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ANALYSIS ON APPLICATION OF TIME TRIGGERED ETHERNET IN SPACECRAFT

Abstract

The main purpose to use Ethernet in spacecraft is to take advantage of its flexibility to reduce the cost and complexity of avionic system. With the increasing complexity and diversification of space exploration, avionic system in spacecraft needs to connect multiple devices, payloads or even other spacecraft in space station, which means communication network in spacecraft have to provide higher bandwidth and flexibility to support its normal operation. Ethernet is the universal solution in commercial networks because of its high bandwidth, lower cost, openness, maintainability and flexibility. However, since Ethernet does not support time-critical or safety-relevant applications, Ethernet extensions with predictable timing were developed, such as EtherCAT, PROFINET, Ethernet/IP, Powerlink, AFDX. Time Triggered Ethernet (TTE), the latest real-time Ethernet extension standardized by the SAE, is based on the time triggered communication paradigm and provides services to meet time-critical, deterministic or safety-relevant conditions for real-time traffic, which suits for the requirements of future distributed avionic system in spacecraft. At present TTE has been used on the Airbus 380 for the airframe pressure control system and for the engine control system for the GE F110 engine for the Lockheed Martin F16 fighter jet, but its use in aerospace applications is just beginning to become common.

This paper firstly generalizes and discusses the characteristics of communication network for distributed avionic system in spacecraft by analyzing the design method of Orion Multi-Purpose Crew Vehicle (MPCV), which already use TTE as its high-speed backbone network and accomplished the ETF-1 experiment successfully. And further, an analysis of TTE protocol is presented, encompassing supported toplogy, mechanism of communication, time synchronization calculation and fault-tolerant performance to make comparisons with other aerospace networks. To satisfy various requirements of space mission, a unified distributed aerospace electronic system architecture that apply TTE as backbone network is also proposed in this paper. Then we theoretically analyze this architecture from perspective of clock synchronization, redundancy fault-tolerant, node bandwidth allocation and multi-data communication and conduct simulation experiments based on network calculus to verify TTE performance. The results represent that TTE are able to satisfy the requirement of current distributed avionic system and it should be considered as the next generation of communication network for critical aerospace applications in spacecraft.