21st IAA SYMPOSIUM ON SMALL SATELLITE MISSIONS (B4)
Space Systems and Architectures Featuring Cross-Platform Compatibility (7A)

Author: Mr. Radim Badsi
OpenCube, France, radim@badsi.info

TELEMETRY DISTRIBUTION SYSTEM FOR HETEROGENEOUS NANOSATELLITE CONSTELLATIONS

Abstract

Similarly to their space counterpart, ground segments of nanosatellite missions are highly heterogeneous in terms of both architecture and technologies. Much of the data processing is often performed using ad-hoc solutions varying from spreadsheets to custom-made data analysis systems. However, the benefits of harmonisation, such as lower cost and higher reliability, are known to nanosatellite designers. There is a significant push to adopt off-the-shelf Mission Control Systems, as is already the case for larger spacecraft. Nevertheless, switching to a complete off-the-shelf standard solution is unrealistic for many missions due to their specific requirements that can only be met with custom ground segment components.

The diversity of ground segments is particularly problematic for missions using multiple spacecraft of different kinds, for example developed by different universities. Telemetry from the satellites that are part of the constellation must be centralised before processing. Modular ground systems are the obvious answer to this problem. Custom-developed components can be placed at various stages of the telemetry processing chain. The interfaces between components become the prime issue in such systems.

We believe that one-to-one interfaces lead to excessive rigidity. Instead, we propose to interconnect the components through an enterprise service bus (ESB). The concept is simple: the various components that constitute the ground segment (decoding, processing, analysis, visualisation, etc.) are autonomous and do not have any direct knowledge of the components producing the input or consuming the output. The ESB facilitates the flow of data between components. This is possible thanks to the Publish/Subscribe mechanism. Instead of waiting for data coming from a specific component, a component subscribes to messages on a particular topic (e.g. raw packets) and produces messages on another topic (e.g. decoded parameters).

Even though an ESB is conceptually centralised, the implementation can be distributed (logically and physically). In practice, telemetry can be decoded and pre-processed in ground stations and pushed, in two flows - housekeeping and payload, to respectively spacecraft operations (specific to each spacecraft) and science processing (common to the constellation).

To validate the concept, we implemented an ESB-based telemetry chain that includes a telemetry decoder, a fast archive for raw packets and processed telemetry and a data visualisation tool. The system follows the plug-and-play approach; additional components can be easily added. We demonstrate this with a parameter processor that generates derived parameters.