INTEGRATING LWDAQ INTO THE DETECTOR CONTROL SYSTEMS OF THE LHC EXPERIMENTS AT CERN

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Abstract

The LWDAQ (Long-Wire Data Acquisition) software and hardware from Brandeis University, Mass., USA provides access to a powerful suite of measurement instruments. Two high precision monitors used to measure the relative alignment between a source and a sensor are included. The BCAM (Brandeis CCD Angle Monitor) cameras take images of point light sources and the Rasnik (Red Alignment System of NIKhef) cameras take images of the NIKHEF developed Rasnik mask. Both systems are used in the LHC experiments at CERN. Brandeis University provides a tool called Acquisifier to script the data acquisition process and to analyse the images to determine the alignment data. In order to incorporate the resulting data from the alignment system into the Detector Control System (DCS) of the LHC experiments a new software component of the Joint COntrols Project (JCOP) Framework was developed. It provides a TCP/IP interface between LWDAQ and the SCADA tool PVSS so that the results of the data acquisition process can easily be returned to the DCS. This new component simplifies the generation of the Acquisifier data acquisition script, controls the run mode of the Acquisifier and collects the results of the acquisition.

INTRODUCTION

JCOP [1] is a collaboration between CERN and the LHC experiments. It focuses on identifying and providing common controls tools, solutions and recommendations that can be used by the controls developers of each experiment to build the DCS. JCOP has chosen the software called PVSS [2], developed by the Austrian company ETM, as the SCADA system for the LHC experiments. In addition to the functionality provided by PVSS, JCOP also develops additional functionality to extend and ease the use of PVSS in the CERN context. This additional functionality is distributed as part of the JCOP Framework [3], which consists of a series of components that can be used and installed, as required, by the controls developers in the LHC experiments. Functionality implemented in the JCOP Framework can be used by any of the hundreds of controls developers working in the LHC experiments.

It had been identified that several of the controls developers needed to integrate LWDAQ hardware [4] into the DCS of their experiment. An example of this was the Geometry Measurement System for the ALICE Muon Spectrometer which required the integration of a total of 460 BCAM and Rasnik sensors [5]. For this reason, the decision was taken to create a new component of the JCOP Framework to provide the required functionality. In this way, duplication of development effort could be avoided by all the knowledge and effort being incorporated into a single product that could then be reused by every developer who needed such functionality.

THE JCOP FRAMEWORK

The JCOP Framework extends the functionality of PVSS to meet the requirements and needs of the LHC experiment controls developers. One conceptual extension that the Framework provides is that of device modelling. This technology allows the easy creation of Framework components that support devices.

A device component for a specific set of equipment includes data structures that define the control parameters and process variables applicable to the hardware. It can also model the possible hierarchical relationships between different types of hardware and configuration information such as alarms on the process variables. This set of device modelling information combines to create what is called a *device definition* [6] in the Framework terminology.

THE LWDAQ SYSTEM

The LWDAQ system developed by Brandeis University, Mass., USA is a scalable data acquisition system designed to handle wire lengths to the sensors of up to 130 meters.

Hardware

The hardware part of the systems consists of *drivers*, *multiplexers*, *repeaters* and *devices*. A device consists of one or more inputs and/or outputs. In the terminology of LWDAQ these inputs and outputs are all considered as *sensors*. Figure 1 shows one possible topology of LWDAQ hardware.

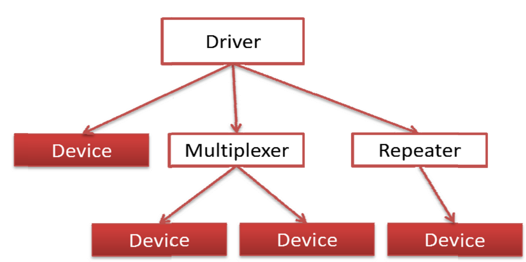

Figure 1: Example LWDAQ hardware setup.

The driver can control and read data from all the LWDAQ devices that are connected to its sockets. Devices can be connected directly with a wire to a driver socket, or via a network of multiplexers and repeaters. The driver hardware is available in two varieties, with a VME interface or with an Ethernet interface.

