Paper ID: 76560
student

IAF SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
Small Launchers: Concepts and Operations (7)

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HIGH-BANDWIDTH TECHNOLOGIES FOR NEXT-GENERATION LAUNCHER NETWORKS: A COMPARATIVE ANALYSIS BETWEEN TTETHERNET AND TIME SENSITIVE NETWORKING (TSN)

Abstract

With the emergence of new space technologies, there is a need for more flexible and cost-effective aerospace intra-communication systems for both launchers and satellites. Traditional protocols like MIL-STD-1553B are facing bandwidth limitations, while other alternatives like TTEthernet are expensive and inflexible. In this context, the use of Ethernet technologies is gaining popularity due to their high bandwidth and compatibility with Commercial Off-The-Shelf (COTS) components, enabling cost savings and increased interoperability. This trend is particularly relevant for micro-launchers, where the payload size is relatively small, and the launching vehicles' reusability and quick production are key factors. As a result, manufacturers are attempting to adopt COTS components and the industry is shifting towards Ethernet-based intra-communication systems, as they offer a viable alternative to traditional protocols. Time Sensitive Networking (TSN) is a new technology that offers a promising alternative to these protocols, providing low-latency and high-bandwidth tailored to meet the needs of aerospace applications. One of the primary challenges of incorporating TSN into launchers networks is the configuration of the Quality of Service (QoS) parameters. QoS is essential for ensuring that critical data is prioritized and delivered with low latency and zero jitter, while non-critical data is transmitted with lower priority. TSN provides a variety of QoS mechanisms, including Time Aware Shaper (TAS) and Queue-Based Scheduling (Qbv), which specify the queue-based scheduling mechanism to support the determinism required by applications such as aerospace. The TAS feature introduces time-controlled gating mechanisms to the egress port queues, but TSN does not immediately provide the same good temporal features as TTEthernet. The main contributions of the study are the following: i) definition of the optimized TSN scheduling specifically for an aerospace application; ii) assessment of TSN solution in an actual network setting, utilizing the messages of VEGA, a small launcher developed by the Italian Space Agency and the European Space Agency; iii) performance evaluation comparison of the optimized TSN schedule and optimized TTEthernet schedule in the VEGA case-study, with different TSN parameters configurations. The performance obtained in terms of bandwidth consumption does not differ from that obtained in TTEthernet-based networks. The performance evaluation shows the feasibility of applying TSN for the avionics network of micro-launchers. Therefore, TSN presents a promising alternative to address the bandwidth limitations of the existing MIL-STD-1553B standard and the costly proprietary TTEthernet solution, which currently has only one vendor.