THE ALICE DETECTOR CONTROL SYSTEM, READY FOR FIRST COLLISIONS

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Abstract

ALICE is one of the four experiments at the Large Hadron Collider (LHC), CERN (Geneva, Switzerland). The commissioning of the LHC in 2008 allowed the experiment to record the first particle induced events and is now preparing for the first collisions foreseen autumn 2009. The experiment is composed of 18 sub-detectors each with numerous subsystems that need to be controlled and operated in a safe and efficient way. The Detector Control System (DCS) is the key for this. The DCS system has been used with success during the commissioning of the individual detectors as well as during the cosmic runs and the LHC injection tests that were carried out in 2008. It was proven that through the DSC a complex experiment can be controlled by single operator. This paper describes the architecture of the Detector Control System and the key components that allowed to come to a homogeneous control system. Examples of technical implementations are given. Improvements that have been implemented, based on a critical review of the first operational experiences are highlighted. It will report on the current status and operational experiences leading up to first physics collisions.

INTRODUCTION

ALICE (A Large Ion Collider Experiment) is a general purpose heavy–ion detector installed on the 27 km Large Hadron Collider (LHC) at CERN. The experiment is designed to study the physics of strongly interacting matter and the quark–gluon plasma in nucleus–nucleus collisions. Data taking during proton-proton runs will provide reference data for the heavy-ion programme and address a number of specific strong-interaction topics for which ALICE is complementary to the other LHC experiments.

The experiment (Fig. 1) is composed of 18 sub-detectors and the collaboration currently involves over 1000 physicists, engineers and technicians from 111 institutes in 31 countries. The overall dimension of the detector is 16x16x26m3 with a total weight of approximately 10 000 tons.

The operation of the experiment relies on several independent online systems. Each responsible for a different domain of activities: The Detector Control System (DCS) for the control and safety of the experiment; this will be described in detail in this article. The Data Acquisition (DAQ) system is responsible for the readout of the physics data for event building and for data transport. The Trigger (TRG) system selects the interesting events and triggers the readout of the sub-detectors. The High-Level Trigger (HLT) system performs online reconstruction of data in order to reject or tag events and to allow for data compression.

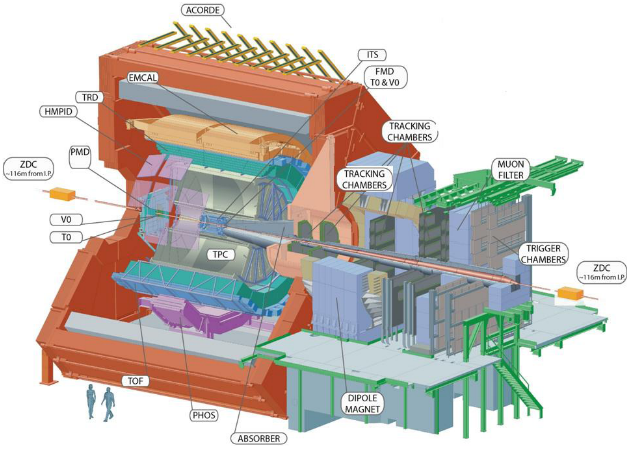

Figure 1: The ALICE detector.

THE DCS IN ALICE

The main task of the Detector Control System in ALICE is to ensure safe and correct operation of the experiment [1]. It provides configuration, remote control and monitoring of all experimental equipment to allow the entire experiment to be operated from the ALICE Control Room (ACR) at LHC point 2, through a unique set of operator panels. The DCS provides the optimal operational conditions so that the physics data taken by the experiment is of the highest quality. The control system has been designed to reduce the downtime of the experiment to a minimum and hence contribute to a high running efficiency. It also maximises the number of readout channels operational at any time.

The DCS handles the handshake with the LHC accelerator to make sure the ALICE detector is always in a safe state, compatible with the accelerators operational cycle. Through the Experiment Control System (ECS), a controls layer on top of the other online systems, the DCS provides the means to synchronise the whole of the experiment with the LHC operation (see Fig. 2 for the context of the DCS within ALICE).

