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CONFIGURATION AND MONITORING ACROSS DELAY-TOLERANT LINKS: ROBUST MANAGEMENT OF SPACE INTERNETWORKS

Abstract

Systems with relative motion between space and ground segments suffer link disruptions from occultation, attenuation, and unpredictable environmental interference. Those systems that operate over interplanetary distances further incur round-trip signal propagation delays that may last longer than the contact period between spacecraft. The Consultative Committee for Space Data Systems (CCSDS) is standardizing a set of protocols to provide packetized internetworking services that tolerate the delays and disruptions in these systems. The collective term for these technologies is "Delay-Tolerant Networking" (DTN).

The migration of space communications away from point-to-point streaming models toward an internetworked model enables the construction of a cost-saving, re-usable infrastructure amongst existing and future space assets. The operational deployment of such a model requires the ability to dynamically manage these assets as network components, even when such components are not in contact with a ground operations center. Such a capability requires a new model for configuration and monitoring based on pre-configuration and autonomy.

This paper presents the Delay-Tolerant Network Management Protocol (DTNMP) that is proposed for standardization within the CCSDS to monitor and control assets over challenged links. The DTNMP is designed around four desirable properties: (1) the intelligent push of information through the network, (2) low messaging overhead, (3) detailed data identification, and (4) compatibility with existing terrestrial management protocols. A reference implementation of DTNMP has been implemented to work with the NASA Interplanetary Overlay Network (ION) flight software suite of DTN protocols and utilities.

We illustrate the system-level challenges of management over challenged links, showcase unique aspects of the DTNMP design and syntax, and present key use cases supporting both ground and space segments. Results of the DTNMP implementation in ION are presented to demonstrate the feasibility of open-loop configuration and standardized autonomous configuration in a variety of disconnected scenarios.

We conclude that the re-use benefit of a multi-space-agency network is, in part, predicated upon the ability to construct an international standard for the management of space assets as networked devices. Such a standard must consider best practices from both flight software systems and terrestrial management perspectives. The DTNMP and our reference implementation in a flight-ready software distribution demonstrate the feasibility of this approach for the management of assets without significant changes to existing command and data handling operations.