capabilities of these satellites, including the downlink of science and telemetry data, are limited by monolithic designs, narrow interfaces, reliability issues, and high mission costs. In addition, ground stations are often built for a single mission or institution, resulting in an underutilization of ground station capabilities. For example, potential beneficiaries are the CubeSat developers, a community of worldwide universities, corporations, and government laboratories who perform space science and exploration using miniaturized satellites.



OBJECTIVE

The goal is to develop a robust optimization algorithm for multi-satellite missions, using a tailored network of ground stations, developed by Leaf Space, an Italian start-up based in Milan. The work aim is to develop a planning approach for the automatic allocation of contacts between a specific network of ground stations and any collection of satellites, in order to find the most effective arrangement of conflict-free visibilities, to maximize performances while accounting for technical and commercial requirements given by Leaf Space.

ALGORITHM APPROACH

The problem of managing contacts among one or more antennae, with one or more space missions (each of them being composed by one or more satellites) often leads to the temporal superimposition of two or more satellite visibilities toward the same antenna: all but one visibilities must be discarded, but the right solution is not always trivial to find.

In a typical schedule, each of the satellites that have access to a certain Ground Station has a number of Data Downlink Opportunities (DDOs) assigned. Some of the contacts may be conflict-free, while others may lead to conflicts, that require proper actions to be avoided. A classical scenario is shown in Fig. 1, where some of the time overlapping DDOs are evidenced.

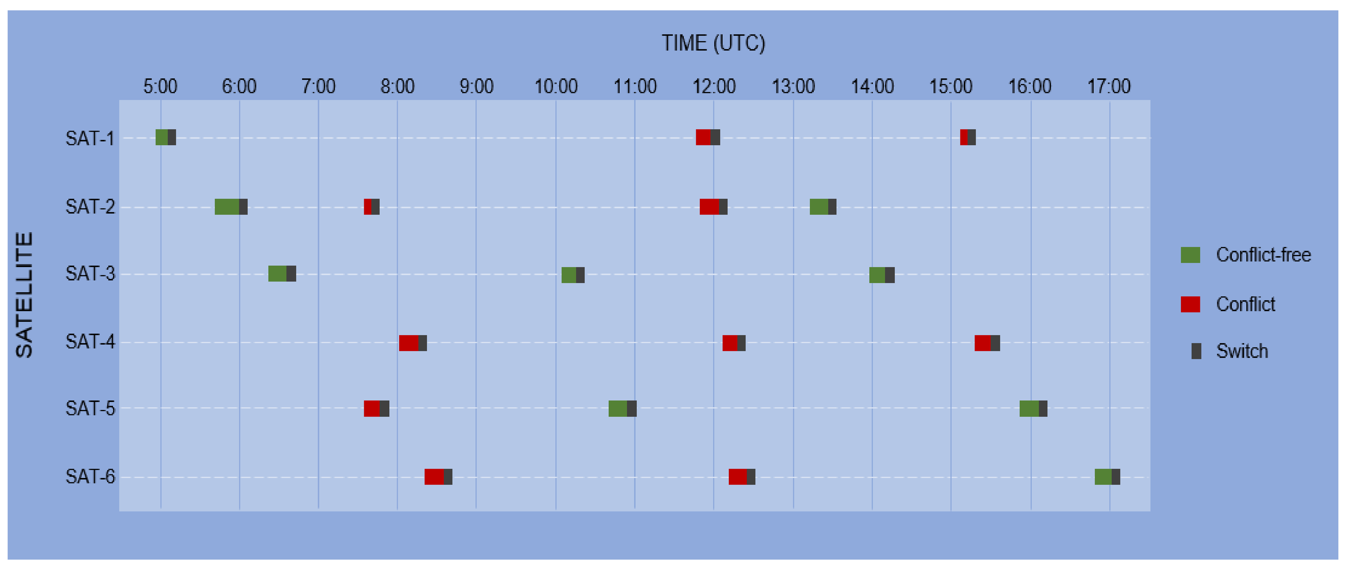


Fig. 1 – DDOs typical schedule

PRELIMINARY RESULTS

The optimization techniques herein presented make use of Gas (Genetic Algorithms), Graph Theory (GT) and Linear Programming (LP) to get an optimal, or near-optimal, solution to the scheduling problem: combining those strategies in a single tool allows to determine an highly fitted and conflict-free resource allocation plan.

The final schedule shows how all the requirements have been satisfied, thanks to the optimization tool. No clashing services are now present, as confirmed by the Gantt diagram in Fig. 2. The proposed algorithm assesses complex situations in a very rapid manner, and gives an optimal (or near optimal) solution, by supplying a strongly fitted schedule that provides maximization of revenues (when the satellite contacts are sold to third parties), optimal handling of antenna duty cycle, and assessment of Ground Station location (during the design phase). The algorithm can be easily extended to more than one ground station.

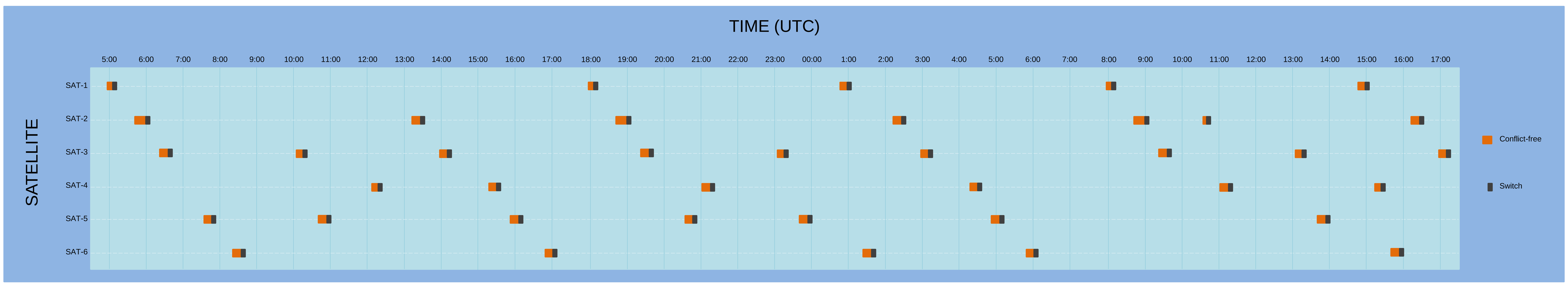


Fig. 2 – Gantt diagram without conflicts

STUDENT CONTRIBUTION

Jonata Puglia is currently doing his MScEng at the Politecnico di Milano. His masters thesis, in collaboration with Leaf Space, deals with developing the complete scheduling algorithm described above. He obtained his BEng in Aerospace from the same university.

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