INTEGRATION OF THE PROCESS CONTROL SYSTEMS FOR THE AUTOMATION OF THE LHC COOLING AND VENTILATION PLANTS

D. Blanc, CERN, Geneva, Switzerland

Abstract

For several years ST/CV at CERN has amassed considerable experience in designing and operating cooling and ventilation plants for the particle beam accelerators and physics experiments. To achieve optimal plant operating conditions a complete study of the control objectives is required. This implies to define carefully the control architecture at the beginning of the process control design stage. The process control design stage integrates the cooling and ventilation requirements, taking into consideration various and complex industrial processes organised in a large geographical disposition. The fact of rejecting specific solutions, and therefore marginal processes, allows opting for industrial control architecture, which are more flexible and capable to cope with the continuous technical evolution provided by industry. In the context of the LHC project ST/CV has produced, in collaboration with other control-oriented groups, a concept of control architecture, oriented towards PLC standards, TCP/IP Ethernet communication links and local monitoring. One major consideration is that this architecture is designed to gradually and smoothly integrate process control projects for the LEP to the LHC migration of the ST/CV plants. In this paper we present the characteristics and the requirements of the ST/CV processes and describe the control architecture currently in use.

INTRODUCTION

Previous history

The Large Hadron Collider (LHC) currently under construction makes use of essential cooling and ventilation systems for the surface and underground technical infrastructure, including dedicated technical facilities for the different experiments. The CERN ST/CV group is completely responsible for the design of the cooling and ventilation plants including the installation, commissioning and maintenance phases. The preparation of the first call for tenders documents started in 98 with the air conditioning of the LHC surface buildings. Accordingly the large ST/CV technical infrastructure of classical industrial nature required an associated process control architecture model based on industrial standards.

Control strategy

A well-engineered design will result in a design strategy that takes maximum advantage of the benefits available from opening the design. This must be associated with an open and global approach based on well-known industry standards, applied in a way that we will go far toward the desired results.

The ST/CV process control architecture is traced to give high level of performance with alternatives for the Technical Control Room (TCR) integration, support, maintenance and further upgrade. Accordingly ST/CV produced for the purpose of the various calls for tender a standard document incorporated to the technical specification. The objective of this document is to provide the contractors with a homogeneous framework for the process control system along the LHC construction. The framework is a collection of tools, mechanism and procedure that allow the implementation of PLC and SCADA software application programs in the control architecture. The contractor uses this framework in order to provide coherent systems over the CERN ST/CV projects.

Major objectives

Today the plant operation is faced with ever-increasing pressure to improve efficiency, quality and productivity. Without making fundamental changes to their processes, improvement can usually be made with the control technology by using appropriate industrial components. The ST/CV control system projects have to be in accordance with a global vision of the environment. The following requirements were identified in 1998 for the study phase of the ST/CV control system architecture [1]:

- Openness: Capability of integrating various and complex Industrial Processes, taking into account the further migration of old decade technology control architectures
- Networking: Capability of integrating processes with a very high degree of geographical distribution to ensure inter-point communication.
- Powerful local supervisory tools: Consolidation of the local supervisory stations as core of the process control system architectures.
- Well-adapted operation and maintenance tools: Capability of fast trouble diagnosis combined with the need of operating the ST/CV complex processes with a more demanding performance in terms of reliability and precision.
- Integration in the TCR monitoring system: Capability of integration in the TCR (Technical Control Room) Technical Data Server by developing and maintaining the appropriated software interfaces.

KEYS TOWARD HOMOGENEITY

General consideration

There is no general solution to cover all the particularities, which result from a global ST/CV process engineering, at least for the most relevant problems. The criteria to create suitable solutions and produce well-adapted control architecture must identify the major constraints and define the proper process integration strategy. For that matter ST/CV group has adopted a similar architecture for the control of all processes including the migration of the process control system for the LEP ventilation into the LHC configuration [2].

ST/CV requirements

The design of plant equipment and therefore a control and automation system is essential to ensure a profitable plant operation [3]. A well-designed control and automation system facilitates the operation, maintenance and upgrades. The complete study of the ST/CV process control system requirements lead us to reject specific solutions adapted to each process. At the contrary the proposed solution provides a global and homogeneous solution capable of following the fast evolution of the technology and the environment. Besides the aspects of the operation and maintenance bargain have been carefully analysed. Subsequent needs have been clearly identified and integrated in term of rationalisation and optimisation. The main conclusion of our analysis is to confirm that keys toward homogeneity cannot be achieved if the following recommendations are not completely observed:

- Industrial standard: The control architecture must be composed of CERN recommended components [4] [5].
- Flexibility: The control architecture must be scalable and modular.
- Reference model: The reference model exhibits all the software & hardware aspects of the control architecture.
- Process integration: There is no marginal and particular solution. The ST/CV Process control integration must be done considering the reference model.
- Technical Evolution: Importance is given at all levels to ease the up-to-date control systems with the lowest effort to contribute toward a cost effective maintenance
- Robustness: The technical innovations must be restricted and well integrate the rest of the control system. Well proved solutions are always put forward

In general, complex processes must not induce complicated process control systems that results in inefficient control architecture.

