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AUTOMATED CONSTELLATION MANAGEMENT WITH SELF-REGULATING DATA-ECONOMIC ACTORS

Abstract

The space industry is undergoing fundamental shifts in paradigms: From few, large satellite buses to many small satellites; from one ground station to many ground stations, from manual telemetry review to an automated treatment; from long in-orbit lifetimes to shorter periods. At the same time, the announcement of large constellations with several thousand active satellites, are challenging the way spacecraft are operated today, conventionally one-by-one per satellite.

Effective management of large fleets of satellites demands for a holistic system view of the constellation. It requires advances in automation strategy for the planning, commanding and execution of recurring, day-to-day tasks. The paper presents a self-regulating method for the scheduling problem of pass allocation on the basis of a data economic concept, in which satellites and ground-based antennas are modeled as dynamic actors in an auction system. On-board payload data is assigned with a certain value which represents the currency. Contact windows, in which satellites can download their data to the ground are regarded as resource. The satellites can place bids on predicted contact possibilities in order to downlink the data and generate reward. This auction-based approach together with a space environment simulator for satellite constellations was implemented as a proof-of-concept.

The study covers a range of constellation sizes from 40 to 1080 satellites, thus demonstrates the scalability of the approach. It evaluates the results with selected metrics, such as the total amount of downloaded data or contact frequency of the individual satellites. It shows that the implemented distributed auction-based scheduling approach can overcome limitations and it is possible to automate the constellation operation with this approach.