Paper ID: 83381
student

IAF SPACE COMMUNICATIONS AND NAVIGATION SYMPOSIUM (B2)
Advances in Space-based Network and Communication Technologies (7)

Author: Ms. Katherine Zamudio-Turcotte
Polytechnique Montreal, Canada

METHODOLOGIES FOR THE DEVELOPMENT OF LOW-COST AUTO-ADAPTIVE SOFTWARE-DEFINED RADIOS (SDR) FOR CUBESATS

Abstract

In the rapidly evolving landscape of digital communication technologies, Software-Defined Radios (SDRs) are becoming an increasingly attractive solution. Their programmable nature offers a level of reconfigurability that is especially useful for building resilient satellite constellations confronted with varying bandwidth demands and evolving protocols. This flexibility allows modern satellite systems to dynamically adjust their RF parameters using software updates, which can be performed in-orbit. As long as the on-board hardware platform can support it, updates can be scheduled continuously, extending the lifetime of the satellite's hardware and, thereby, making it more cost-effective. Moreover, recent advances in the field of artificial intelligence open the way for software-defined radios that could reconfigure themselves without human intervention.

Despite their many benefits compared to fixed-hardware receivers, however, accessibility to SDR technology can be hindered by the cost of the required RF front-end components and the programmable hardware chip. For research teams and student engineering groups, developing custom SDR software for an FPGA/SoC, GPU or CPU platform can become a challenge, depending on their throughput requirements and link budget. On one hand, low-cost development boards sometimes don't exhibit sufficient computing capabilities for the design of a complex SDR system, or simply do not pair easily with RF front-ends with the required range for satellite communications. On the other hand, higher-end development boards might not demonstrate the power efficiency required for a battery-powered embedded system.

This article therefore focuses on proposing SDR design methodologies tailored for CubeSats and destined for cost-efficient FPGA platforms. From the RF front-end to the FPGA and/or software payload, this work outlines design workflows that streamline the end-to-end design of software-defined RF systems. Notably, we delve into open-source-based development approaches for auto-adaptive SDRs, which leverage neural networks to adjust their own parameters without human intervention.

Our proposed methodologies aim to empower research teams and student engineering project groups, allowing them to produce a performant, cost-efficient and low-power CubeSat RF system prototype using mainly off-the-shelf components. To demonstrate practical implementation, some of these methodologies will be evaluated on a Zynq-7000 FPGA development board combined with a Nooelec NESDR dongle. Through this experimentation, we will illustrate trade-offs between cost and performance, providing valuable insight for future innovation in SDR development.