THE NEW CONTROL SYSTEM OF THE SPS TARGET SECTOR

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Abstract

The SPS, the Super Proton Synchrotron at CERN, is an accelerator originally designed and commissioned in 1976 for protons. The control system of the SPS target stations, beam absorbers and other aperture limiting devices was developed in the seventies. It was mainly based on home made electronics and equipment dependent software. With time, this electronics has become obsolete, difficult to maintain in operation and not suitable for integration into a modern control system. In 1997, a project was set up to modernise the electronics and the related software. The new control system is largely based on standard industrial hardware and software components. SIEMENS Simatic S7-300 programmable logic controllers have been used as equipment controllers. They have been connected through PROFIBUS to a Windows-NT front-end PC running the SIEMENS WinCC SCADA package which acts as local controller and remote access gateway. This fully industrial solution has been successfully integrated into the actual SPS accelerator control infrastructure and is open to other industrial communication protocols. The design, development and realisation of the selected solution have been outsourced to industry.

1 INTRODUCTION

The SPS target sector comprises all kinds of beam obstacles used in the SPS accelerator and its transfer lines to other accelerators or experimental areas. This includes target stations, beam dumps and stoppers, collimators and other aperture limiting devices.

The control part of this equipment consists mainly of DC motor controllers used either to move an equipment from one position to another, with a typical precision of 0.1 mm (SERVO), or to displace equipment between two fixed positions (IN/OUT). Supplementary functions such as temperature acquisition, cooling status and water flow control are required for supervision and safe operation.

Up to now the local control was implemented through push buttons in front of the control electronics for the commands and LED indicators for the status information. The remote control was performed through application programs written in NODAL [1]. These programs communicated with the equipment through specific C libraries and equipment servers running in a LynxOS front-end computer. The hardware link consisted of a MIL-1553 field bus used in command/response mode, connected to a MPX acquisition interface [2]. No software was involved in the processing of the controller functions at this level, nor in the local control of the equipment.

2 THE PROJECT

In 1997, a project has been set up to modernise the complete control electronics of the above mentioned equipment. The corresponding hardware volume is given in table 1. The project comprised:

- removal of the MIL-1553/MPX electronics,
- replacement of all other home made electronics,
- software compatibility with the existing application and expert programs,
- exclusive use of off-the-shelf industrial hardware and software components,
- subcontracting of the project realisation to industry.

Table 1: Amount of signals involved and controllers used.

Digital input	1000
Digital output	400
Analog input	400
Analog output	400
SERVO controller	75
IN/OUT controller	25

A technical specification for a configurable, modular, data driven and industrial solution has been written at CERN in 1998 [3] followed by a call for tender. The contract has been awarded to TERMA. The design, development and realisation of the project have been carried out within one year.

3 TECHNICAL SOLUTION

One of the project goals was to use solely proven industry standards for hardware and software and to use only off-the-shelf industrial components. No specific hardware development has been necessary throughout the complete project. One specific piece of software had to be developed in order to interface the new industrial system to the CERN SL-EQUIP package [4], the software method used to access equipment in the SPS accelerator from the application layer. This interface maintains the required software compatibility with the actual application programs and guarantees a smooth transition from the home made solution to the totally integrated industrial solution.

3.1. Architecture

The hardware architecture (Fig. 1) consists of SIEMENS Simatic S7-300 Programmable Logic Controllers (PLCs) [5] connected through a PROFIBUS [6] field bus to a rack-mountable front-end PC running under Window-NT.

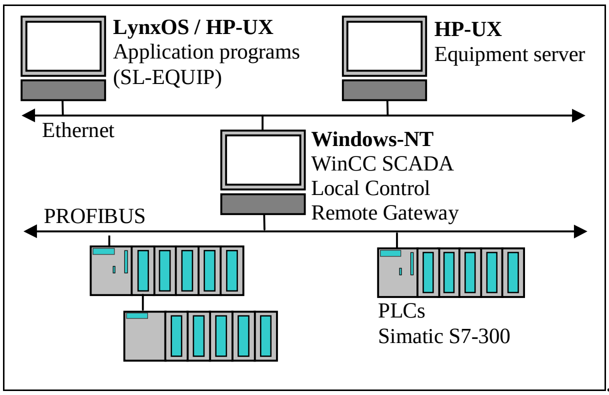

Figure 1: Hardware architecture.

The front-end acts as PROFIBUS master and carries out the data exchange between the different nodes on a cyclic or event driven basis. On the other side, the front-end is connected to an Ethernet TCP/IP network for communication with the application layer. It provides the local control facilities and forms the interface between th equipment specific PLCs and the accelerator-wid controls network.

3.2. Software

The software architecture (Fig. 2) is divided into three different layers: controller, front-end and application. Controller and front-end layers communicate through the standard PROFIBUS-DP protocol and are implemented within commercial packages. The application layer software consists of application, operation and expert programs connected to the front-end layer either through SL-EQUIP, or through automation standard protocols.

3.2.1. Controller Layer

The controller layer software implements the specific low-level functions to be performed by the various controllers.

The SIEMENS "STEP7" development environment has been used for the configuration and parameterisation of PLC hardware modules, for the definition and setting up of the field bus communication and for the programming of the controllers.

