DEVICE CONTROL IN ALICE

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Abstract

A large variety of equipment and devices are used in the ALICE experiment and a powerful and efficient control system is requested to operate them. In order to assure safe operation, each device needs to be configured, controlled, and monitored and all the data involved must be properly refreshed, monitored and stored. The device control is mainly based on Ole Process Control (OPC) servers, and the Supervisory Control and Data Acquisition (SCADA) system PVSS customized by CERN. This paper describes the device control architecture and how safe and coherent operation is achieved using the OPC server/client technology. It also discusses the impact of the communication performance for large-scale control systems dealing with large amounts of data and how this has been optimized.

INTRODUCTION

ALICE (A Large Ion Collider Experiment) is devoted to heavy ion collision studies, and is one of the four large detectors of the 27 km Large Hadron Collider (LHC) at CERN. The experiment saw the first circulating beams in September 2008 and is preparing for the first collisions before end of the year 2009. The ALICE experiment is composed of 18 sub-detectors (Fig. 1), each with up to 15 different sub-systems, such as high voltage, low voltage, front-end electronics, that need to be controlled with a high level of reliability.

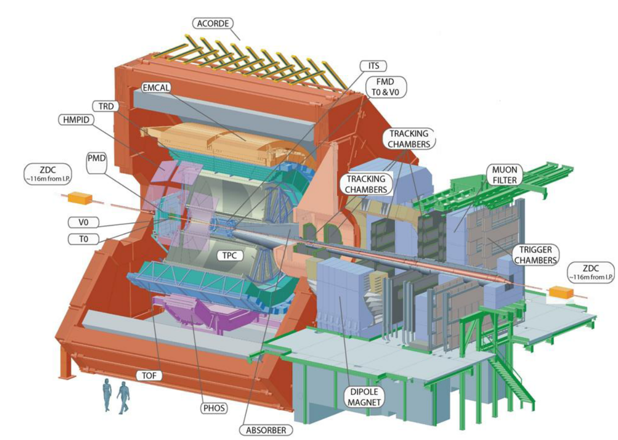

Figure 1: The ALICE experiment.

ALICE DCS CONTEXT

The primary task of the Detector Control System (DCS) is to ensure safe and correct operation of the ALICE experiment [1]. It provides configuration, remote control, and monitoring of all experiment equipments. In order to ensure a coherent control and limit the resources needed to develop it, communalities across the sub-detectors are exploited and common solutions are developed and employed wherever possible. The work of about 100 contributors is coordinated by a small central Alice Controls Coordination (ACC) team. To standardize the development and facilitate the coordination the 18 detectors use CERN recommended hardware and software solutions as far as possible.

The Detector Control System has been designed to allow the operation of all the experiment equipments from a single workplace located in the control room. To achieve a coherent control of all the sub-detectors devices, the ALICE DCS hardware architecture is hierarchically organized. The detector needs in terms of control devices have been identified through User Requirements Documents (URD) [2]. Figure 2 shows an URD overview drawing of the hardware architecture for the Muon Tracker detector.

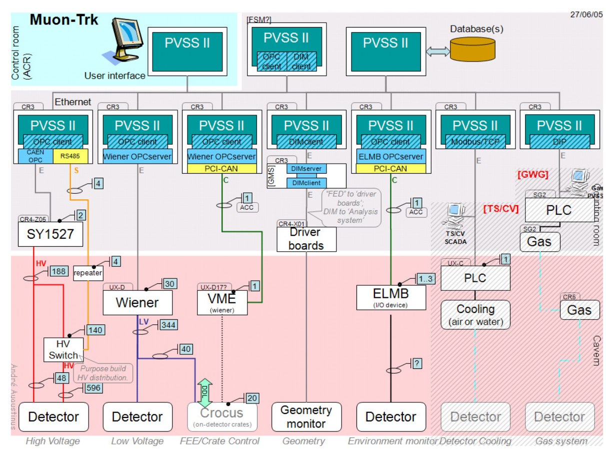

Figure 2: User requirements document of muon tracker.

