Paper ID: 83061
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IAF SPACE SYSTEMS SYMPOSIUM (D1)
Cooperative Systems (4)

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DELAY TOLERANT NETWORKING PROTOCOLS APPLIED TO PROLIFERATED SATELLITE CONSTELLATIONS

Abstract

This paper applies Delay Tolerant Networking (DTN) protocols to large-scale heterogenous networks containing hundreds of spacecraft, from multiple satellite constellations. In such proliferated constellations DTN protocols are necessary to enable the extraction of actionable insights to the improvement of service delivery and availability of critical space-based capabilities.

Low Earth Orbit (LEO) satellite constellations typically communicate with only their own ground-based infrastructure during intermittent contact opportunities. This restricts the data routing opportunities within the system causing significant delay and disruption challenges. By increasing connectivity, new opportunities for communication and data routing are created to overcome these challenges. Inter-satellite links (ISL), an emerging technology in LEO, enables the transfer of data between spacecraft. Using ISLs to build on the concept of altitude-bounded orbital shells, a model is developed in which LEO satellites and ground stations are modelled as agents traversing nested orbital surfaces or “shells”. The interactions between these agents on different shells are used to generate a contact plan forming a unified network. The DTN algorithm Contact Graph Routing (CGR) is then implemented to route data through the contact plan of the time-varying network enabling the assessment of viable routes to ensure optimal service delivery. CGR has only previously been implemented on networks containing tens of satellites to simulate a standard constellation. This paper applies CGR to networks on a scale of thousands of heterogenous satellites, representing a proliferated space architecture, and ground targets to show the improvements to service metrics such as data latency and packet-loss; analogous to the expected orbital environment should current launch trends continue.

LEO is at its most accessible in history. Thousands of new satellites are launched each year creating an orbital environment that is becoming increasingly congested with many different stakeholders, often deploying large constellations of satellites. Modelling the Earths orbital environment as a single heterogeneous system of systems, through which data can be routed using DTN protocols, allows the analysis of interactions between constellations at a large scale. This model shows that cooperation between stakeholders separated by institutional and/or trust boundaries will allow critical data from a broad range of use cases to transfer in real-time to target destinations beyond line-of-sight without reliance upon one constellation topology. Delivering measurable improvement to a wide range of critical global applications such as weather monitoring and disaster relief will empower a shift towards a more cooperative and sustainable space ecosystem.