Integrating Fieldbuses at the application level: C interface and LabView integration.

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ABSTRACT

The controls group of the SPS and LEP accelerators at CERN, Geneva, uses many different fieldbuses in the controls infrastructure, such as 1553, BITBUS, GPIB, RS232, JBUS, etc. A software package (SL-EQUIP) has been developed to give end users a standardised application program interface (API) to access any equipment connected to any fieldbus. This interface has now been integrated to LabView. We offer a powerful graphical package, running on HP-UX workstations which treats data from heterogeneous equipment using the great flexibility of LabView. This paper will present SL-EQUIP and LabView, and will then describe some applications using these tools.

I. INTRODUCTION

The mission of the European Laboratory for Particle Physics is pure science - particle physics - probing the innermost constituents of matter to find out how our world and the whole of the Universe works. To do this, it operates a number of particle accelerators, the largest of which is the LEP electron-positron collider. Beams of electrons and their antimatter counter-parts, positrons, are circulating in a 27 kilometer underground ring at nearly the speed of light and collided together. A chain of accelerators, including the Super Proton Synchrotron (SPS), provides beams for LEP. The LEP machine consists of various equipment installed in the 27 km ring tunnel and in 8 surface buildings, their associated pits and underground areas. The SPS and LEP Control System extends from a central control room to all the surface buildings and underground areas in order to provide command and acquisition facilities for the collider and the particle beams.

II.THE CURRENT SPS AND LEP CONTROL SYSTEM ARCHITECTURE.

The architecture of the SPS and LEP control system is modelled on three layers [1] [2]: the Control Room Layer, the Front End Computing Layer, and the Equipment Control Layer.

A.The Control Room Layer

The Control Room Layer is based on modern UNIX workstations, servers and X-Terminals. Human Computer Interfaces are developed using an X-Window and OSF/Motif User Interface Management System. Several other UNIX servers are used for file storage, for public displays, for the management of the alarms, and for an ORACLE on-line relational database. The current computer installation for this layer is the following :

40 Hewlett Packard 700 workstations
~100 X-Terminals

B.The Front End Layer

The Front End Computing Layer consists of Front End process computers (FEs) based on PCs and VMEbus crates. Their main function is to provide a uniform interface to the equipment as seen from the workstations and act as data concentrators for equipment interfaced via various fieldbuses. The task assignment between FEs is made on geographical or functional criteria. The communication between the Human Computer Interfaces (HCI) running in the SPS and LEP control room and the FEs is achieved through Remote Procedure Calls (RPC) or direct TCP/IP socket connections. The current computer installation for this second layer is the following :

150 OS/9 VMEbus systems
110 LynxOS 2.2.1 80486 PC systems
45 LynxOS 2.1.0 VMEbus 680x0 systems
150 XENIX 2.3.1 80386 PC systems (currently replaced by LynxOS 2.4 VMEbus PowerPC systems[3])

C.The Equipment Layer

The Equipment Control Layer consists of Equipment Control Assemblies (ECAs) connected to the FEs via various equipment fieldbuses (1553, GPIB, BITBUS, JBUS) or via RS232/422 links. The ECAs ranges from G64 6809 systems running FLEX to 3U and 6U VME 68k systems running OS-9. The accelerator equipment is distributed in underground halls and in surface buildings.

D.The SPS-LEP Network .

Network communication is made by local Ethernet segments bridged to Token-Rings or 100 Mbit FDDI backbones, one for the LEP general services linking all the surface buildings and others for the accelerators. The data distribution is based on the TCP/IP protocol suite and the network management is achieved with SNMP.

III. STANDARDISED ACCESS INTERFACE: THE SL-EQUIP PACKAGE

Equipment access has always been crucial for the SPS and LEP controls group. The heterogeneous mix of accelerator devices has led us to develop a generic equipment access facility[4]. The main goal of this SL-EQUIP package was to offer a simple and generic Application Programming Interface (API) to access any equipment independent of its nature or its geographical

location. SL-EQUIP hides all network communication mechanisms as well as local hardware accesses. An Equipment is identified by a logical name and a database contains its localisation and its type. The SL-EQUIP package allows programs to make single or multiple calls to read, write or write/read bytes, words, doubles or raw data to/from any type of equipment. Special library accesses have been implemented for GPIB, BITBUS or RS232 equipment. Fig. 1 gives a graphical overview of the data flow inside the SL-EQUIP package.