SYSTEM ARCHITECTURE

Distributed architecture

From the LEP accelerator construction, large-scale distributed systems have been growing in size and complexity. Manufacturers Technology, tools and techniques to control these systems have also been changing. The first approach to manage a system with growth and complexity is to divide the initial system up in sub-systems and then organise components in order to compose the system architecture with hardware and software analysis method.

For architecture involving large distributed systems, the analyse of the communication process between the different systems and sub-systems involved, for the LHC inter-points data transmission, has been particularly considered [4].

ST/CV process architecture

Figure 1 provides an overall view of the ST/CV process control architecture. The control architecture is divided into four layers:

- Layer 1: Process Automation
- Layer 2: Local ST/CV supervision
- *Layer 2+: Experiment supervision*
- Layer 3: TCR remote supervision
- Layer 4: ST/CV process data handling

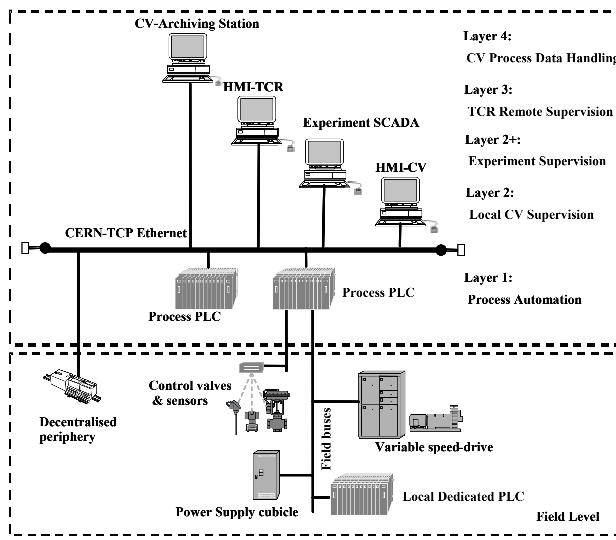

Figure 1: Overall ST/CV process control architecture

1. Generality

At different levels of the process, the nature of the tasks is different. The control consists of acting on the process by means of orders. Therefore control involves a top-down flow of information, which acts on the lower levels. On the contrary, the supervision is a bottom-up flow of information where sources are the signal sent back from the process to the supervision level. Whatever the ST/CV applications at the different layer (process automation, supervision, etc.), the use of different models of the process is necessary.

2. Process automation layer

At the process automation layer the control–command system generates commands to the different actuators from information generated by sensors. We distinguish two sections of automatic control which are both incorporated in the programmable logic controller (PLC):

- Sequential logic
- Feedback loop

The analysis of the control command system has to enable the complexity to be overcome by the different function and running modes of the process being understood. In the production plants the control-command system is very autonomous and the intervention is limited only when failures occur either in the ST/CV production plants or in the control command system itself. In general it is the autonomy of the control-command system that defines the automation level of the human machine system. So the analysis of the control command system takes a particular importance for the design of the different supervision levels.

3. Supervision layer

Supervision consists of taking the actions of commanding a process and supervising it working [6]. Therefore the supervisory system of a process must collect important sources of data linked to the process display the local synoptic, alarms and records events. Considering the increasing complexity of the ST/CV production plants and subsequently the high level of automation, the supervisory system design becomes more sensitive and must be centred on the definition of the needs required by the different level of supervision:

- Local ST/CV supervision: This level of supervisory system is the most important source of information. This level allows access to the complete measurable information in relation with the process. Information and means are given at this level to the ST/CV technician and maintenance operator to perform the local maintenance plants operation.
- Experiment control room (ECR) supervision: The experiment is responsible for the operation of the secondary cooling circuit. This means the possibility to change the set point, switch the circuit on/off, to set interlocks and to change modes. The ECR receives at this level all the information (status, alarms, etc.) to be able to supervise the correct operation of the dedicated secondary cooling circuits.
- Technical control room supervision: At this level the view of the installation and operation is global. Therefore TCR operator must access this pertinent information, without having special knowledge about the process in itself. Most important are information concerning the evolution of the process state, giving the means that permit results of TCR operator's action to be checked quickly.

CONCLUSION

Several LHC cooling and ventilation plants are now in operation after a successful commissioning. The CV plants have, with the increased complexity become more demanding to operate. One of the overall objectives is to minimize distortion between the functional analysis and the real process control transcription. Noticeable is an inability to obtain a global vision of the processes in the design of a control system, nevertheless, the control system for operating CV plants is highly efficient in its performance. It enhances the usability and maintains a high level of productivity which finally is the goal. The information presented to the operators is consistent, allowing a fast identification of the problems and preserves good process operability [7]. Moreover, the CV control system is flexible and can meet any changing requirements for a variety of clients.

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