MANAGING INFRASTRUCTURE IN THE ALICE DETECTOR CONTROL SYSTEM

M. Lechman[1], A. Augustinus[1], P. M. Bond[1], P. Chochula[1], P. Rosinsky[1], O. Pinazza[1, 2], A. Kurepin[1, 3]
[1]CERN, Geneva, Switzerland
[2]INFN-Bologna, Bologna, Italy
[3]RAS/INR, Moscow, Russia

Abstract

The main role of the ALICE Detector Control System (DCS) is to ensure safe and efficient operation of one of the large high energy physics experiments at CERN. The DCS design is based on the commercial SCADA software package WinCC Open Architecture. The system includes over 270 VME and power supply crates, 1200 networked devices, over 1,000,000 monitored parameters, as well as numerous pieces of front-end and readout electronics. This paper summarizes the computer infrastructure of the DCS as well as the hardware and software components that are used by WinCC OA for communication with electronics devices. The evolution of these components and experience gained from the first years of their production use are also described. We also present tools used for monitoring the DCS infrastructure and for supporting its administration together with plans for their improvement during the first long technical stop in LHC operation.

INTRODUCTION

ALICE (A Large Ion Collider Experiment) [1] is one of the big LHC (Large Hadron Collider) detectors at CERN that is optimized to study quark-gluon plasma generated from Pb-Pb nuclei collisions.

ALICE consists of 18 sub-detectors constructed by different research institutes taking part in the project. All these subsystems have dedicated control systems implemented using the commercial SCADA package WinCC Open Architecture (WinCC OA) [2].

The central Detector Control System (DCS) [3] integrates all the sub-detectors and allows operating the whole experiment in a safe and efficient way from a single workspace in the ALICE control room.

The DCS also provides many services (like rack management, B-field and environment monitoring, etc.) as well as the exchange of information with many other critical systems (e.g. responsible for magnets, gas, safety, etc.).

The supervisory and control layers of the DCS have been implemented largely from common software components developed jointly by all the LHC experiments and CERN Engineering Department within the Joint Controls Project (JCOP) framework [4].

In order to hide the complexity of the detector (over 1,000,000 monitored parameters) from the operator, the hierarchy of control units has been built using the SMI++ package [5] implementing a concept of finite state machine.

HARDWARE INFRASTRUCTURE

The field layer of the DCS includes various types of equipment - HV and LV power supplies, VME crates, ELMBs [6], PLC controllers, power distribution units (PDU) controlled via Ethernet and front-end and readout electronics (FERO) of particular sub-detectors. In total, there are over 1200 networked devices and over 270 VME and power supply crates.

An important part of the infrastructure is the computer cluster with over 200 machines serving to host worker and operator nodes of the control system as well as supplementing services like the archive and configuration database, booting servers for diskless cards, file servers, network gateways, etc.

Connectivity

Most of the devices are connected via Ethernet, nevertheless, there are also different industrial buses (CAN, RS232, Profibus, Modbus, JTAG) being used for communication with the equipment. It has been necessary to install and validate an additional layer of hardware interfaces (e.g. CAN-to-USB) for these non-networked devices, so that they could be linked with the control servers. That additional complexity has resulted in an increase in the effort required for providing support for the system. Fortunately, one can observe on the market that more and more industrial hardware is equipped with network cards. Thus, in the future it should be possible to gradually replace ageing devices with such equivalents.

The DCS uses a private computer network isolated from the CERN general domain for safety reasons. The CERN IT department provides and manages the network infrastructure.

Standardization

Despite substantial differences in designs of particular sub-detectors, a big emphasis has been placed on the standardization of all the hardware components, aiming to minimalize the total cost of their maintenance during the whole lifecycle of the LHC project. Thanks to this policy it was possible to limit the number of various types of equipment (e.g. there are only 3 power supplies vendors). The key to success included regular reviewing of the requirements and the proposing of common solutions by the central DCS team from the beginning of the project.

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The standardization also allowed well defined processes, relating to the service and support of the hardware, between the ALICE experiment, the main vendors and the CERN Electronics Pool service (provided by the PH-ESE group) with a role of a broker.

