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Advance Higher Throughput Communications for GEO and LEO satellites (3)

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USING PREDICTIVE ALGORITHMS TO AVOID INTERFERENCE ON WIDEBAND DOWNLINKS

Abstract

Wideband downlinks from LEO can normally be treated as clean Gaussian channels. Highly directional antennas ensure that the user has near-exclusive access to the service volume defined by the RF beam. However, sporadic interference can occur during a conjunction with another satellite using the same (or overlapping) frequency assignment. Since user demand far outstrips the available spectrum, the chance of interference during a conjunction is relatively high. And, with an ever-growing LEO constellation, the probability of a conjunction on any given pass is increasing.

Conventional techniques for handling errors are limited in their ability to separate the signal of interest from the interference. Error correcting codes are unable to handle the long dropouts that occur during the interference. Multiple-access techniques (including spread-spectrum) require excess bandwidth that is not available when the entire band is consumed by the signal of interest. Error-detection and retries (e.g. UDT) are often employed, and this can be a viable solution in some circumstances. However, this approach requires bidirectional communications, and results in considerable latency. Variable or adaptive modulation protocols (such as VCM/ACM in the DVB-S2 standard) aren't helpful, because they only change the modulation and coding combination in response to changes in the Gaussian nature of the channel. However, interference is not a Gaussian process.

We observe that conjunctions can be predicted in advance. With this knowledge, we can build an agile communication system that works to avoid interference by seamlessly switching transmission modes during the conjunction, and then switching back to full bandwidth when past the conjunction. As an example, if two spacecraft are under control of the same operator, each can be given the full channel for most of the pass, reducing to half of the channel during the conjunction. Or, they can be assigned to alternate polarizations, effectively doubling the channel capacity. Because the transitions are seamless, there is no reacquisition time. Although the overall throughput is reduced during the conjunction, this is unavoidable in any solution. But by using an avoidance strategy, the throughput reduction is kept to a minimum, while preserving low latency.

This paper defines an adaptive protocol for predicting conjunctions and providing channel assignments to participating spacecraft. It also provides techniques when only one of the spacecraft is a participant in the protocol. It defines the necessary signaling and synchronization so that the transitions are performed seamlessly, without loss of lock on the ground receiver.