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REMOTE SYSTEM-ON-CHIP RECONFIGURATION FRAMEWORK FOR FLEXIBLE UPDATE AND REPAIR OF NANOSATELLITE FIRMWARE IN-ORBIT

Abstract

This paper presents a remote System-on-Chip (SoC) reconfiguration framework for flexible update and repair of nanosatellite firmware in-orbit. At OroraTech, we use nanosatellite imaging technology for wildfire detection services, making post-launch SoC reconfiguration crucial for upgrading processing algorithms, fixing unexpected design errors, and addressing corruption in the SoC configuration memory. The current payload uses a Zynq-7000 SoC platform.

To overcome the problem, a reconfiguration framework was engineered. It is based on the use of several features offered by Xilinx's Zynq architecture that control the flow of the SoC booting and configuration; as well as on a tailored "reconfig" application that, through a customized protocol, allows the user to also alter the normal flow of the SoC configuration and to change the contents of the configuration memory; and on RSA authentication to identify memory corruption. Thus, the design is able to execute update and special boot procedures and to trigger contingency processes for fallback flow.

As a SRAM-based SoC, the Zynq requires a non-volatile memory to store its configuration files; this memory is the structural core of this work. In this design, it contains four binary images stitched together, each one fulfills a specific role and can only be loaded and executed one at a time. In a normal reconfiguration flow, two of them are run; one starts the "reconfig" application, and another programs the SoC's FPGA fabric and launches the payload application. The other two are backup images executed in case of failure. Furthermore, with a proper use of the "reconfig" application, the user can add and delete images, or completely change the memory contents to fully revamp the SoC operation.

This work is valuable because it allows for complete customization of the SoC's software and hardware components, making it highly adaptable and flexible. Moreover, it is superior to other methods that are radiation sensitive, such as partial reconfiguration that only works in the logic fabric and requires a static portion of it to remain unchanged, and software-based solutions that need the microcontroller code to be intact. It also outperforms scrubbing solutions that require additional modules and don't offer firmware updates.

The framework was extensively tested to reach TRL8 stage and can be adjusted for use in other SoC architectures. It will be part of the payload scheduled to launch in June this year.