Industrial Control Systems for the Technical Infrastructure at CERN

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Abstract

Industrial control systems have been used for several years for the control of CERN's technical infrastructure, particularly for fire and gas detection, access control and cooling water systems.

Until recently, industrial equipment has been connected to the control network at the lowest level via CERN specific front ends. Since 1993 they have been integrated using industrial supervision systems drivers. Today the integration is performed using TCP/IP based protocols and the distributed Technical Data Server (TDS) supervision system. This paper summarises the evolution of the different techniques, the control system architectures and our integration philosophy. The safety system of the Chorus and Nomad experiments, the West Zone and the PS cooling water systems are based on Siemens Programmable Logic Controllers (PLC) the Siemens proprietary fieldbus Sinec L2 and Ethernet protocol Sinec H1, in combination with the driver from the supervisory system FactoryLink for data integration into the control room layer. The Access Control and Machine Interlock Safety systems of the SPS accelerator have been implemented using PLCs connected to Sinec L2 fieldbuses and the H1 protocol over a specific Ethernet network. This system is entirely supervised by a FactoryLink software application. The re-engineering of the control of the SPS air conditioning, gas and fire detection uses a new Siemens technology for TCP/IP communication and the new concept of industrial control system integration of the TDS. The PLCs communicate via TCP/IP on a public Ethernet segment with a TDS Equipment Controller (EC). This process converts and integrates PLC specific data to the TDS, using an asynchronous data exchange protocol based on TCP/IP.

1 Introduction

Ten years ago, industrial control devices (PLC) or stand alone control systems) were integrated at the lowest level (Equipment Access layer) of the CERN control system using simple protocols such as RS-232. The integration was usually difficult we were still in the era of the "close and proprietary" control system. Today such industrial control devices are designed for integration in heterogeneous control systems and many options are offered to the control engineers. This paper will illustrate three different options of industrial controls and their integration in the CERN control room environment.

2 Industrial control integration in the TCR

2.1 Introduction

CERN's Technical Control Room (TCR), is responsible for the overall surveillance and control of the technical infrastructure. The TCR is an alarm-driven control room in the sense that the arrival of an alarm alerts the operator and makes him take appropriate actions. The operator acts upon the alarms primarily by consulting and interacting with mimic diagrams. These human-computer interfaces, alarms and mimic diagrams have been structured systematically and they have been standardised to a large extent, in spite of the large diversity of installations being supervised [1]. Any new installation must be integrated harmoniously into this environment. Since 93, Siemens PLCs are being increasingly used and in conjunction the industrial supervisor FactoryLink has been integrated in the existing control system for the supervision of four different systems.

2.2 Systems

2.2.1 Safety applications

We are currently monitoring the refurbished safety systems at CERN using the above-mentioned system. The systems include fire and gas detection, emergency stop equipment and other safety related data. The system comprises around 2500 data points controlled by 15 different PLCs around the site

2.2.2 Cooling water west zone

The cooling water circuits servicing the CERN 'West Zone' are controlled by two PLCs, programmed and delivered by an external firm. The field bus used for the previous safety system was extended to include these two PLCs. The communication functions for the PLCs were provided by CERN to ensure compatibility. The TCR monitors approximately 300 data points from this system.

2.2.3 Cooling circuits of the PS accelerator

The Proton Synchrotron (PS) had its cooling water control systems entirely rebuilt in the period 1994-95. The project was given to an external firm who was asked to deliver a SINEC H1 connection to an HP machine running FactoryLink. The machine comprises 15 cooling stations controlled by PLCs connected to a concentrator by two separate field buses using the SINEC L2 protocol; the PLC is itself connected to FactoryLink running on the HP machine using the SINEC H1 protocol over Ethernet. Due to the large number of equipment parameters controlled and the relative stability of the system, an event driven data acquisition system was implemented. The TCR monitors approximately 1000 points from this system.

2.2.4 Cooling circuits for the computer centre

In 1995, the CERN computer centre cooling circuits were provided with new control facilities. Connecting the computer centre PLC to the existing SINEC L2 network for the PS cooling made the integration of this system possible. The TCR monitors 120 points from this system.

