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EXTENDING MISSION CONTROL TO DEEP-SPACE MISSIONS

Abstract

The emergence of CubeSat swarms/constellations for deep-space missions in the near-future inevitably kick starts the evolution of better mission control systems. By better, we mean lighter, robust, scalable and semi-autonomous networks that enrich the mission(s) while reducing operational complexities. The current state-of-the-art comprises of having positioned satellite relay(s) complementing existing earth-based deep-space networks. While these may be the starting point(s) of pioneering missions; the need for remote semi/fully-autonomous ground control is necessary to ensure mission success and to offload secondary tasks. They can be classified as "agent relays".

The deep-space agent relays might be semi/fully-dedicated CubeSats themselves, or asteroid/planetary-based ground control coordinating multiple mission(s). Having feasible CubeSat constellations for deep-space missions ultimately boils down to power, coordination, time, redundancy, and time budgets; agent relays ensure that this happens. The closer the relays are to the constellations, the more efficient the missions become.

Our research is to plan, simulate, and visualise different network growth patterns for deep-space communication networks to find optimal strategies on deep-space mission control deployment. We explore existing computer network architectures, challenges in time synchronisation and protocols, and cybersecurity concerns. The agent relays may be further empowered by providing them with semi-autonomous decision frameworks and blockchain-based data retention to further enhance the missions.

The end-result emerging as guidelines for different networking strategies for deep-space missions referencing purposes, budgets and, lifetimes. The topics are covered starting at a high-level to provide maximum awareness and to inspire more insightful research in this domain.

Some of the key points explored regarding the agent relays are:

- Expendable and cost-effective design strategies
- Deployment, fault tolerance, and maintenance
- Optimal network deployment and growth planning
- Data redundancy and reliability (blockchain) concerns
- Cybersecurity challenges
- Semi-autonomous decision making and subsequent effects

While larger spacecraft missions possess the luxury of having dedicated radio telescope networks and relays for ground control; we aim to publish and present our findings tailored to ensure deep-space CubeSat missions truly succeed.