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P. Ciriani, A. Guiard-Marigny, H. Laeger, M. Rabany, R. Saban and A. Swift

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Equipment Industrially Controlled

R.Saban, P.Ciriani, A.Guiard-Marigny, H.Laeger, M.Rabany and A.Swift

CERN, Geneva, Switzerland

With its chain of accelerators and its large experimental physics detectors, CERN is one of the world's most important research centres for particle physics. Besides that, CERN builds and operates a number of classical and advanced technical utilities to serve its research activities. These utilities are generally equipped with industrial control components purchased with the equipment itself. This paper describes some of the utilities and their controls and proposes a strategy for the integration of diverse industrial control systems into a coherent industrial environment of communication and supervision.

1. Introduction

CERN has traditionally built the control of its accelerators around home-made and later home-engineered systems. Although it can be claimed that this was due to the technical and scientific culture of its staff, it is undeniable that in the past industrial control systems have failed to satisfy key requirements such as real-time (10 ms) communications over long distances (few km). It is worthwhile mentioning that Programmable Logic Controllers are present on the site since 1978 and are used as stand-alone systems with utilities such as electric distribution and water cooling stations.

Because of the widespread use of similar equipment in industry, some of the utilities of LEP, the largest and most recent collider, were ordered together with their industrial control systems. Whilst being specialists in their own field, the equipment owners did not always have the necessary knowledge, experience and possibility for engineering the integration of these systems *industrially*; rather, they judiciously exploited the facilities made available by the accelerator control group.

The majority of these systems was integrated by programming the proprietary protocol onto an RS-232 serial port of the accelerator control system. This approach provides a flexible and rapid access to the equipment, but tends to reduce the facilities intrinsically offered by industrial systems in areas such as *communication* and *supervision*. Furthermore, the user of the industrial equipment is offered a flavour (look, facilities, etc.) of supervision particularly suited for accelerator/collider operators

interested in machine physics rather than in industrial process steering.

Today, the number and the size of industrially controlled systems on the site, together with the gradual build-up of industrial controls competence, have set a favourable climate for industrially reengineering the integration of the industrial controls systems and for redefining and resizing the level of supervision from the accelerator/collider and technical control rooms.

2. Industrial Controls

The *architecture* of the industrial control systems (Figure 1) follows one and the same pattern: the basic unit consists of a few Programmable Logic Controllers (PLC). Within these units, the PLCs are interconnected by a *local bus* via which they exchange process information. The interfacing to the process itself is achieved, either by directly connecting actuators and sensors to analogue or digital input/output ports or, by connecting smart sensors and actuators via a *fieldbus*. The units are then interconnected via a *plant network* to each other and to a control centre for remote supervision, logging and data archiving.

For the *local bus* and the *fieldbus*, the European market leaders are split between the followers of the proprietary busses, of Profibus and of FIP. Interoperability at this level cannot be foreseen for the near future. For the *plant networks*, the major European manufacturers conform to the ISO8802.3 standard for the physical layer (Ethernet CSMA/CD) and to the ISO8802.2 standard for the datalink layer [1,2,3]. Mixing of industrial control systems from different manufacturers is possible at this level within

the limits of the network bandwidth. Some, like Siemens, claim to conform to ISO8473 and to ISO8073 standards for the network and transport layers of the ISO OSI model.

Figure 1: Architecture of industrial control systems

Although some international standardization efforts are under way, the *programming methods* and *languages* remain for the moment particular to each manufacturer. They range from assembler, to ladder logic, block diagrams, Grafcet and also C; the latter is rarely used.

3. Equipment Industrially Controlled

In the time interval between the 70's and the era before the LEP project some utilities used PLC-based controls. With the LEP project, a number of utilities were either purchased with their industrial control system or separately. In both cases this contributed to the wide introduction of industrial control systems into CERN. The majority of cases followed the practice of *global purchase*. The current trend confirms this evolution. The paragraphs below give a short description of these systems.

Access Control to the Radiation Zones in the PS experimental areas and in the SPS tunnel are currently being reinstalled using Siemens PLCs interconnected by the Siemens SINEC L2™ local bus. The supervision and integration into the accelerator control systems [4,5] is done via the workstation based industrial supervision package FactoryLink™ connected to the accelerator control ethernet. These installations total more than 30 PLCs connected via two local busses spanning the large distances of the SPS tunnel. *Building Monitoring* manages safety related signals in experimental halls and laboratories. Safety devices for the new *Chorus* and *Nomad* experiments are being installed using Siemens PLCs connected via a Meyrin site-wide Siemens SINEC

L2™ bus. The specification of the newest *Electric Distribution Substation* which is currently being tendered follows the same lines adopted for building monitoring and access control. In the *cooling and ventilation* field PLCs (Telemecanique, Siemens) are installed to control the SPS demineralized water production and distribution as well as pumping stations. Landis & Gyr equipment has been in use since 1980's for the control of *heating and ventilation in buildings*.

