Wireless Mesh Networks for Small Satellites Subsystems

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Wireless mesh networks are a network topology where all the nodes of a system are able to communicate with every other node in the network. This enables an adaptable network that is scaleable and has the capability to self-repair and self-configure. The Modular Rapidly Manufactured Small Sat (MRMSS) Project is a small satellite project where we are developing a modular CubeSat architecture. One of the goals of the project is to develop a system that is quick and simple to integrate with a minimal amount of wiring involved. Wireless mesh networks are well suited for this configuration because of the self-configuring and self-repairing aspects of the network. This enables a satellite developer to add subsystem nodes to the network without the need for much hardware re-design. This paper will detail the background of wireless mesh networks, the advantages and limitations of using wireless mesh networks for space applications, and the technical progress of the wireless mesh network development of the MRMSS project.

Wireless mesh networks have been used for many purposes including military communications, emergency communications, industrial networking of machinery, and many other applications. The ability for each node to communicate with eachother wirelessly greatly reduces cost, mass, and complexity in large systems. Unlike in a normal WiFi system, each node will be able to act as a client and a router. Wireless mesh networks used for internet connectivity has been growing in cities to enable larger area wireless coverage. It is also used in developing countries where one node can connect to the internet, and all the other nodes will be able to have net connectivity though it. A series of nodes could also be used to relay internet services to remote locations where normal internet access is hard to reach. There are many applications of wireless mesh networks and bringing them to space will help reduce launch costs, and satellite complexity.

As network enabled consumer devices become ubiquitous, advances in network architecture could enable interesting coordinated behavior of many devices. The strategy of composing systems from smaller fungible components has already seen a broad scope of applications, ranging from computing and secure encryption algorithms[1,2] to overcoming physical limitations for electromagnetic transceiver systems.[3] Recent work on fractionated spacecraft[4,5] is exploring the application of this strategy to constellations of satellites.

This project takes this a step further, to the components that the satellites are composed of, for the purpose of developing a highly robust spacecraft component system that is either topology agnostic and/or can perform self discovery. A strategy for large scale long duration spacecraft is to build the spacecraft from many fungible components, to allow for dynamic repairability (and reconfigurability, if necessary).

The current systems plans to utilize low cost COTs components to integrate into a CubeSat to test the feasibility of the system. Each board will consist of sensors such as gyros, accelerometers, a radio and the ability to carry custom payloads to act as an independent spacecraft. These component boards will be able to connect together physically to form a larger modular cubesat. Many of the designs and concepts come from past projects such as NASA's M-PACE[6] and Cornell University's KickSat Project.[7]

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This paper will also detail the power requirements from current CubeSat systems and how wireless mesh network will affect them. A comparison of different COTs low power wireless mesh network hardware will be completed to choose the best components suited for our applications. Software and routing techniques will also be detailed in this paper.

References

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