SMALL SATELLITE MISSIONS SYMPOSIUM (B4)
Space Systems and Architectures Featuring Cross-Platform Compatibility (7)

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

Mr. Christopher Krupiarz
The Johns Hopkins University Applied Physics Laboratory, United States

FROM SCIENCE TO SCIENTIST:
BUILDING AN INSTRUMENT TO SCIENCE OPERATIONS CENTER OVERLAY

Abstract

Spacecraft instrument data traverses a varied path to its eventual destination in a Science Operations Center (SOC). Initially, data are captured at the instrument, transferred over an internal connection to a spacecraft computer, telemetered through one or more hops in a space segment, and received at one or more ground stations. Once on the ground, data is ferried to a Mission Operations Center (MOC), sometimes to an Instrument Operations Center (IOC), and ultimately to the destination SOC. Each network boundary presents unique challenges in the areas of security, quality of service, and management. This process introduces significant latency between the construction of data on the instrument and its availability to scientists at the SOC. Further, the need for software to understand the individual needs of each constituent network in the data path increases the cost of engineering and testing application software and the cost of manually inspecting data over the course of the mission.

Reducing latency and administrative cost requires several architectural advancements over the current state of the art in space systems, including multi-path transmission, automatic re-transmission of data, interoperability between ground systems, and network protocols that work over "air-gaps". The most promising solution to this problem is the use of a delay-tolerant network (DTN) overlay. An overlay network provides a homogenized view of data in cases where multiple, heterogeneous, underlying networks are necessary for transmission. DTNs provide store-and-forward messaging services that can span networks exhibiting significant delays and disruptions, including the need to air-gap data across permanently disconnected networks such as a flight operations network. Specifically, the Bundle Protocol (BP) is an overlay protocol that implements DTN concepts over a varied set of terrestrial and flight transmission protocols.

This paper presents a BP overlay encompassing networks involved in the transmission of instrument science to the SOC. Analysis of security and management concerns along the data path, including physical disconnection of operational networks from the Internet, is presented. Additionally this paper describes the manner in which the BP reduces mission cost (in both flight and ground software), enables multi-path routing through the confederated network, and provides a standardization mechanism through which ground systems may cooperate in data exchange. A unifying concept of operations is proposed. Ultimately, it is concluded that DTN protocols uniquely enable missions to construct largely automated, secure paths from spacecraft instruments to SOCs and that this overlay concept reduces software development and mission operations costs.