The plants for the production of chilled and warm water, the cooling of the LEP machine and experiments, the ventilation of the LEP underground areas, are all equipped with PLCs from a variety of manufacturers (Siemens, ABB, Telemecanique, Texas Instruments). They perform closed loop controls as well as monitoring and automatic sequencing. The 250 PLCs are connected to 4 local busses. These clusters have been interfaced with the LEP control system with the only possible mechanism consisting of G64 electronic crates with RS-232C ports using the Siemens proprietary protocol. Intracuster communication, necessary for the closed loop control of some of the processes, is achieved by traversing the LEP control system. Whilst local supervision is made using industrial equipment, namely ABB MasterView™ and in the near future LabView™, remote supervision is achieved making use of the accelerator control system facilities.

There are four distinct *Cryogenics* services: LEP100 and experimental physics support, LEP200, LHC R&D and the central liquefier. The LEP100 and experimental physics support together with the LEP200 cryogenics [6,7] are exclusively controlled with ABB equipment: over a hundred racks (MasterPiece™ 100/ 200), 10 local busses and two (MasterBus™ 100/300/300E) LEP wide local area networks are installed for controlling more than 30000 process parameters. LHC R&D cryogenics uses Siemens equipment: about ten PLCs are interconnected via a Siemens SINEC H1™ local area network to the rest of the equipment of the LHC magnet test facility and to the LHC half cell test facility. The central liquefier and its helium distribution service is controlled with ABB and MakModul PLCs.

The operators of the Technical Control Room (TCR) are in charge, among other things, of some level of supervision and exploitation of some of the utilities. They monitor them making use of UNIX based workstations running DataViews applications distributed with the X11 protocol. Alarms originating in the industrial control systems of all utilities are sent to a Central Alarm Server, logged, displayed in the control rooms and dispatched to the responsible personnel.

4. CERNwide Coordination

As expected, the industrial control systems presently managing the utilities have been performing successfully. The trend towards making larger use of these systems has been confirmed and the number of applications is rapidly growing. The coordination effort deployed by an interdivisional group¹ of CERN staff involved in the field has obviously (!) concluded that specification, acquisition, installation, management, maintenance and eventual upgrade of industrial control systems could be greatly eased if a common *industrial control strategy* addressing each of these fields was adopted.

The issues which have already been the subject of a study and discussions or deserve further reflection include the supervision of industrial processes (the integration, the expandability) and the communications (fieldbus, plant network).

A guide for the *specification* [8] of equipment including PLCs has been published. The Industrial Control group has launched several sitewide *tests and evaluation of industrial fieldbusses* [9] and *plant networks*; these have shown the feasibility of the industrial approach also for CERN applications. A number of installations currently being commissioned or planned implement this approach.

Manufacturers of industrial control systems and specialized software companies provide sophisticated *supervision packages* including facilities such as alarm handling, logging, process visualisation and control. Their coupling to the accelerator/collider control network is done on a loose basis: whilst only the operational information is passed to the control room, a complete dedicated supervision console is available for the specialist. Experience with the control of cryogenics confirms the validity of this approach.

It is the interest of CERN to remain open to the very lively European competition in the domain of industrial controls. However, for obvious economical (intellectual and engineering investments) reasons, their number must be limited.

5. Conclusion

A recent study [10] on control systems at CERN has concluded that the *slow controls* of utilities at

CERN can be built around industrial products. This study also strongly advises that industrial solutions are given priority and sub-contracting of complete systems are encouraged. The current practice of the people in charge of the CERN utilities and of medium sized laboratory or test installations suggests a trend towards an increased utilisation of communication mechanisms and supervision facilities proper to the industrial world. This trend has been positively received by the accelerator control groups traditionally in charge of controls at CERN. Furthermore, the creation of an Industrial Control Group three years ago and the encouragement to CCIP indicate the support of the CERN management for industrial solutions.

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¹ CCIP - Coordination des Contrôles Industriels de Processus, an interdivisional group aiming at coordinating and promoting the industrial solutions within CERN.