Low-level equipment control, data acquisition algorithms and feedback loops have been embedded in the PLC user programs written in conformity with the IEC-1131-3 standard.

The user programs consist of a set of independent functional blocks providing the different required functions. A unique instance data block containing configuration parameters like hardware addresses and operational settings identifies a specific controller. At runtime, the functional blocks are sequentially invoked and supplied with the declared instance data blocks.

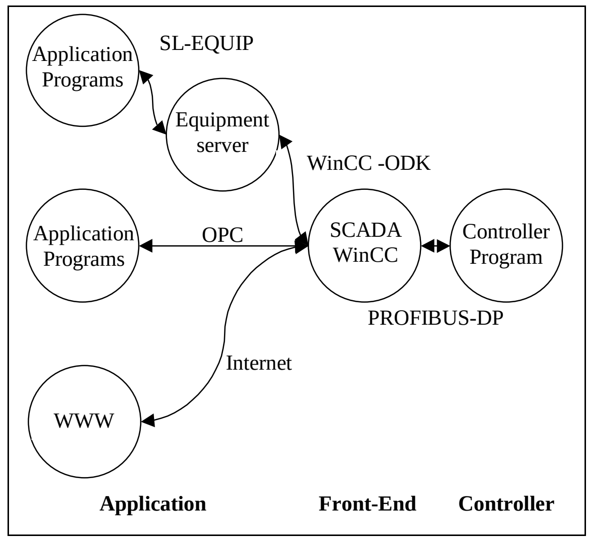

Figure 2: Software architecture.

3.2.2. Front-End Layer

The front-end layer software is hosted in a standard industrial PC and is based on the SIEMENS WinCC Supervisory Control And Data Acquisition (SCADA) system. The WinCC application provides local process visualisation and operator control screens together with remote access facilities for the application layer.

3.2.3. Application Layer

The application layer consists of existing high-level programs using SL-EQUIP. Access to the new controllers happens through a specific equipment server. This server uses SIEMENS WinCC Open Development Kit (ODK) libraries to access remotely the WinCC internal runtime database. This approach to use an intermediate layer permits to keep the required compatibility with the actual application software.

Simultaneously, the openness of the implemented architecture allows new applications to access the front-end layer and communicate with the WinCC internal runtime database using automation standard protocols.

The OLE for Process Control (OPC) [7] client/server interfaces, available within WinCC, permit to access and/or exchange process data variables between different OPC compliant applications in a distributed computing environment. Furthermore, the Web navigator client/server interfaces, also part of WinCC Version 5, allow to monitor and even operate the equipment across the Internet/Intranet from a standard Web browser at the client side.

3.3. Performance

So far, a full hardware and software setup has been produced for the new control of the SPS north area target stations (Fig. 3). In this example the hardware consists of one front-end PC, one PROFIBUS segment with 7 nodes, 6 PLCs, 21 SERVO controllers and 9 IN/OUT controllers. Typical update performances for a group of 10 WinCC variables are shown in Table 2.

Table 2: Typical performance.

PLC execution time	50 ms
WinCC runtime database size	800 items
WinCC runtime database update time	5 ms
OPC client update time	15 ms
SL-EQUIP client update time	200 ms

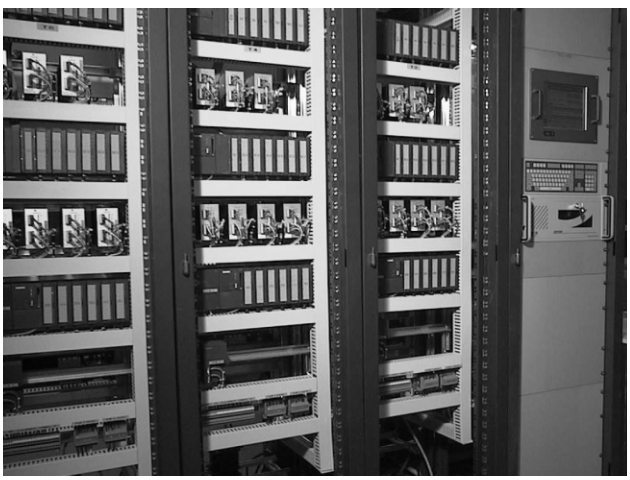

Figure 3: New control racks of the SPS north area target stations (3 targets) showing front-end PC (right) and PLCs and motor controllers (left).

4 CONCLUSION

The new control system of the SPS target sector has been realised using only fully industrial hardware and software components. It has been successfully integrated in the CERN-SL accelerator control system.

The use of industrial components has permitted to reduce the development time and the overall project cost and has resulted in an open and modular solution at the end of the project. In order to fully preserve these advantages, the overhead for integration into the accelerator controls infrastructure has to be reduced to the minimum and also be based on industry standards.

Subcontracting this project to industry was relatively straightforward since the project and its boundaries were well defined and since the requirements could be met using, with the exception of the SL-EQUIP interface, solely industrial hardware and software components. Furthermore, during the whole project, a close collaboration and a precise separation of responsibilities has been made between CERN and the contractor. The contractor had the responsibility to choose the most appropriate hardware and software architecture and to develop the software. CERN has kept the responsibility of the hardware cabling and installation, and the commissioning of the final system in place. This separation permits to keep the complete knowledge of the final system at CERN.

5 ACKNOWLEDGEMENTS

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