Chapter 4

Efficient Space Communication and Management (SCOaM) Using Cognitive Radio Networks Based on Deep Learning Techniques:

Cognitive Radio in Space Communication

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ABSTRACT

The future of space communications has evolved towards being cognitive in order to improve energy and spectrum efficiency. Nowadays, near-Earth space satellites for weather, civil defense, and public commercial sectors are rapidly increasing, thereby resulting in congestion. Cognitive digital radio is a form of dynamic wireless communication in which a transceiver can intelligently detect the parts of communication channels that are currently not in use and instantly move into vacant channels while avoiding occupied ones. A challenge for communication between satellites and ground terminals involves calibrating both the time and frequency channels during rapid relative movement. A more dynamic and highly-precise algorithm for enhancing communication between satellites and base station terminals such as deep learning in cognitive radios is proposed that enables significant degree of automation in the space communication networks where spectrum interference is a key issue.

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INTRODUCTION

Communication is vitally important to astronauts while they are in space. Not only does it allow them to talk to their friends and family back home, it also allows them to communicate with the team of experts on the ground that helps them carry out their mission safely. Communication in low Earth orbit, where the International Space Station (ISS) orbits, is almost instant. When travelling further into space, communication becomes a bit tricky. The further out you travel in space, the more issues you have with communication. For example, it could take 20 minutes to send or receive a message between Earth and Mars. The majority of space missions never return to Earth. Thus, after launch, a spacecraft's tracking and communications systems is the only means with which to interact with it. In addition, any issues with the spacecraft can only be diagnosed, repaired, or mitigated via the communications system. Without a consistently effective and efficient communications system, a successful mission would be impossible.

Space missions are designed several years before deployment, using technology that is state of the art at the time of design. Once deployed, the equipment cannot be reconfigured easily without risking the loss of communication. Suppose that a future mission uses a new modulation scheme. Without cognitive capabilities, all in-orbit hardware will need to be updated with information about this scheme to co-exist. Similarly, future traffic patterns, regulatory policies or spectrum sharing guidelines are not available several years in advance. Therefore, cognition-based autonomy is especially necessary in space networks.

A cognitive radio has the potential to learn and adapt to its operating environment without intervention from human operators. Current space networks are manually configured. The Cognitive networks and cognitive radios have received a lot of attention due to their promised feature of autonomy, cost, and scalability. Adaptive radio software could circumvent the harmful effects of space weather, increasing science and exploration data returns (Chenji, Stewart, Wu, Javaid, Devabhaktuni & Bhasin, 2016). A cognitive radio network could also suggest alternate data paths to the ground. These processes could prioritise and route data through multiple paths simultaneously to avoid interference. The cognitive radio's artificial intelligence could also allocate ground station downlinks just hours in advance, as opposed to weeks, leading to more efficient scheduling. Cognitive radio may make communications network operations more efficient by decreasing the need for human intervention. An intelligent radio could adapt to new electromagnetic landscapes without human help and predict common operational settings for different environments, automating time-consuming processes previously handled by humans.

SPACE COMMUNICATION CHALLENGES

Demands placed on space communications systems are continuously increasing. NASA estimates that the space communications capability will need to increase nearly by a factor of 10 each for the next three decades. This trend is in step with our increasing knowledge of the cosmos -- as more detailed scientific questions arise, the ability to answer them requires ever more sophisticated instruments that generate even more data. New high-resolution hyperspectral imagers put further demands on their communications system, requiring even higher data rates.

An important challenge for deep space communications systems is to maintain their extreme reliability and versatility, in order to accommodate the long system lifetimes of most planetary missions. These challenges must be met with a communications system that requires maximum utilization of minimal available spectrum. The Space Network consists of antenna placed at three locations around the world