Multiplexers are used to connect several devices to a single driver socket and repeaters are used to boost signals if the length of a single wire would exceed the permitted limit.

Software

LWDAQ includes software to control each type of device. The components of the LWDAQ software that control the devices are called *instruments*.

In the context of JCOP, it was requested to support the instruments for two types of alignment devices; the BCAM [7] and Rasnik [8] cameras.

The BCAM system determines the relative alignment between two BCAM devices. One device flashes laser diodes and the other acts as a camera to observe these flashes. The BCAM instrument then calculates the position of the observed flashes. Figure 2 demonstrates how the position of the observed flashed from two diodes can be used to determine a change in alignment.

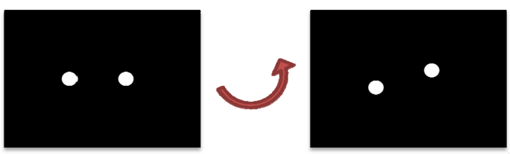

Figure 2: Determining changes in alignment from the position of the received flashes from two BCAM diodes.

The Rasnik system can measure alignment using a single camera device taking an image of a special pattern, called a *Rasnik mask*, developed by NIKHEF. The Rasnik instrument can process the image taken by the camera and can calculate position, rotation and magnification of the mask.

The software interface to the LWDAQ hardware driver is via a TCP/IP interface. It is possible to use the existing software tools developed and distributed by Brandeis University or to develop custom software that interfaces directly to the driver using the specific LWDAQ message protocol.

One powerful LWDAQ tool that exists is called *Acquisifier*. With the Acquisifier, it is possible to script a data acquisition cycle that will acquire the desired results from the devices defined in an acquisition script. When the Acquisifier triggers an acquisition of data, it obtains a block of data which is referred to as an image, which is simply a set of data and not necessarily a visual image. This resulting image is then processed and modified to give the required data from the acquisition process.

THE DESIGN

To enable integration of the BCAM and Rasnik instruments into the DCS of the LHC experiments, it was required to develop a new JCOP Framework component to make this functionality widely available to the controls developers. The essential data to be included in the DCS was the result of the analysis of the BCAM and Rasnik images. For instance, in the case of BCAM devices, the retrieved data must include the position of the flashes that were detected in the result image. Support for only the Ethernet variant of the LWDAQ driver was required.

In line with the philosophy of the Framework, to avoid duplication of efforts, it was decided to reuse as much of the existing LWDAQ solution of Brandeis University as possible. After initial analysis of the available tools, it emerged that the Acquisifier would provide almost all of the required functionality. The key features required for the development of the new component included:

- Support for BCAM and Rasnik instruments.
- Ability to script the acquisition process.
- Control to start/stop the acquisition process.
- Monitoring of the current acquisition status.
- Remote configuration, control and monitoring of the Acquisifier software via TCP/IP.

The Acquisifier almost completely covered the needs of the development. One requirement that was not met was that of getting the results sent back to the DCS from the Acquisifier. At that time, the Acquisifier could save results to a file or transmit them to a separate TCP/IP server socket. A decision was taken with the developer of the Acquisifier to add the possibility to return the results through the same TCP/IP socket as used for the Acquisifier control and monitoring. This was added to the tool very promptly and meant that the software could be reused to form part of the solution for integrating LWDAQ into the DCS of the LHC experiments.

PVSS, on which the DCS is based, provides support for several communication technologies and protocols. For the case of TCP/IP, it is possible to access TCP/IP sockets directly from the scripting language of PVSS, called CONTROL, or via the C++ API. In this instance, as high performance was not essential, the CONTROL script solution was chosen. Using CONTROL script has the advantage that compilation is not necessary, particularly recompilation against new library versions when upgrading to a new PVSS version.

