Paper ID: 13372
oral

SPACE SYSTEMS SYMPOSIUM (D1)
Lessons Learned in Space Systems (5)

Author: Mr. Alan Mick
The John Hopkins University Applied Physics Laboratory, United States, Alan.Mick@jhuapl.edu

MODELING AND SIMULATION OF THE SOLAR PROBE PLUS SPACEWIRE VIRTUAL DATA BUS

Abstract

The Solar Probe Plus (SPP) mission will explore the Sun's corona, one of the last unexplored regions of the solar system. The spacecraft will carry a complement of instruments closer to the Sun than any spacecraft has ever ventured. The mission concept calls for a minimum perihelion of 9.5 solar radii over an extended campaign of in-situ and simultaneous remote observations.

To meet the power, mass, fault management and electromagnetic interference constraints of the mission, the SPP spacecraft architecture uses SpaceWire as the primary data communication interface. SpaceWire has been widely used for payload data-handling and includes many desirable features, such as integrated time code distribution, more than adequate through put, and a flexible network configuration that supports the SPP avionics architecture. The avionics applications require timely, deterministic data delivery; to meet these requirements a "virtual spacecraft bus" was developed over the SpaceWire network using time divisions based on the SpaceWire time codes and the SpaceWire Remote Memory Access Protocol as a transport layer. This allows the primary CDH processor to serve as the "bus controller" and schedule transactions in order to achieve the required response times and throughput in a deterministic manner.

In order to design and verify the "virtual bus schedule", a discrete event model was developed using an open-source simulator. A router component was created that models the characteristic SpaceWire wormhole routing. SpaceWire protocol overheads and scheduling inefficiencies were accounted for dynamically producing more realistic results than could be obtained through a static, analytical process. Various operational modes (e.g., data collection during encounter or downlinking science from the mass storage) were simulated and shuffled into "what if" scenarios. Link rates, data rates and response times were altered to perform margin analysis and optimization. This iterative modeling helped to develop and validate the virtual bus transaction schedule, and will aid in further refining it as the SPP design progresses. It is anticipated that the model will be useful for designing and refining system and integration tests, and will help to understand and predict spacecraft behavior in advance.

This paper describes the SPP SpaceWire architecture in detail with a focus on the use of discrete event modeling and realistic simulations of the protocols and transaction schedule to validate and refine the concept of a virtual data bus that meets the through-put requirements of the science payload as well as the deterministic requirements of the avionic control functions.