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A SELF-ADAPTIVE DATA HANDLING SYSTEM FOR SMALL SATELLITES AND ITS IMPACT ON FUTURE SATELLITE OPERATIONS

Abstract

The work in this project is part of PolyOrbite's satellite design for the Canadian CubeSat Project. PolyOrbite is a technical student society at Polytechnique Montreal and designs a 2U CubeSat to demonstrate self-adaptive systems for spacecraft. The aim of the satellite is to show the benefits of self-adaptivity on two payloads: a self-adaptive data handling system (DHS) and a self-adaptive greenhouse. In this paper, we present the self-adaptive DHS and discuss its potential impact on future satellite operations—from single satellites to mega-constellations.

In recent years, we have seen a fair amount of research focusing on software libraries and frameworks for self-awareness. Despite existing works, there is no framework available that takes into account the characteristics of space systems, and their strict need for real-time and fault-tolerance. We discuss tools and techniques necessary for the implementation of a self-adaptive computing system for aerospace. Our system—capable of adaptation—deals with uncertain environments, heterogeneous resources, and irregular workloads, while taking into account housekeeping (e.g. power consumption, attitude control) and scientific, payload related tasks.

We address several challenges as why to implement reconfigurable systems with self-adaptive capabilities: programmers have to deal with the advent of multi-core systems, which made the task of writing solid code much more complicated than it was for single-core systems; this code should achieve desired levels of quality of service in multiple scenarios that might not be known a priori; moreover, the same code is required to run on multiple architectures. The complexity of all these tasks is skyrocketing and it is impossible, or too expensive, to find programmers having such strong competencies both in software design and in architecture-related issues. Therefore, the best way to deal with this problem is to adopt reconfigurable systems. A reconfigurable system is able to mask this complexity to the programmer and satellite operators, by adjusting itself when changes in the environment occur.

Our research is focused on the aerospace domain and has the potential of improving efficiency, fault tolerance, computational capabilities and cost of aerospace computer systems. In our vision, this research will allow the creation of a new generation of satellites and satellite constellations able to autonomously perform their tasks for longer periods of time, fostering simpler and cheaper space exploration, reducing the ground segment cost and thus directly impacting future satellite operations.