Ph.D. in Information Technology
Thesis Defenses

March 14th, 2025
At 9:00 a.m.
Aula Seminari Alessandra Alario – Building 21

Andrea COSTA – XXXVI Cycle

UPDATES AND NEW DEVELOPMENTS OF THE DAQ FIRMWARE AND HARDWARE FOR THE DSSC CAMERA AT THE EUROPEAN XFEL
Supervisor: Prof. Nicola Lusardi

Abstract:

The DEPFET Sensor with Signal Compression (DSSC) project at the European X-ray Free Electron Laser (EuXFEL) in Hamburg has developed a cutting-edge megapixel X-ray camera capable of ultra-fast imaging at a 4.5 MHz frame rate. The camera produces a continuous data stream of up to 134 Gbit/s, necessitating an advanced data acquisition (DAQ) system to handle this high throughput. The current DAQ system utilizes a two-stage architecture: the first stage is composed of 16 identical Spartan-6 FPGA boards, and the second stage consists of 4 Kintex-7 FPGA boards, both designed by Xilinx. This system efficiently manages data output through ordered UDP Ethernet packets. This PhD research is focused on advancing and renewing the existing DAQ system to ensure its future-proofing, simplify the readout mechanism, and unlock new potential for enhancing the overall camera performance. Initial efforts concentrated on analyzing, modifying, and optimizing the firmware for the Spartan-6 (IOB) and Kintex-7 (PPT) boards, along with the custom Linux build system running on the PPT. These efforts led to significant improvements, correcting system misbehaviors, introducing new features, and making the system more robust and user-friendly. In parallel, new technologies were evaluated to redesign the DAQ system, particularly considering the end-of-life status of the Spartan-6 and the aging of the 7-Series devices. The research identified Xilinx's UltraScale+ devices as ideal candidates for the DAQ renewal plan. These devices offer enhanced performance, scalability, and energy efficiency, critical for supporting the DSSC camera and future upgrades at EuXFEL. A comprehensive evaluation process was conducted to select the most suitable FPGA, focusing on area occupation, power consumption, and timing performance. The chosen UltraScale+ devices promise significant improvements in operating frequency, resource availability and large bandwidth transceivers, ensuring that the new DAQ system can accommodate both current functionalities and future developments. The Bill of Materials (BoM) for the redesigned IOB PCB has been defined in various options, considering many use cases, including direct replacement of the current IOB, feature enhancements, and standalone module configurations. This research lays the groundwork for the next generation of DAQ systems, ensuring they meet the evolving needs of the EuXFEL and maintain cutting-edge performance in X-ray imaging.

PhD Committee

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