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PREDICTIVE ALGORITHMS TO ASSESS INTER-SATELLITE LINKS AVAILABILITY IN AUTONOMOUS SATELLITE NETWORKS

Abstract

Low Earth Orbit (LEO) Satellite Networks aim at satisfying the current low-latency and high resolution user demand. This architecture was proposed at the beginning of the 90's, although it has been just recently that they re-gained popularity, thanks to Mega-Constellation projects. This kind of network is characterized by having mobile nodes that follow a well-known deterministic orbit trajectory. This mobility pattern makes physical links between two adjacent satellites, called Inter-Satellite Link (ISL), evolve over time. Therefore, an ISL is identified by a lifetime in which the communication is active. The ISL changes provoke that a satellite network topology is represented by a set of snapshots, each one showing the active ISLs at certain time. In this scenario, the determination of a route (i.e. a set of ISLs) between distant satellites is a challenging problem.

Some proposals have addressed this challenge by determining a satellite constellation as a mesh network (e.g. Iridium constellation), in which each satellite has four ISLs with its neighbor nodes. This solution directly depends on the satellite constellation architecture, limiting the number of possible applications. On the other hand, other researchers addressed the problem improving the routing protocol using the deterministic trajectory. This protocol is the responsible to determine the routes between satellites. For instance, the Predictable Link-State Routing (PLSR) protocol aims at predicting the evolution of the routes by pre-computation the snapshot sequence using the ground facilities. The routes are then uploaded into the satellites to be operatives. This non-scalable solution is ground dependent and thus with high impact in the operations cost of the mission.

Alternatively, the Internet of Satellites (IoSat) paradigm proposes the autonomous deployment of Inter-Satellite Networks without pre-assuming any specific architecture. Following this concept, and the fact that the satellite trajectory is deterministic, the present work proposes an algorithm by which a satellite identifies other neighbor satellites, and predicts when an ISL will be established between them. To achieve this solution, an ISL has been modeled as a "close approach" between two satellites at certain time. This scenario has largely been studied in the satellite collision or debris field. Therefore, a new algorithm has been created to predict ISLs which extend the current Probability of Close Approach (PCA) of two satellites techniques. In addition to the algorithm definition, the presented work also compares the performance of different PCA techniques. Results demonstrate its feasibility and the benefits in real satellite constellations.