THE ALICE CONTROL SYSTEM – A TECHNICAL AND MANAGERIAL CHALLENGE

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Abstract

ALICE (A Large Ion Collider Experiment) is one of the four detectors at the CERN Large Hadron Collider (LHC) currently being built and due to start operations in 2007. The development and construction of its Detector Control System (DCS), which involves people from the entire world-wide collaboration as well as many infrastructure and service groups at CERN, poses many technical and managerial problems. This paper describes some of the technical and managerial challenges involved and the strategies and methods the ALICE Controls Coordinating team (ACC) has adopted to face them. An implementation example is also described.

INTRODUCTION

The ALICE experiment is dedicated to heavy ion physics, however it will also fully participate in the proton-proton physics program of LHC. The detector is designed to be general-purpose and sensitive to the majority of known observables and many different detector technologies and detector types are represented. As a result ALICE is composed of as many as 18 different sub-detectors which are being built by about 1000 people from 80 institutes in 30 countries.

The Control System, which can be seen as the neural system of the experiment, has to be present throughout the detector and interface and control a wide variety of complex devices and systems and be available continuously during physics as well as shutdown periods. A well designed and performing Control System is crucial to the overall performance of the experiment including the quality of the physics data. The challenges involved and how the collaboration is facing them will be developed in the following sections.

CONTROLS CHALLENGES

The main task of the Controls System is to enable operation of the entire experiment from a single workplace in an efficient and reliable way. The operator must be able to supervise and control each part of the experiment in a coherent and easy way despite the large number and the variety of devices and systems involved. Each sub-detector is composed of several sub-systems, such as High Voltage (HV), Low Voltage (LV), Front End Electronics (FEE), etc., for which control interfaces and applications must be provided. Furthermore, a range of services, such as gas, electricity, water, cooling & ventilation, magnets, safety and the infrastructure services need to be controlled. The Control System also need to interface to other detector systems, such as Data Acquisition (DAQ), Trigger (TRG), High Level Trigger (HLT) and Offline systems as well as to the LHC machine. Figure 1 below shows how much the Back-end of the Control System constitutes a cross-road between sub-detectors, services and external systems and obtaining a homogeneous and coherent approach to all the various partners involved is a major challenge.

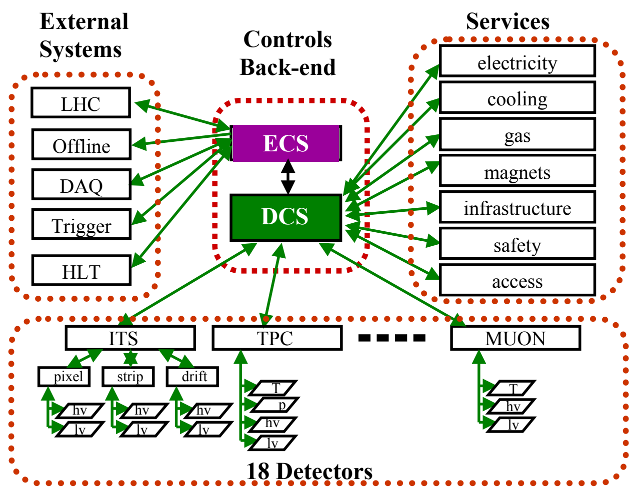

Figure 1: Controls Context

The physical size of the ALICE detector is about the same as the previous generation of LEP experiments, however the number of channels and parameters to control has increased considerably due to the use of highly integrated components. The Controls System therefore has to cope with large amounts of data. A typical example is the TRD sub-detector, which requires about 250 MB of data to configure its Front-End Electronics (FEE) including 540 Linux systems and 250 000 MIMD processors placed on the detector.

The tracking performance of some of the sub-detectors is strongly temperature dependent and in certain cases a temperature stability of 0.1^{0}C over large volumes is required. As these sub-detectors are exposed to potentially large heat sources; about 350kW is dissipated inside the closed volume of the ALICE solenoid; it is very challenging to guarantee such high stability and it imposes 'state of the art' cooling and controls techniques.

The access to sensors and detector electronics inside the ALICE solenoid is very difficult due to the compact and layered detector construction and will only be possible during shut-down periods. Furthermore, the entire underground experimental area, which houses a large amount of devices, controllers and communication equipment, is not accessible during the physics runs. Further constraints are imposed as these locations will be exposed to radiation and magnetic fields. This imposes that high reliability components are used and redundancy techniques are employed.