Evolution

From the point of view of devices, the biggest changes in the DCS infrastructure have been triggered by the evolution of computer architecture and operating systems. During the first long shutdown in the LHC operation (LS1), the DCS cluster will be migrated to Windows Server 2008 R2 and CERN Scientific Linux v 6.

As a result of these changes, existing PCI cards must be replaced by their USB equivalents and all the drivers need porting and validating on the new operating systems. For the moment, laboratory tests of these new components are satisfactory but full regression tests (including performance) will have to be done on the production setups.

SOFTWARE

The OPC (Open Platform Communications) [7] protocol has been selected as the software standard to communicate with the devices. In the ALICE DCS there are 48 instances of OPC servers in use that, in total, exchange data via over 180,000 OPC items.

Software maintenance contracts were signed between CERN and the key vendors of the devices to formalize rules of support and further development of the OPC servers.

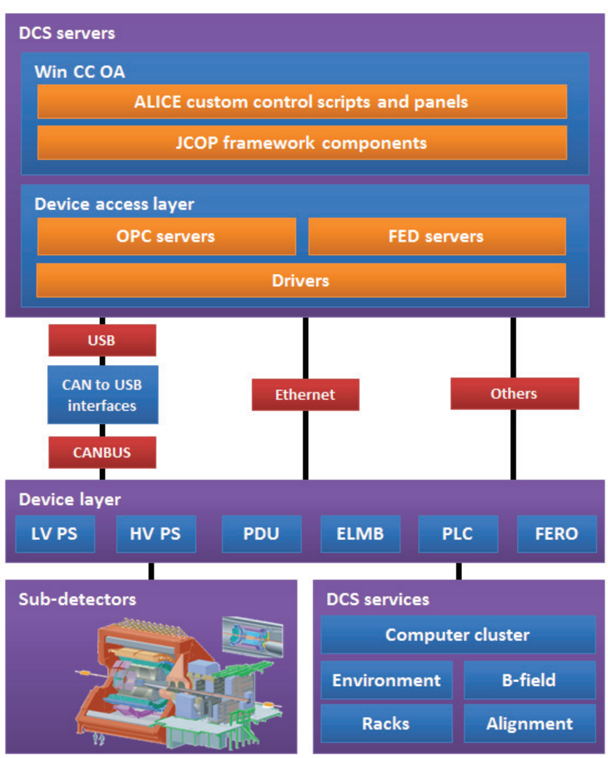

Figure 1: Integration of devices into ALICE DCS.

Since FERO hardware is specific for every sub-detector, it has been necessary to standardize its integration with the control layer. Therefore, an additional abstract layer was introduced: Front End Device (FED) [8]. The FED servers and WinCC OA communicate via CERN DIM protocol [9]. This architecture was adopted for integrating devices without OPC access.

The full context of the devices in DCS is illustrated in Fig. 1.

INFRASTRUCTURE MONITORING

The monitoring of the DCS devices is realized mostly at the WinCC OA level via JCOP framework components and custom ALICE panels. Despite the overall complexity of the control system, it is very easy to notice any possible failure and to locate its source in the hardware. This was achieved thanks to the alert mechanism and organization of sub-systems into hierarchies of logical and device units.

Centralized monitoring of the machines and processes running on them (including WinCC OA managers and OPC servers) is performed via the JCOP System Overview Tool [10]. The configuration data used by this tool is stored in the framework System Information database [11].

Supervision of the computer cluster is also performed via the Intel Server Management (ISM) and Microsoft System Center Operations Manager (SCOM) tools.

MANAGING INFRASTRUCTURE

Due to a big number of hardware elements in the ALICE DCS, it was necessary to prepare dedicated software for their efficient administration. The most important of these tools are described below.

Detector Construction Database (DCDB)

The aim of the DCDB system [12] is to provide a universal repository for parts that exist in the ALICE detector. This storage is based on a generic data model that allows defining new types of components (together with attributes) and creating their hierarchies.

A naming convention has been prepared for assigning a unique identifier to every registered part in the system [13] to allow proper labelling of the hardware.

