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DISTRIBUTED ON-BOARD COMPUTING ON SCIENTIFIC CUBESAT MISSIONS

Abstract

The DFG Cluster of Excellence ORIGINS currently develops several space science missions. These include a CubeSat mission to measure the flux of antiprotons within the South Atlantic anomaly (SAA) and a mission to measure the polarization of X-rays originating from the Cygnus X-1 binary system, also aboard a CubeSat. These missions have widely diverging requirements: While the first needs to reliably operate inside the radiation environment of the SAA, the second requires an advanced attitude determination and control (ADCS) system for precise inertial pointing to Cygnus X-1. We develop a robust yet flexible command and data-handling system for CubeSats that meets the requirements of these two missions and that allows the reuse of hardware and software among current and future missions.

The VA41620 microcontroller by Vorago Technologies is the base of the system. This radiation-hardened ARM Cortex-M4 microcontroller allows reliable operations within the SAA. We performed initial radiation tests of the microcontroller that showed promising results. We thus expect this platform to operate nominally within the high radiation environment of the SAA. Inherently radiation tolerant magnetoresistive memory (MRAM) provides storage for firmware and gathered data. The system's operating system is based on the DOSIS framework, which provides a variety of features required to develop mission-specific firmware. DOSIS offers ready-to-use abstractions for different parts of the overall firmware, including pre-defined functionality and a type-safe and statically checked interface based on modern C++ features. These abstractions simplify the reuse of components for different missions. Additionally, the framework provides time synchronization for multiple nodes with guaranteed timing suitable even for distributed control algorithms of an ADCS system.

Due to its interface abstractions and the available time synchronization, the DOSIS framework enables distributed control algorithms and thus the simplified distribution of workload across several nodes. A CAN bus interconnects nodes, minimizing the required cabling because periphery can be attached to the closest node. This setup enables flexible expansion or adaptation of the on-board computing system to the demands of future missions.

In this paper, we present details of the hardware platform and our experience using the VA41620 microcontroller. Based on this platform, we demonstrate the key features of the DOSIS framework and the simple development of a potentially distributed firmware for specific missions based on shared components.