The 18 sub-detector groups, each with members from many physics institutes in different countries, are responsible for building the sub-detectors including the required controls functionalities. As many of the participating physics institutes are relatively small and do not have access to controls specialists, the controls work is often handled by the detector physicists on part-time basis. As a result very many people, often non-specialists, are contributing to the development and construction of the Controls System and it is a major managerial challenge for the small team based at CERN to coordinate and lead the project and obtain a homogeneous and coherent system.

Each sub-detector is master of his own budget and decides which devices or equipment to use. Any detector-wide decision which might have financial impacts, such as the use of common standards and devices, can not simply be imposed but are subject to negotiations. Furthermore, the timescale is relatively short since, on one hand, the controls requirements only can be defined once the sub-detectors are defined, and on the other hand, the controls must work before the sub-detectors are installed.

STRATEGIES AND METHODS

To limit the dispersion of solutions and to reduce the development effort the obvious overall strategy is to use common tools, common components and common solutions wherever possible. Certain communalities exist between all four LHC experiments and for this a framework of tools and components is being developed by the Joint Control Project, JCOP [1].

Further standardization is applied within the ALICE collaboration and this effort is described here. This relies on the ACC team which, on one hand participates in the JCOP activity and, on the other hand has strong links to the sub-detector users.

In the sub-detectors many similar types of sub-systems need to be controlled, such as High Voltage and Low Voltage systems, cooling systems, etc., for which common components and solutions possibly could be used. To enable the identification of communalities it was decided to systematically collect the controls requirements for each sub-system involved by establishing User Requirements Documents (URD's). Defining the controls requirements is a long and iterative process since it goes hand in hand with the sub-detector design. The URD's are therefore conceived to be light-weight working document which allows the sub-detector user to write down his knowledge of the sub-system requirements as the sub-detector development advances and to communicate them to the coordinating team and to other sub-detector users. The URD's are used as repositories of knowledge on all the sub-systems and enable the identification of communalities across sub-detectors for which common solutions then can be developed. They favor the exchange of information between the sub-detectors users and they foster a common language, common definitions and common standards straight from the beginning of the project and this naturally leads to a coherent approach and a homogeneous system.

COMMON SOLUTIONS

Figure 2 shows the hierarchical treelike software architecture [2] which has been defined to represent the Controls structure from physical devices via sub-systems and sub-detectors to the detector level at the top.

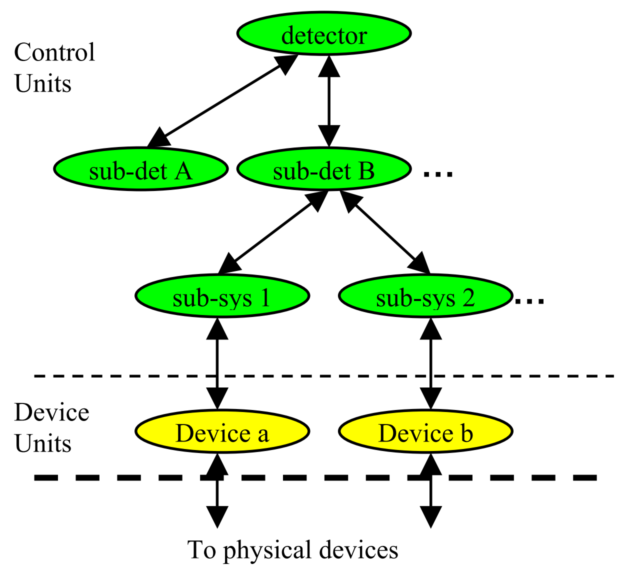

Figure 2: Hierarchical software architecture

The software structure, which is built within the PVSS SCADA system [3], is composed of two basic building blocks; a Control Unit (CU) and a Device Unit (DU). The functionality of the CU is based on a Finite State Machine (FSM) model and can be described by a state-transition diagram. The CU receives commands from its parent CU, transform them to commands for its children via the FSM mechanism and, at the end of the tree the DU passes a command to the hardware or software device. In a similar way but in the opposite direction, status and alarm information flow up from the device via the DU's and CU's to the supervisory application at the top. The DU's and CU's also provide the access to configuration and logging databases and take care of the access and alarm handling as shown in figure 3.

