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COMMUNICATION SYSTEM ARCHITECTURE AND FIRMWARE DESIGN FOR NANO SATELLITES

Abstract

In earlier days, very few countries were a part of space race and only a couple of space agencies worked towards space exploration. But today, with privatization of space industry many new public-private players have emerged and collaborated to develop various missions for deep space exploration activities. New space industry is a collaborative effort by private companies, startups, public and private research institutes and governmental reforms to enable these collaborations for realizing the global vision of space exploration. The upcoming space exploration missions are focused to establish permanent human presence on Moon and Mars. Many studies have been conducted to analyze the different challenges and risks of such courageous missions. One of the main challenges is to stay connected all the time with the least possible delay at the highest possible throughput. This is an active research topic addressed in the field of deep space infrastructure design. This paper addresses the development of a lunar communications infrastructure based on a network of nano satellites. While the hardware is based on commercial-of-the-shelf technology for software-defined radio together with some previously published optimized RF stages, special focus in this report is put on the firmware architecture design. It is presented how open source software and related libraries can be utilized to implement a reconfigurable system. The different high-level software blocks used for the communications system design are introduced first, followed by a thorough description of their internal architecture. Experiments were conducted using the center frequency of 2360 MHz and 2361 MHz. Laboratory measurements using modulation schemes such as, binary phased shift keying (BPSK) and quadrature phase shift keying (QPSK) show that a data rate of 1Mbps is supported by the system. Due to the design of the experimental setup, this is also the data rate expected for a link between the Moon and a ground station on the earth. It is further shown how the architecture allows for adaptive reconfiguration of the transmission schemes, which enables the system to adapt to changing channel conditions and/or power constraints of the platform. It is presented how this approach can be further utilized for creating complex and more robust communication software for various small satellites

missions. The approach presented in this contribution is particularly attractive for CubeSat missions that provide an opportunity for students and educational institutions to effortlessly develop a working system for technology demonstration in space.