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DESIGN AND IMPLEMENTATION OF THE PROTOCOL STACK OF THE CONTROL PLANE IN HYBRID INTER-SATELLITE LINK TERMINALS

Abstract

Recently, optical technology is emerging as a candidate in satellite communications to provide high throughput links. Moreover, it offers resilience to interference, and simplifies the administrative burden to obtain the frequency coordination. This disruption has triggered the discussion of how optical and radiofrequency (RF) technologies can coexist. There is indeed a trade-off between these two technologies. Depending on the configuration, the RF technology can provide long range links at the expense of reduced data rates. Moreover, the ability of the antennas to radiate signal isotropically enhances the connectivity with other satellites. Conversely, optical communications are characterized by a very narrow beamwidth in which the radiated power is concentrated. This firstly improves the performance in terms of data rate, security, size, weight, and power. However, the narrow beamwidth poses a challenge of properly pointing (and keeping the stability) the terminals.

In order to alleviate the reduced connectivity of optical terminals, this work is based on a hybrid communications concept in which a control plane handles the signaling data via an RF inter-satellite link (ISL) terminal, and a data plane transmits the useful data via optical ISL terminal. Following the evolution of this hybrid concept, this work contributes with the design and implementation of a protocol stack to deploy the control plane. The protocol stack is based on the OSI model, where the physical and data link layers are implemented. On one hand, the physical layer uses Long-Range (LoRa) technology as an implementation of the Chirp Spread Spectrum (CSS). This technique enables to extend the link distance without increasing the transmitted power thanks to including an additional code gain. Moreover, the inherent low data rate is not a problem as the volume of data to be handled by the control plane is limited. In addition, the physical layer harnesses the low-power and low-cost characteristics of this type of Low Power Wide Area Network (LPWAN) technology, which make it suitable for small satellite missions. On the other hand, the data link layer uses Proximity-1 protocol to guarantee a collision-free communications channel. The characteristics of this channel are first agreed upon in a non-dedicated channel. The benefits of the designed communications protocol stack are demonstrated through experimental tests, in which two LimeSDR Mini v2 Software Defined Radios (SDR) communicate to each other. The results will be presented in the final article.