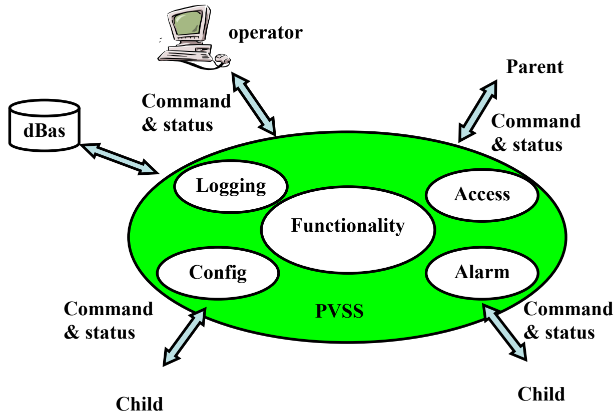

Figure 3: A Control Unit (CU)

Controls slices for more than 100 sub-detector sub-systems need to be developed, each represented by a CU and one or more DU's. The aim is to standardize and use common solutions as far as possible. At the device level the sub-detector users are encouraged to use similar types of devices whenever possible and common specifications are developed for devices to be purchased such as LV and HV supplies. Manufacturers are in this way asked to provide standard controls interfaces based on OPC and CERN standard field-buses. For the Front-End Electronics (FEE), which is custom made for each sub-detector, a standard software interface is defined and this is described in the next section.

Common solutions should however not only consist of standard interfaces to popular devices but should furthermore concern the entire CU such that standard CU's are defined for the most common sub-systems.

Standard FSM's are therefore being defined and developed for each type of sub-system. In this way a common HV FSM has been defined which is valid for all sub-detector HV sub-systems independent of the hardware device involved.

Standard interfaces to configuration and logging databases are provided as well as common solutions for access and alarm handling.

At present some 10 standard CU's and DU's are being developed for the most common sub-systems and devices. In this way the total need is reduced to 10 common and about 15 specific solutions

CONTROL OF FRONT-END ELECTRONICS

The Front-End Electronics (FEE), which mostly is located on the physics detector itself, is customized to the particular needs of each sub-detector and therefore each of the 18 sub-detector FEE's are different. Since the FEE's were conceived at an early stage, before any controls standards had been defined, no common low level interface to the Controls System was foreseen.

In order to still achieve maximum communality a Front End Device (FED) has been defined which integrates the low level differences between all different FEE's. A common DIM [4] client-server software interface has been adopted which makes implementation details transparent to higher software layers. The server has a common part which recognizes and executes commands and publishes services common to all FEE's and it has a part where commands and services are specific to a particular FEE. An example of the implementation for the SPD sub-detector is shown in figure 4. The SPD FEE consists of a VME router module which communicates with the Pixel Halfstave Multi Chip Module over a JTAG connection [5].

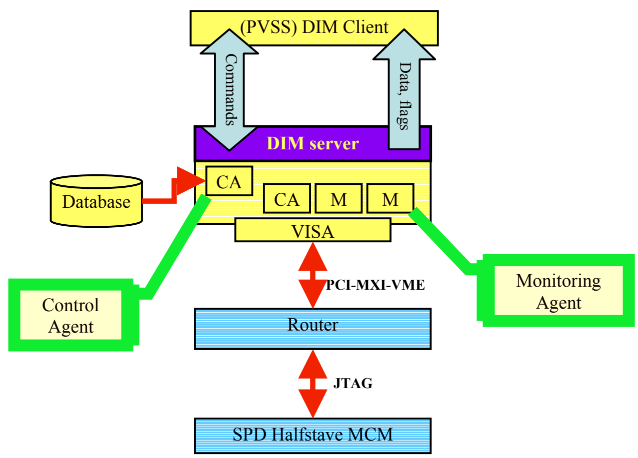

Figure 4: Control interface for the SPD FEE

CONCLUSION

The development and construction of the Controls System involves many technical and managerial challenges. ALICE benefits from the work performed in common with the other three LHC experiments whereby tools and components are developed in the framework of JCOP. In addition, within the collaboration a strategy has been adopted to develop and share common solutions as far as possible. This saves manpower and money but it is also essential for obtaining a coherent and homogeneous system.

REFERENCES

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