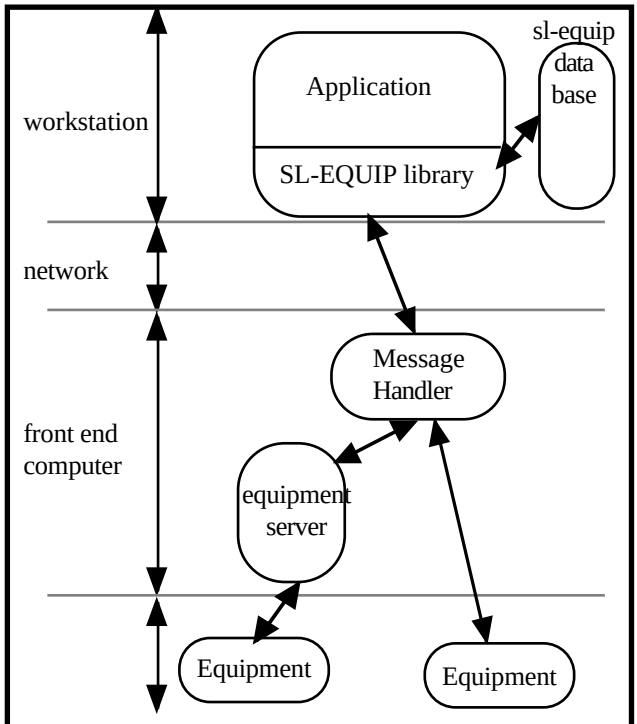

fig.1: SL-EQUIP graphical view

IV. LABVIEW

LabView is a product developed by National Instruments[5]. It is a very powerful tool based on a graphical programming language which allows control of a wide variety of equipment through an easy-to-build graphical interface. It is designed to use the concept of Virtual Instruments (VIs) and SubVIs to build more complex instruments and runs on several platforms ranging from MacIntoshes and Windows PCs to HP-UX and SUN systems. In our case we are using LabView on the HP-UX workstations.

V. LABVIEW and SL-EQUIP

Having a graphical tool in one hand and a generic equipment access package in the other hand, we decided to build a LabView interface to SL-EQUIP to combine those two powerful tools. This was achieved quite easily by using a shared version of SL-EQUIP client library and by writing a small interface VI which converts arguments between both LabView and C formats. These VIs can be used stand alone to make one simple equipment access or as subVI in high level application. Fig2 shows a typical LabView-SL-EQUIP application.

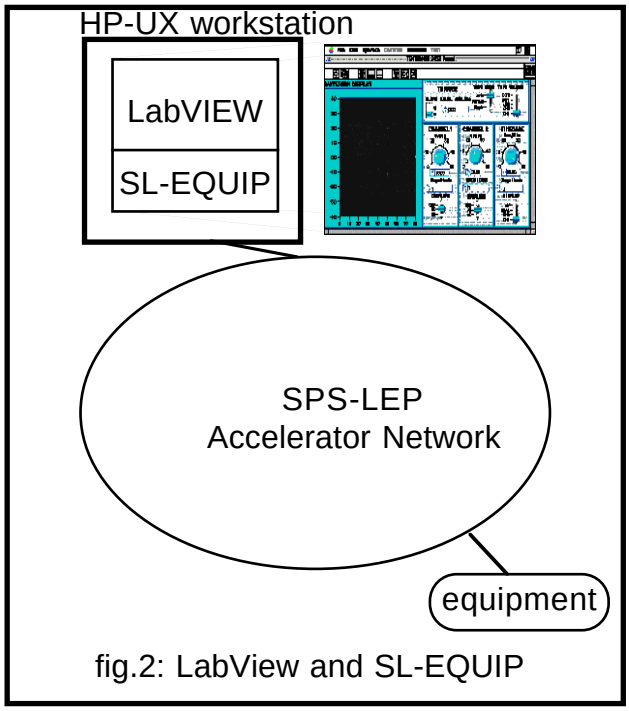

fig.2: LabView and SL-EQUIP

VI. GPIB and RS232 devices

In LabView, there are specific communication SubVIs that encapsulate low-level GPIB or serial instruments. In SL-EQUIP, there are specific calls for GPIB or serial instruments connected to our controls infrastructure. In other words, a GPIB instrument can easily be accessed by use of simple SL-EQUIP calls. It was then logical to rewrite the LabView communication subVIs using SL-EQUIP interface to emulate direct GPIB or serial calls to the equipments. To convert GPIB or serial address to SL-EQUIP address format (logical family member pair), the VIs of this communication libraries use a global variable (SL address.vi) which contains a string array. The usual LabView address is the index of this table to get the corresponding logical family-member pair.

The first application using the GPIB connection was to display a remote LeCroy digital oscilloscope. We took the VI for that oscilloscope from the National Instrument Website and replaced the GPIB access VI by our SL-EQUIP GPIB VI. The oscilloscope is connected in the LEP underground area by a GPIB link to a LynxOS Front End computer and it is now possible to view and control this device from any X-terminal in the control system.

VII. USAGE

The SL-EQUIP interface is widely used for SPS and LEP equipment access for normal machine operation and for equipment specialists programs. We are now encouraging people to use LabView as an easy tool to build test and diagnostic software. Maybe that in the future this tool will be used in the control room for operation.

Several projects such as electricity specialists programs, LEP girder control, VME timing card tests, Beam Instruments Oscilloscope display, ..., are already operational.

VIII. CONCLUSIONS

The possibilities offered by the LabView and SL-EQUIP combinations are very wide. Almost any equipment can be connected to the SL Front End computers and therefore can be visualised in LabView. This product could naturally evolve by adding other equipment type interface such as VXI, Profibus, Can, WorldFIP, etc.

IX. ACKNOWLEDGEMENTS

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