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Author: Mr. Edward Birrane
The Johns Hopkins University Applied Physics Laboratory, United States

Mr. R. Lee Pitts
MSFC, United States
Ms. Samantha Jacobs
Johns Hopkins University Applied Physics Laboratory, United States

PACKETIZED SPACE NETWORK MANAGEMENT WITH APPLICATION TO THE INTERNATIONAL SPACE STATION

Abstract

NASA is investigating Delay Tolerant Networking (DTN) to increase network bandwidth and resiliency through packetized, multi-path data communications. Path variety in the network, and the resultant increase in data volume, requires new management techniques for mission operations centers. Mechanisms managing the terrestrial Internet fail to scale with delays and disruption and lack the autonomy to adjust for long periods of disconnection from network operators. The Delay Tolerant Network Management Protocol (DTNMP), in development by NASA, addresses these limitations in a way that supports both near-Earth and interplanetary space internetworks. DTNMP introduces unique concepts that must be validated by the network architects and mission operators who must ultimately support its adoption in existing networks.

DTNMP enables monitoring and configuration in scenarios such as low-rate communications, unidirectional links, and asynchronous operation. It allows operators to configure rule-based responses to predefined conditions. This network-level autonomy reduces cognitive load for mission operations and provides constant management of devices, even when not in contact with the ground. A reference implementation of DTNMP, released by NASA as open-source, validates technical portions of the specification and is used to assess the logistics of incorporating packet-based management into operational architectures.

NASA seeks to deploy DTNMP to platforms such as the International Space Station (ISS) as a necessary step to raise the technology readiness level of the software implementation. NASA also seeks to leverage the lessons learned from these test deployments to refine the specification as it undergoes standardization in the Consultative Committee for Space Data Systems (CCSDS).

This paper presents work to implement, test, and analyze portions of the DTNMP specification in the context of the ISS. We provide an architecture for incorporating this protocol and discuss key differences between packetized and streaming link management for space networks. We discuss prototype visualizations for the command and configuration of DTNMP-enabled flight software and present the design of our initial deployment of this capability through a distributed mission operations center consisting of computers from the NASA Jet Propulsion Laboratory (JPL), the NASA Goddard Space Flight Center (GSFC), and the Johns Hopkins University Applied Physics Laboratory (JHU/APL).

We confirm the technical function of the DTNMP and conclude that its deployment to operation centers is feasible and discuss how to adapt standing operational concepts to this paradigm. We provide a roadmap for utilizing DTNMP on DTN machines planned for deployment to the ISS in 2014 and 2015.