2.3 System architecture

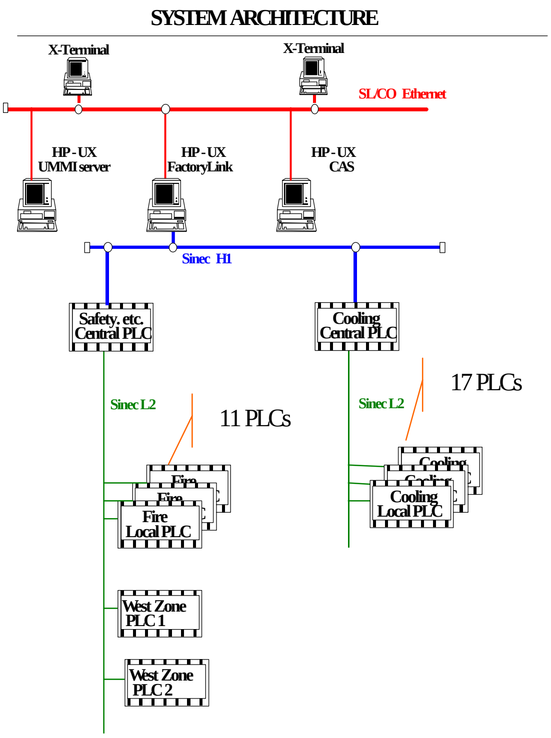

Figure 1. TCR integration architecture

2.4 Main system characteristics

- 4000 points monitored
- 32 Siemens S5 - 115-U PLCs
- HP Server running FactoryLink and in house alarm and HCI interface

2.5 Control room layer integration

The Central Alarm Server (CAS) [1] is the common alarm server for all alarms handled by the TCR. It receives the alarms from the equipment, and dispatches them to the users. Hence a special CAS interface module was developed and added to the FactoryLink application in order to transmit alarms a standard way.

All mimic diagrams used in the TCR have been developed using a high-level graphics environment called the Uniform Man Machine Interface (UMMI) [2]. Again, for reasons of standardisation, we chose to develop an add-on data acquisition module to FactoryLink in order to be able to use the UMMI.

3 SPS access control and machine interlock

3.1 Introduction and definitions.

The safety of personnel entering the accelerator, comprising radiation and electrocution risks, is provided by the Access Control System that conforms to the following rules:

⇒ All equipment related to beam circulation can only operate when nobody is inside the machine,

⇒ Personnel are only allowed to enter the machine when dangerous beam circulation equipment is not in operation and radiation is at a safe level.

Considering the above rules and the related consequences, the design of the access control system consists of two complementary functional blocks: the Access and Search Interlock and the Machine Interlock System.

3.2 Systems

3.2.1 The access and search interlock - A&S.

The purpose of the SPS Access and Search Interlock System is to control the different access equipment (doors, separating grids, shielding doors, etc.), of the various buildings and sectors of the tunnels, called "Important Safety Components for the access - ISC-access"

3.2.2 The machine interlock system - MIS.

The purpose of the Machine Interlock System is to control the machine equipment (power supplies, magnets, dumps, beam stoppers, targets, vacuum chambers, etc.), responsible for beam circulation. All this equipment is called "mportant Safety Components for the machine - ISC-machine".

3.3 Architecture.

The complete Access Control System of the SPS is based on the tight integration at the "Safety Desk" level of the A&S and the MIS systems.

The A&S and MIS have the same logical structure, based on local PLCs (managing local interlocks) which communicate to a central controller (managing central interlocks) through dedicated Sinec L2 branches.

The central controllers exchange summary data with a master PLC located within the "Safety Desk" of the SPS-LEP control room (PCR) using the SINEC H1 protocol. The master controller manages the integration of the A&S and MIS through the "resultant master interlock chains".

The flow of information, through Sinec H1 and L2, can be summarised as follows :

- the central controllers receive "commands" from the FactoryLink supervisor and dispatch them to the local controllers;
- the central controllers receive "statuses" from local controllers and dispatch them to the HP and process them,

in order to provide the master controllers with their respective resultant interlocks chains

Each system has its own hardware redundancy for data exchange between local, central and master controllers.

The global system is also equipped with a dedicated "Service Network" based on RS-232 lines for contingency reasons, connecting the master controller to the local sites. This network is used to distribute the "Access" database.

3.4 Main system characteristics.

- 130 access elements (doors, grids, turnstiles, keys, search boxes, .etc.),
- 600 keys (access and safety keys),
- 15 film badge readers (Bar Code reader),
- 50 machines (magnets, RF systems, dumps, ...),
- 26 Siemens S5-115-U Programmable Logic Controllers
- 1 Sinec H1 network,
- 6 Sinec L2 networks (up to 5km),
- HP-UX FactoryLink (V. 4.3.1) application software.

3.5 Control room layer integration

System operators supervise the access system on workstations connected to an HP server running Factory link. This server is connected via the Sinec H1 network to the master PLC controller.

Figure 2.- SPS Access Control and Machine Interlock.

4 SPS fire detection and ventilation systems

4.1 Introduction

The refurbishing of the SPS fire detection and ventilation systems uses a new Siemens technology allowing PLCs to communicate directly over TCP/IP, and the new concept of industrial control integration and data distribution proposed by the TDS [6].

