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IP-BASED PROTOCOL STACK FOR NANOSATELLITE COMMUNICATIONS

Abstract

Many nanosatellite missions employ custom communications protocols for the space-ground link. Such protocols are typically designed according to the requirements of a specific platform and/or mission. Industry-standard protocols, such as the CCSDS protocol suite, have been considered by many, and even implemented with success on several nanosatellites. In comparison with a custom approach, standard protocols encourage reusability and carry lower risks due to their heritage. However, CCSDS protocols can be perceived as unnecessarily complex for a small mission due to their holistic approach. Additionally, the limited availability of development tools increases further the required effort to implement them both in the spacecraft and in the ground segment.

We propose an alternative, modular approach that reuses generic technologies widely deployed in other mission-critical applications and with mature tools readily available. The proposed protocol stack employs a service-oriented architecture independent of any specific hardware or software configuration. It defines a small set of essential services, including housekeeping and telecommand handling.

All communications are connectionless (i.e. each packet is self-contained) and encoded in structured messages, serialised with Protocol Buffers, a simple but highly efficient interchange format developed by Google. Messages are then encapsulated in UDP/IPv6 packets. The relatively large overhead is reduced using stateless compression. HDLC, a mature data link protocol, performs frame synchronisation.

Thanks to the reuse of existing protocols, COTS hardware and software can be used on the ground. Spacecraft designers can easily extend any layer of the protocol stack with, for example, payload-specific services or file transfer services, while maintaining compatibility with existing systems.

Our protocol stack exhibits good performance in terms of reliability and throughput in environments with a high error rate and frequent drop outs. Its connectionless nature makes retransmission of damaged or lost packets straightforward. The entire stack has been implemented and tested, with success, on an ARM system-on-chip. An on-orbit demonstration is currently being planned by the OpenCube Initiative, a non-profit international project led by young space professionals, enthusiasts and students, with the aim to research and develop new technologies and explore new approaches to challenging problems in nanosatellite engineering.