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INTEGRATION OF CUSTOM SYSTEMS INTO INDUSTRIAL SYSTEMS FOR LHC COMPONENT TEST BENCHES

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Abstract

The LHC component acceptance test benches require integrated controls, data acquisition and measurement systems. For this purpose CERN-built custom systems have been integrated into industrial systems. The approach that we have used for the integration is based on the usual tree structure, extended with a new feature to allow device sharing: the "tower" structure. Examples of integrated systems are given, one on a magnetic measurement bench, the other on a superconducting strands test bench. Related aspects of remote monitoring and control are covered.

1 INTRODUCTION

A typical acceptance test bench of LHC components consists of industrial systems as well as custom systems, which need to be integrated into the former. Industrial systems have been used as much as possible [1,2], but for applications where these were not available, custom systems have been developed. For example the LHC dipole magnets test bench is composed of two industrial systems, one for Cryogenic Control, the other for Quench Recording, and a custom built Magnetic Measurement System (MMS) [3].

An important characteristic of such a system is that frequent changes are necessary and new equipment has to be integrated. For example the integration of a new type of measurement is done by adding new specific equipment, but the new control software needs also to access an existing device already used by another application.

A tree-structured architecture does not allow access on the same control level. Existing solutions such as using a lower level (hardware switches) or communication through a higher level are not satisfactory because they are either not flexible or have poor performance in time response and reliability.

To meet our requirements of flexibility and good time response we have developed a new architecture, called "tower" in contrast to "tree", that allows communication at the same control level.

In the following sections the general architecture is described and some examples of integration with other systems are given.

2 GENERAL ARCHITECTURE

2.1 Architecture Overview

In a tower architecture (Fig. 1) we do not only have branches but also cross links at the intermediate level which reinforce the structure.

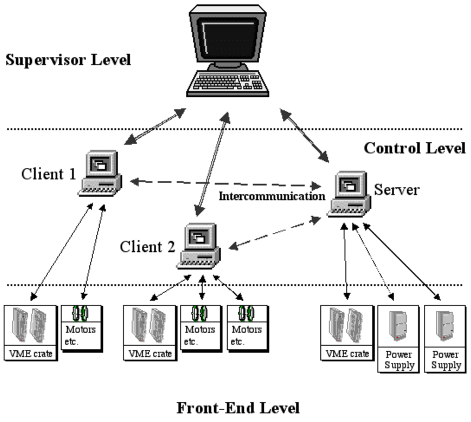

Figure 1: The tower architecture.

We define three levels:

- The Front-End Level (FL), which is the low level, constituted by the peripheral devices like power supplies, VME crates, motors etc, needs to be controlled by a higher level. At this level, the devices are not inter-communicants.
- The Control Level (CL), which includes the computers and the software running on them, is the intermediate level. At this level, the system performs all kind of operations needed for the measurement such as controlling, reading out, storing and analysing data coming from the FL. The computers are interconnected through Ethernet allowing the low-level equipment to be shared.
- The Supervision Level (SL), connected through Ethernet to the CL, monitors processes and controls the status and the most important parameters of the CL. It logs all operations keeping track of the full test program.

Using CL communication we can extend device control to newly added applications keeping the advantage of the tree structured modularity. In this way industrial or custom systems can not only be removed or substituted without interfering with the other parts of the system, but can also be added and given control over existing devices.

To have a high modularity in hardware and in software we have used industrial devices interconnected with standard busses (VME, GPIB, RS232 and Ethernet) and we have developed software written in LabVIEW¤.

The final LHC magnets test setup will have a maximum of 12 benches with central supervision, where each set of two benches will share the most important devices. These devices are normally large and expensive and, due to the nature of the test, they are not needed simultaneously. An example of such a device is the power supply used to feed the magnets.

2.2 Power Supply Sharing

We have implemented a multi-server system in which a set of clients has access to one particular server. Each power supply is physically connected to a server of the CL, but another computer (client) can use it.

A computer of the CL which, for a particular measurement, requires a particular power supply, needs to reserve it and keeps control of it for the full time of the measurement. To manage the power supply reservation, an access control system has been implemented. Once a power supply is reserved, it inhibits access from other clients.

The decision about access needs to be defined at the SL, where the overall system is monitored.

2.3 The Monitor and the Access Control

The Monitor is a process that runs at the SL. It monitors the different operations and access rights of the different benches. This process acquires the information through Ethernet by use of a UDP socket mechanism. UDP sockets do not need a permanent connection between the processes: in this way, the CL can also run if the Monitor is not running or if there is no network communication with the SL.

The Access Control is also defined at the SL and the information of which client can control which device is sent to each station of the CL through TCP sockets. With the use of this type of socket, we make sure that the CL computer is informed of the new settings.

3 MOLE MAGNETIC MEASUREMENT SYSTEM

An example of integration is the Mole [4]. Its name was chosen because of its small size and of its ability to move a probe through a 15 metres LHC dipole magnet, for magnetic field quality measurement at room temperature.