4.2 Systems

The aim of the system is to detect fires in the SPS accelerator and to automatically activate the tunnel ventilation system according to a predefined plan. The supervision of these security systems is performed from the CERN Technical Control Room (TCR), Safety Control Room (SCR) and locally from the SPS surface buildings.

4.3 Architecture

The TDS integrates equipment data coming from 3 different sources: Siemens PLCs monitoring the SPS ventilation and fire detection systems and the industrial Landis and Staefa Visonik control system of the SPS air conditioning.

The ventilation and fire detection PLC data concentrators communicate via TCP/IP on a public Ethernet segment to an Equipment Controller (EC). This process converts and integrates *PLC* specific data frames to the *TDS*, using an asynchronous data exchange protocol based on *TCP/IP*.

The Landis & Staefa Visonik control system communicates to the TDS with a dedicated EC.

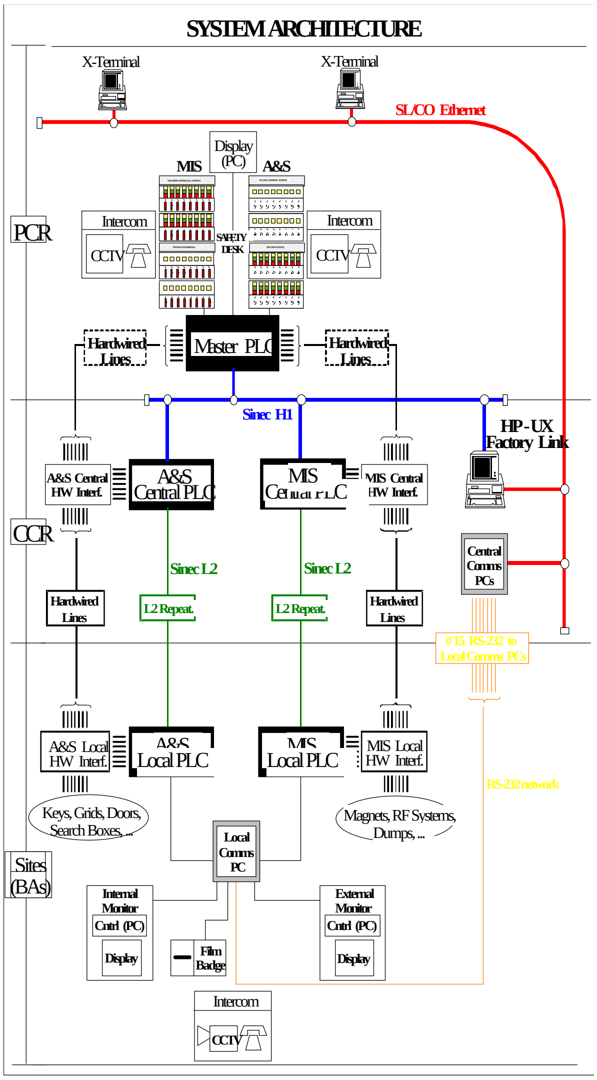

Figure 2.- SPS Access Control and Machine Interlock

The TDS interfaces with the EC trough TCP/IP sockets in an oriented connection mode (stream mode). The exchanged messages are defined in the. Generic TDS Equipment Access Protocol (GTEAP)[5].

The delivery of each EC is under the responsibility of the company providing the local control system.

Equipment data has to be defined in an Oracle reference database (TdrefDB) along with the TDS topology to host this new interface.

The EC may run on any platform selected by the company as long as it matches the specification for integrating a new device on the control network [6] and that it communicates through TCP/IP. The TDS communicates with ECs on PCs running OS2, PowerPCs running Lynx OS and HPs running HPUX. These systems are supervised by the CERN/SL network management system.

4.4 Control room layer integration

The TDS provides equipment data storage in a real time database, alarm delivery to the central alarm server, data logging, automatic sending of command to the equipment, and data delivery to mimic diagrams [7].

Data send by the ventilation and fire detection systems will automatically trigger commands to the L&G Visonik system to alter the ventilation of the tunnels.

4.5 Main system characteristics

- Siemens S5-95-U PLCs to collect data from fire detection units and air conditioning systems
- Siemens Profibus,
- Siemens S5-115-U acting as data concentrator, and connected to the SPS Ethernet network via a specific TCP/IP card.
- HP servers running the TDS/RTworks processes

5 Conclusion

Industrial control components may be used today at every level of the standard model. The robustness of the industrial programmable logic controllers and of the field buses makes them very efficient devices for controlling local processes particularly in "industrial areas" (dust, electromagnetic noise). Today the PLCs may be connected to TCP/IP networks easing integration with the control room layer. However when integrating several local control system in a global monitoring system, a clear strategy must be defined. At CERN, for the monitoring of the technical infrastructure, we have built a Technical Data Server whose distributed architecture allows the integration of any local control systems via a defined protocol based on TCP/IP.

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