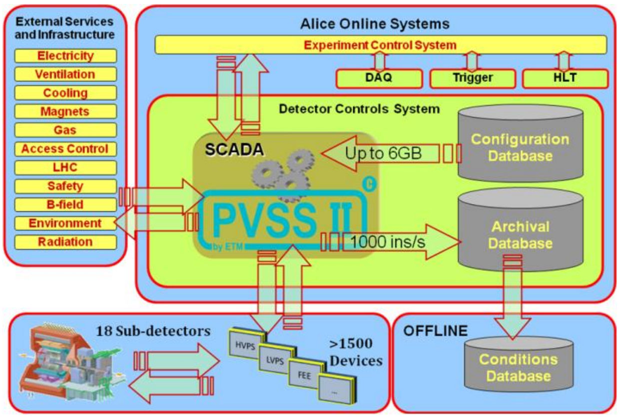

Figure 2: The DCS context in ALICE.

The sub-detector control systems are provided by the contributing institutes; this work of over 100 developers from all around the world and from various backgrounds is coordinated by a small central ACC team (Alice Controls Coordination). The core of the controls system is a commercial Supervisory Control and Data Acquisition (SCADA) system: PVSSII [2]. It controls and monitors the detector devices, provides configuration data from the configuration database and archives acquired values in the archival database. It allows for data exchange with external services and systems through a standardized set of interfaces.

In order to complement the PVSSII functionalities, a software framework has been built around PVSSII. It provides tools and guidelines for easy implementation of the detector control systems. The core of this framework is built as a common effort between the LHC experiments, in the context of the Joint COntrols Project (JCOP) [3]. The main tools cover Finite State Machine (FSM), alarm handling, configuration, archiving, access control, user interfaces, data exchange and communication. To cater for specific ALICE needs, the JCOP framework is complemented by components specific to ALICE. The complete ALICE framework is used by the sub-detector experts to build their own control applications, such as high voltage control, front-end electronics control, etc. Well over 100 such applications are finally integrated to for a large and global ALICE control system.

THE DCS ARCHITECTURE

The device control framework, part of the above mentioned framework, is used to build the so called system plane (as depicted in Fig. 3). This plane adheres to the classical three tier architecture.

The field layer connects to the devices such as power supplies, monitoring devices, Front End Electronics etc. For device communication industrial standards (OPC) or well established CERN developed (DIM,[4]) protocols are used. In ALICE a total of around 1200 networked devices and over 250 VME crates and networked power supply crates can be found.

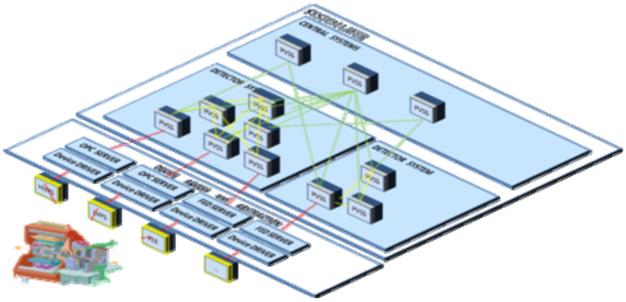

Figure 3: The ALICE DCS System plane.

The controls layer consists of around 100 computers and a number of PLC and PLC-like devices. The control layer is built with the above mentioned framework based on PVSSII. Each PVSSII application runs a well defined controls task. The tasks are strictly separated per sub-detector to avoid cross-dependencies. Within a sub-detector the topology is arbitrary, and mainly defined by hardware resources needed for a given control task. The so called PVSSII projects form a distributed PVSSII system per sub-detector. The central system is a distributed system of sub-detector systems.

The supervisory layer provides the operator interfaces separating the interactive tasks from the control tasks.

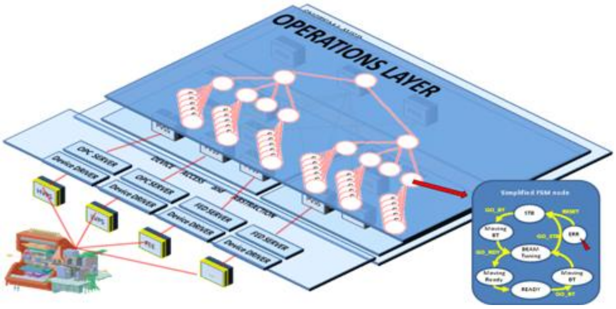

Figure 4: The ALICE DCS Operations plane.

A tree like, hierarchical operations layer is built on top of the system layer (see Fig. 4). The behaviour and functionality of each unit in the control tree is implemented as a finite-state machine (FSM). The finite-state machine concept is a fundamental component in the control system architecture. It is an intuitive, generic mechanism used to model the functionality of a piece of equipment or a sub-system. The object to be modelled is thought of as having a set of stable 'states' between which it can transit and execute 'actions'. The transitions are triggered either by commands from an operator or by other objects above ('parents') or by state changes of objects below ('children').