DEVICE CONTROL LAYERS

The detector control system hardware architecture can be sub-divided in the standard three-tier structure; field layer, control layer and supervision layer. The three layers are inter-connected via a large panel of field busses and communication protocols such as CANbus, RS232 and Ethernet TCP/IP. The ALICE DCS Local Area Network (LAN) ensures safe and protected data transmission between the different layers. More than 1400 devices are connected to this LAN with cable lengths of up to 200 meters.

Field Layer: A Large Number of Devices with Heterogeneous Connectivity.

All the various sensors and devices belong to the field layer. This includes temperature, humidity, magnetic field and radiation sensors which mostly are connected to

Embedded Local Monitor Boards (ELMB). It also includes a large number of Front-End Electronics units with on-board processors and TCP/IP connectivity, high voltage systems with about 3000 channels providing up to 100 kV output and controlled via CANbus as well as low voltage systems with about 200 low voltage devices connected through Ethernet TCP/IP. The low voltage devices have recently been upgraded to support BOOTP and to enable remote firmware upgrading,. Some 50 VME crates controlled through the robust CANbus also belong to the field layer. Other connectivity protocols, such as JTAG for fast data reading and RS232 for exotic devices like Nuclear Magnetic Resonance devices (NMR), tesla-meters, barometers, and voltmeters, are used. Making this large variety of devices transparent to the operator is a major challenge. This is the role of the control layer.

Control Layer: Collect, Treat, Archive, Command

The control layer hosts the Worker Nodes (WN's), the database servers and the PLCs. The task of this layer is to pass commands and settings and trigger actions on the field layer and to collect, treat and archive the information coming from the field layer (i.e. devices). The core components of the control layer are PVSS systems, acting as clients, and OPC's acting as servers [3]. The client/server mechanism is implemented on the worker node computers with Windows XP as operating system. Each detector makes use of several PVSS systems according to their needs. In general one PVSS system is needed for each detector sub-system. For example, the TOF_LV PVSS system corresponds to the low voltage (LV) sub-system of the Time Of Flight (TOF) detector. In total more than 100 PVSS systems are deployed and operated from a single console in the ALICE Control Room (ACR).

Supervision Layer: The Graphical User Interface (GUI)

The Operator Nodes (ON's), where the ALICE User Interfaces (UI's) are running, are part of the supervision layer. They are connected to the control layer through the PVSS distribution managers. Each detector is equipped with an ON remotely connected to the WN systems, and operates through the UI. The connection to the control layer is transparent and the operator feels like controlling all the devices from the UI. The central ALICE ON is located on top of the detectors ON's from where all the experiment devices can be fully controlled and monitored, all the way down to a single device parameter.

SOFTWARE DEVICE CONTROL

The device control software is also sub-divided in a number of layers which are described below. Device control solutions are often shared between the four LHC experiments as well as between the various detectors. Most of these solutions are based on the client/server architecture. For standard industrial devices, the server side is based on the OPC protocol while for the non-standard devices a Distributed Information Management (DIM) server developed at CERN is used. The clients are provided by the PVSS supplier Siemens/ETM [4]. The clients have been customized at CERN and form part of a global software framework. The top control layer is based on the Finite State Machine mechanism implemented within PVSS.

OPC Server / PVSS Client Schema

An OPC server is an abstraction layer between the device hardware and the user. The main vendors of devices commonly used in the LHC experiments provide OPC servers for their equipment. This is the case for most of the high and low voltage power supplies and for the VME crate power supplies. The users of such devices therefore don't need to develop drivers or servers to control their equipment. The server provides, in a set of OPC items, the data available from the hardware and sends the commands to the device. Although OPC servers are very easy to use, they are relatively complex to develop. In addition, as OPC is based on Microsoft's Com/DCOM technology, the OPC client and server only run on Windows platforms. PVSS acts as a client in this schema and provides a generic OPC client. The PVSS clients are developed at CERN within a global software framework.

JCOP and ALICE Framework Components

A framework approach is used to complement the functionality of PVSS and to develop and share tools and components between the LHC experiments at CERN. This development collaboration called "Joint COntrol Project" (JCOP), identifies common needs and provides standard solutions [5] for configuration, monitoring, trending, alerts handling, access control, storage, etc. The JCOP framework enables non-expert users to rapidly develop and set up their controls solutions. Framework components are available for the devices most commonly used in the LHC experiments.

