Image Acquisition and GPU Processing Application using IRIO technology and FlexRIO devices

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***Abstract*–The large amount of data generated by image diagnostics used in big physics experiments requires an efficient use of hardware technologies in real time data acquisition and processing applications. In order to get the best performance of the hardware, it is necessary to provide the hardware and software tools that enable a fast and easy way to deployment these kind of solutions. IRIO technology allows an easy development of advanced data acquisition applications and their integration in EPICS using National Instruments Reconfigurable Input/Output (RIO) FPGA-based cards. Using IRIO software tools, it is possible to minimize the development time to build specific application for different hardware configurations. IRIO uses the open source version of NI-RIO Linux device driver supporting direct DMA access from FlexRIO devices to NVIDIA GPUs. For the development of image processing applications the hardware platform selected has been implemented using a FlexRIO device with a cameralink adapter module and a NVIDIA Kepler architecture GPU. With the help of IRIO tools the user have to focus the development exclusively in the implementation of the FPGA application for the FlexRIO device using LabVIEW/FPGA and the GPU algorithm using NVIDIA CUDA tools. Additionally IRIO provides the EPICS integration for these applications using the software model developed by ITER and Cosylab that simplifies the development of EPICS device support by mean of Nominal Device Support approach. This is a set of libraries with C++ classes simplifying the development of these device supports.**

To demonstrate the full development cycle an algorithm for image compression based on JPEG standard has been evaluated and tested using a hardware configuration with the same elements defined in the ITER fast controllers hardware catalog. This image standard allows high compression ratios and can include additional metadata information related to the image. These software tools has been tested in ITER CCS (Codac Core System).

I. System Description

IN this work an application that allows image acquisition from a camera link camera and their processing using a NVIDIA GPU, has been developed and tested using the IRIO software tools. An algorithm for image compression based on JPEG has been chosen. This algorithm has been implemented using the software tools available in the SDK CUDA for NVIDIA boards and third-party image libraries.

Manuscript received May 30, 2016. This work was supported in part by the Spanish Minister of Economy and Competitiveness under the project ENE2015-64914-C3-3-R.

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978-1-5090-2014-0/16/$31.00 ©2016 IEEE

The hardware architecture is compliant with ITER fast controllers (see Fig. 1). It consists in a PICMG 1.3 computer connected to a PXIe chassis, by MXI Link, with a NI FlexRIO 7966R card and a cameralink adapter module [1] [2]. An NVIDIA Tesla k20 GPU (professional series card) is responsible of the processing part. In this configuration IRIO software is using the open source version of NI-RIO Linux driver implementing the direct DMA from FlexRIO devices to NVIDIA GPUS boards. IRIO software provides specific functions implementing this functionality, avoiding an unnecessary copy using the CPU memory.

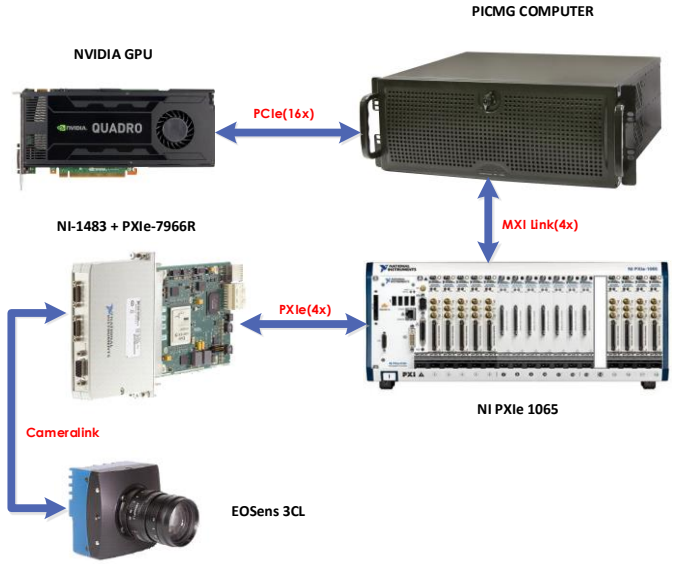

Fig. 1. Architecture of the PXIe system for a high performance image and processing system.

The solution has been implemented using the following software elements (Fig. 2):

1. LabVIEW for FPGA project. It supports the implementation of the framegraber using the cameralink interface. The output of this software implementation is the bitfile for the FPGA.
2. GPU library and application. It provides the processing algorithm and the abstraction software layer that allows access to GPU resources.
3. IRIO Library. It allows to the user to access resources implemented in the FPGA, manages

image acquisition, direct data buffering to GPU memory and GPU processing.

4. NDS C++ classes. It supports the implementation of a customized EPICS device support for the hardware implementation in the FPGA/GPU that acquires and processes images.

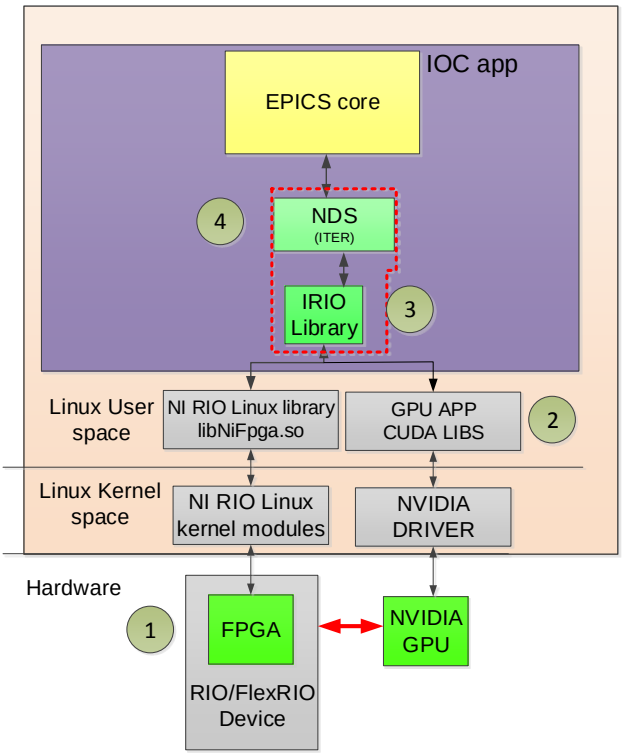

Fig. 2. Software layers used for the implementation of the image acquisition and processing system.

IRIO software tools are currently integrated in ITER CODAC CORE SYSTEM v5.2 (released in February 2016) and has been officially tested. IRIO tools are available to the EPICS community and other possible users with a GPL V2 license. The final contribution to the conference will include the description of the solution implemented, including the evaluation and performance of the algorithm implemented in the GPU [3] [4], the suitability to integrate it in EPICS using NDS approach, and the proposal to generalize the implementation of image acquisition and processing applications for physics experiments such as ITER Diagnostics.

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