FIRST OPERATIONAL EXPERIENCE

Installation of the DCS infrastructure and its first systems started early 2007, and detector systems were commissioned during 2008. In individual integration sessions with experts from each detector all systems were validated and integrated in the ALICE DCS. In common sessions groups of detectors were operated by a single central operator. Thanks to careful coordination and extensive commissioning the ALICE DCS was fully operational before the LHC startup in September 2008 and allowed for a successful and safe operation of the experiment with first beams.

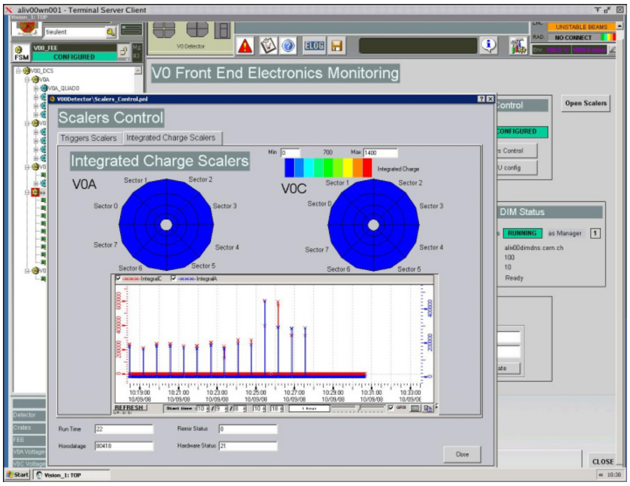

Figure 5: Evidence for first circulating beam.

Scalars read by the V0 DCS system were the first experiment signal to confirm the first circulating beam in LHC on 10.09.2008. The lower peaks seen in Fig. 5 show bursts of particles going through ALICE, but were stopped just before completing a full turn. Removing the last beamstop made the protons pass twice through ALICE, doubling the number of detected particles in the V0 detector.

During this first running period several points were identified that would need attention to be able to move to single operator operation. With all detector experts present for this first operation these points were not a real issue during this running period. However for centralised operation such things as an easy configuration of all systems and documentation for non-expert operators are essential.

TOWARDS CENTRAL OPERATION

Central Configuration

Before the start of each run, for each detector a configuration has to be applied to all sub-systems according to detector role and run type. Initially this will be done by detector experts. All such configurations are stored in the configuration database.

Figure 6: Expert preparing and tagging configurations.

Detector experts can tag well tested configurations suitable for a given run type with self explaining tags, and make them visible for non expert operators (see Fig. 6).

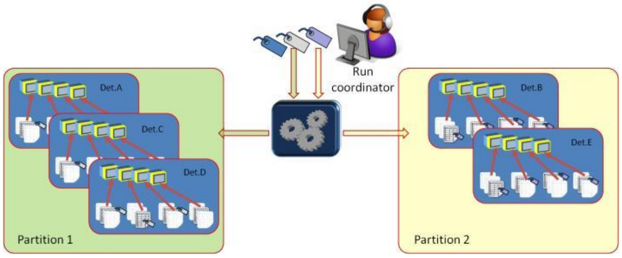

Figure 7: Non expert operator using tagged configurations.

The run coordinator decides on the data taking program, composition of the running partitions and the configuration of each partition. By selecting the appropriate tag for each partition the configuration tool configures all detectors in the partition (see Fig. 7).

Documentation for Non-expert Operators

A major effort is underway to collect all documentation and instructions to allow a non-expert, central operator to operate the experiment. This is much more a managerial challenge than a technical one.

LOOKING FORWARD TO FIRST COLLISIONS

On 28.09.2009 or the first time ever, lead ions have arrived at the doorstep of the LHC. Lead ions were extracted from SPS into the TI2 transfer line towards LHC and dumped at the end of the transfer line. Located 200m downstream of this dump, ALICE observed the secondary muons: the first heavy-ion induced events in LHC.

LHC is now gearing up for first injections tests, with first beam through ALICE expected on 25.10.2009. The Detector Control System is ready to ensure the safe operation of the detector during these tests, and is well prepared to allow central operation of the experiment to welcome the first physics events mid-November.

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