Once the PVSS framework is installed the user can setup and control a device simply by clicking or pointing. Only basic knowledge of PVSS and the OPC server is required to setup and operate quite complex devices. Each OPC item providing data from the hardware is automatically mapped onto one or several PVSS process variables called datapoints. The datapoints contain all the relevant information coming from the device such as measured voltage, current, temperature, versions, alarms, etc.

On top of the JCOP framework an ALICE framework is added. It contains all the ALICE specific components, tools and guiding rules for the ALICE controls community. Should an ALICE specific component become of interest to other LHC experiments it will be integrated in the JCOP framework. This is the case for the object libraries of a high voltage device used in ALICE. [6].

VME CRATE CONTROL

In this chapter the control of VME crates is described to illustrate the device control concept of ALICE.

In ALICE about 50 VME crates are used and they are located partly in the ALICE experimental cavern 50 meters below ground and partly in the counting rooms on the surface. The crate power supplies are equipped with two types of cooling; water cooling for those in the cavern and conventional fan cooling for those in the counting rooms. Water cooling is required due to the presence of stray magnetic fields in the experimental cavern that make fans inoperable.

Interface Standardisation

Thanks to a major standardization effort at CERN all the VME crate power supplies required for the four LHC experiments were set to be equipped with a CANbus interface for its remote control. Furthermore, since at the early stage of the ALICE controls project the future of PCI was uncertain, it was decided to go for USB as interface at the computer end. Therefore, as CANbus is widely used in all four LHC experiments it was decided to develop a CAN to USB adaptor at CERN. The ALICE VME crate power supplies are therefore connected to the control layer via CANbus and hooked to the Worker Node computers via a CAN to USB adaptor.

VME Crate OPC Server / Framework Client

The schema consisting of PVSS clients communicating with OPC servers provides powerful means for controlling the VME crate systems in ALICE. A dedicated OPC server is provided by the VME crate supplier for this device. In order to ease its integration in PVSS an accompanying JCOP framework component has been developed. The OPC server and its corresponding framework component are installed on the Worker Node computers allowing users to develop their controls applications. The framework component also provides means for expert monitoring.

The aliVME Framework

In order to further ease the work of the applications programmer an additional ALICE-specific VME crate component "aliVME" is installed on top of the JCOP framework component. It contains a Finite State Machine (FSM) implementation, an object library and a reference application panel.

The FSM implementation provides global status information such as READY, NOT READY, ERROR, NO_CONTROL, etc. The object library consists of atomic monitoring and control elements easy to use when building user application panels. In this way a secure application is obtained with standardized look-and-feel. A trending tool and an access control mechanism also accompany the object libraries.

Central Monitoring of the VME Crate Device

The VME crate owners each monitor their crates using their applications panels. A main operator panel offers in addition a logical view representing the VME FSM state of each detector (as shown in Fig. 3) and a geographical view representing the racks and which allows for localizing each VME crates.

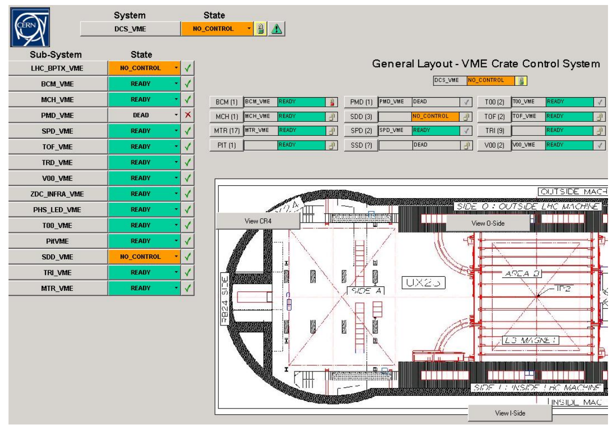

Figure 3: VME crates central monitoring.

CONCLUSIONS

The hardware architecture of ALICE, with as many as 18 different sub-detectors and a large variety of devices, can be considered as complex and the integration of all the heterogeneous devices has been a major challenge for the controls team. However, during the latest cosmic runs the device control has proven to work very well and one can consider that the challenge has been met.

This is the fruit of strong standardization efforts straight from the beginning, both in terms of hardware and software, and thanks to the choice of a suitable industrial standard complemented by a common framework solution.

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