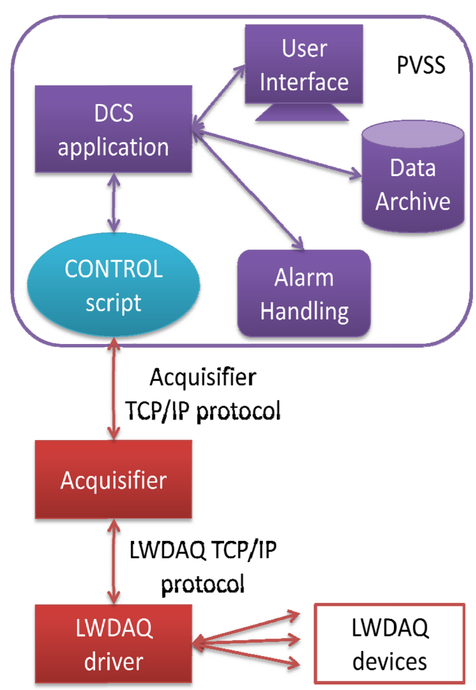

Figure 3: Architecture of LWDAQ integration.

The custom LWDAQ TCP/IP interface to the Acquisifier is a simple, text-based, documented protocol. The bulk of the development effort was to implement this protocol in the PVSS CONTROL script and to retrieve and store the results from the Acquisifier. The final architecture of the integration of LWDAQ into PVSS is shown in Fig. 3.

THE IMPLEMENTATION

Features

The component, called *fwLwdaq*, that was developed for the Framework provides the following key features:

- Creation and deletion of instances of drivers, multiplexers, BCAM and Rasnik devices in the DCS and organisation of these into a hierarchy representing the hardware layout.
- Definition of the pairing of BCAM devices to indicate which one will act as a source and which as a sensor.
- Support for archiving of data in PVSS and configuring of alarms on resulting image data.
- Automatic generation of the acquisition script for the Acquisifier based on the instances configured in the DCS.
- Starting/stopping acquisition, with the option to run the acquisition once or in a loop.
- Feedback on the operation state of Acquisifier.
- Support for the Acquisifier running on a remote PC.

Configuration

The installation of the component is performed with the standard *JCOP Installation Tool*. Once installed, it is possible to create the instances of the devices in the DCS that represent the real hardware. After creating the devices, the next step is to configure the pairing of the BCAM devices and to make any changes to the default image acquisition settings.

Following the configuration of instances in the DCS, the Acquisifier script can be generated automatically.

This Acquisifier script contains the complete configuration needed by the Acquisifier to retrieve the images from the hardware. In addition, it contains specific details that are used in the DCS to interpret the results as they are returned. For example, all results strings are modified to conform to a defined data format, containing a specific prefix and a device name that follows a strict naming convention. This makes it possible for the PVSS CONTROL script to identify and handle the results. After being generated, the Acquisifier script must be copied to the PC where the Acquisifier software is installed.

Operation

In operation, the CONTROL script of PVSS opens up a TCP/IP port to communicate with the Acquisifier. It configures the Acquisifier to use the acquisition script and to return the results to the DCS through the same socket as used for the commands and monitoring.

When the communication is established, a periodic check is made by the CONTROL script to check the status of the Acquisifier. The user can issue commands to start and stop the acquisition at any time.

As the Acquisifier steps through the acquisition script, it gathers the result images from the hardware and transmits it, via TCP/IP, to the DCS. As the PVSS CONTROL script receives the results string, it processes the data and determines which device this data relates to. Then the important alignment values are extracted from the string and written into the instances of the LWDAQ devices in the DCS. From here, alarms can be generated and the data can be archived if necessary.

CONCLUSIONS

Using the features of PVSS and the JCOP Framework, a component supporting the LWDAQ system was made for the controls developers of the LHC experiments.

After requesting a change to the Acquisifier software, it was possible to benefit from the functionality of this powerful software by using it as an interface between the PVSS CONTROL script and the LWDAQ hardware.

The component provides a generic solution for BCAM and Rasnik devices. Controls developers have benefitted from this functionality, quickly implementing applications based on these devices. By distributing the work as a component of the JCOP Framework it has avoided the need for each DCS developer to implement a custom solution, thus avoiding duplication of effort.

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