The Mole, a fully industrial turnkey system, includes an axial and rotating movement system driving a measurement probe, a camera for the skew determination, and a local controller. This system has been integrated into the CERN MMS using predefined specifications of communication protocols and interfaces.

The MMS consists of two parts: one is the measurement electronics and the read-out system, including the display and analysis software; the other is the axial and rotating movement system, including the software control.

Using the predefined communication protocol, the MMS has easily been integrated into the Mole, replacing a custom built part (Fig. 2). From the point of view of software, we have implemented a high level driver for moving the Mole, translating the generic commands to those of the Mole, thus giving to the MMS full control of the Mole.

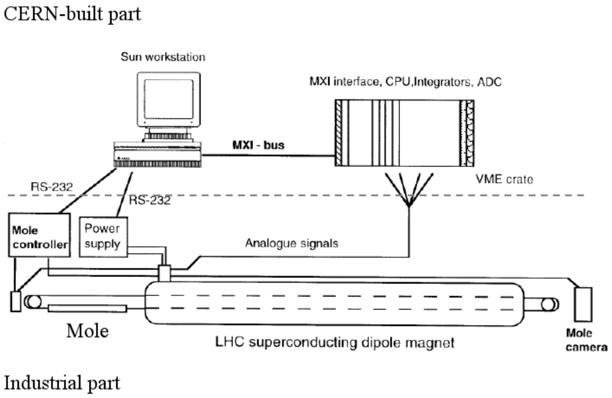

Figure 2: The Mole system.

The Mole can be driven in remote mode by the MMS or by an application that emulates the local controller. In this way it is possible to remotely set the most important hardware and software parameters.

4 SUPERCONDUCTING STRAND TEST BENCHES

An example of a modular system is the measurement and control system of the Superconducting Strand test benches (SStb). Seven small test benches connected to GPIB instruments and occupying in total 40 metres in length needed to be controlled both from a central control room and locally.

The large number of instruments, the important bus traffic they would generate and the large distance to be covered excluded the use of a single GPIB bus. On the other hand, to have one computer with a GPIB interface per test bench would have been a too costly solution. Therefore, we decided to use one GPIB/RS-232 converter per test bench. The seven serial lines, covering the distance through current-loop transformers, connect each set of instruments to a few central workstations in the control room (Fig. 3). Local control is obtained with an X-terminal installed near a test bench and using one of the central workstations to access the instruments.

This system is flexible, because there is no direct correlation between the number of workstations and the number of test stations. In addition, any screen can be assigned to the control of any test station, and every screen can display the summary information about the state of the other stations.

The connection of the GPIB/RS-232 converters to Unix workstations running LabVIEW¤ applications requested the development of a driver. This was achieved in the form of a generic GPIB driver, implemented in LabVIEW¤ using RS-232 calls. Such a driver accepts standard GPIB commands and produces either GPIB calls or their equivalent in RS-232, depending on a software switch. This makes the type of interface completely transparent to the calling program. When using RS-232 with a transmission rate of 38400 baud, the data transfer speed is only 15% slower than using the GPIB standard.

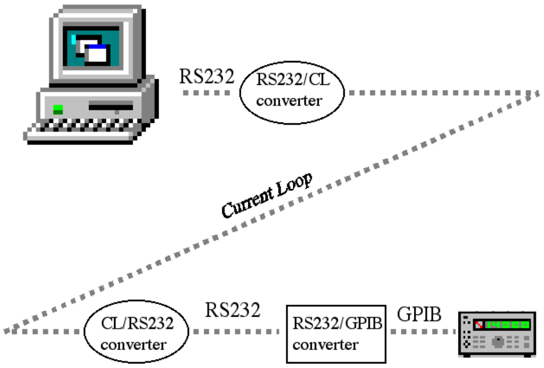

Figure 3: The SStb connection.

This driver is now being extended to include remote calls over TCP/IP using the server system, which is described in section 2.2. This will allow remote computers to access GPIB instruments that are physically connected through GPIB or GPIB/RS-232 to the control room workstations.

The access control principles and supervision described in section 2.3 can be used for the SStb system without modification.

5 CONCLUSIONS

Industrial systems have the advantage of being readily available and cost effective.

Furthermore, the choice of widely used standards provides a simple integration of custom systems into industrial systems.

However, changes in the measurement requirements need frequent extensions and adaptation. This can be achieved through the flexibility of the tower architecture we have described that allows easy device sharing in addition to the modularity of the tree structure.

The Mole magnetic measurement system and the Superconducting Strand test benches are examples of using this approach.

REFERENCES

[1] M. Rabany, Interfacing industrial process control systems to LEP/LHC , ICALEPCS 91, Japan, November 1991.

[2] R.J. Lauckner, Integration of Industrial Equipment and Distributed Control Systems into the Control Infrastructure at CERN , ICALEPCS 97, China, November 1997.

[3] J. Billan, 15 m long Twin Rotating Coils for cold magnetic measurements of LHC dipoles , MT-16, U.S.A, October 1999.

[4] L. Bottura, A Mole for warm magnetic and optical measurements of LHC dipoles , MT-16, U.S.A, October 1999.