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A DECENTRALIZED SOFTWARE ARCHITECTURE FOR CELLULAR SATELLITE AGGREGATIONS

Abstract

With recent advances in SmallSat and particularly CubeSat technologies, the future of satellites is increasingly compact and modular. However, the current nature of these satellites only allows modifications (via "plug and play") up to launch. Additionally, attempts have been made with some success towards constructing satellites in space, but these attempts do not include re-configurability. With the more recent advent of the concept of Satbotics, which allows modification and autonomous (self-) reconfiguration while in orbit (or beyond), we will soon be able to launch fleets of satbots that can aggregate to form larger satellites of varying and reconfigurable designs. Currently, a limiting factor in Satbotics is that there does not exist a unified software architecture that allows for seamless integration and re-configurability in space.

Here we present a general-purpose decentralized software architecture with a periodic electoral cycle. The design includes system model redundancy to minimize the damage of node failure to the aggregation network. Independence from mission requirements is also achieved as the software architecture serves as an abstracted layer apart from any user constraints or objectives. Mission tasks are delegated through the network in a locally distributed, but globally decentralized manner. The task allocation follows a greedy approach that optimizes over the nodes of the network by current and expected burden, which we define as the relationship between available computational resources and computational load. We show that the electoral process does not produce a bottle neck in processing nor a halt in mission function. A theoretically linear bound on messages sent/received in the communications network is proven while still maintaining network consensus which is implicitly enforced in the construction of the architecture. Further, we demonstrate using networks of various sizes and nodes of various capabilities the scalability and robustness of the architecture with simulated operations based on real world requirements.