In the past, industrial software for printing labels was being used. However, recently, due to its high maintenance costs and relatively low demand on new labels after the main construction of ALICE sub-detectors finished, it was decided to replace it with a Microsoft Office package.

The DCDB is mainly used to manage occupancy of the racks and as a repository of data about the cabling that is loaded from operational spreadsheets. However, there are plans to include additional information about the DCS infrastructure, e.g. about CAN-to-USB interfaces, versions of firmware and OPC servers used in particular setups, etc.

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Component Information Service (CIS)

The CIS is a web application that has been created in order to provide a common interface to all the aforementioned data sources containing information about the devices used in the DCS..

This new tool has been developed using Oracle APEX technology and it has been integrated with CERN SSO (Single Sign On), LDAP and E-Groups mechanisms to provide authentication and authorization of the users.

Access to the data stored in the System Information database has been implemented via mechanism of Oracle database links.

Using the CIS interface, it is also possible for a particular component to easily obtain information from the CERN LAN database (LANDB) that keeps the track of all devices connected to the network.

The layout in the CIS application has been optimized so that it can be easily operated from mobile devices. The labels for new devices will contain QR codes to enable quick access to relevant data via the CIS interface to all users equipped with smartphones.

The main information flow using Component Information Service is presented in Fig. 2.

CONCLUSIONS

The successful implementation and operation of the DCS in ALICE proved that the design of the system and the introduced standards were efficient.

Due to the complexity of the system there is still room for improvement in terms of tools that could support administrative and maintenance tasks.

It is envisaged to extend the functionality of the Component Information Service and to invite other ALICE groups in the future to assess its usefulness in their projects.

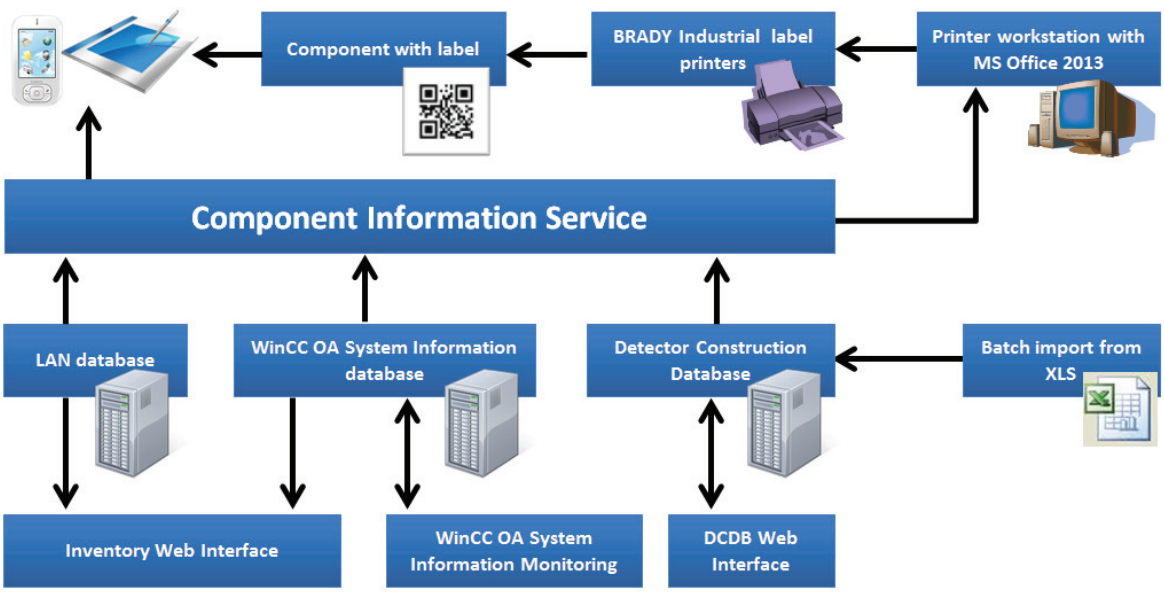

Figure 2: Flow of information from components using Component Information Service.

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