 Paper ID: 46204

16th IAA SYMPOSIUM ON BUILDING BLOCKS FOR FUTURE SPACE EXPLORATION AND DEVELOPMENT (D3)
Strategies & Architectures as the Framework for Future Building Blocks in Space Exploration and Development (1)

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KEY BUILDING BLOCKS FOR FUTURE SYSTEMS OF SYSTEMS FOR EXPLORATION + MODULAR, SCALABLE AVIONICS

Abstract

Future space exploration missions will require system architectures with highest levels of autonomy and fault tolerance. In addition, when targeting deep space there will be extreme constraints on size, weight and power – reducing the potential for sparing and increasing the need for hardware commonality. This paper explores how the cross-industry TTEthernet technology can be leveraged to address these challenges by simplifying the design and integration of distributed *spacecraft systems of systems*. While regular Ethernet is attractive for its flexibility, high throughput (multi-Gbps), and widespread availability, and therefore increasingly being used in spacecraft (e.g. by SpaceX), it cannot meet the needs of systems requiring strict guarantees regarding successful and timely message delivery (e.g. a sensor input for a docking manoeuvre). Time-triggered Ethernet (as defined in the SAE AS6802 standard as well as in an upcoming ECSS standard) therefore extends classical Ethernet with a dual fault-tolerant decentralized clock synchronization service enabling the fully deterministic delivery of time-triggered messages (timing, latency and jitter). The derived TTEthernet protocol provides two forms of event-driven communication, together enabling data traffic of mixed-criticality to coexist on the same, single physical network - strictly partitioned from each other. This facilitates the use of standardized computing platforms (miniaturized COTS PCs?) able to perform any number of roles within the system architecture. Gateways between systems can be eliminated and the need for costly unique software developments can be greatly reduced. And last but not least, the need for dedicated command and control buses is also completely eliminated. We have worked since a number of years with NASA JSC in Houston on this highly attractive use case for TTEthernet. The tight synchronization (nanosecond precision) of sub-systems allows to also synchronize software applications to the stable, fault-tolerant network time base. By synchronizing tasks and network scheduling, it is possible to realize a fully distributed real-time system of systems with built-in fault tolerance. Since the configuration of such a large system is complex, system-level configuration and verification tools are necessary in addition to those used for network scheduling. An overview of this tooling and typical software architectures will be given and the expected benefits for systems of systems in terms of development, integration and testing efforts will be presented (re-use of building blocks). Examples drawn from current research and development activities in Europe, North America and Asia will be shown.