RESULTS CONCERNING THE NEW CONTROL SYSTEM OF THE VIVITRON BASED ON AN OBJECT ORIENTED DATABASE

R. Baumann, T. Diaz, B. Humbert, A. Jbil, E. Kapps, R. Knaebel, JC. Marsaudon, N. Lahera, L. Michel, J.Persigny, G. Prevost, Y. Stamm, JY. Thoré
IReS
UMR 7500, CNRS-IN2P3 et Université Louis Pasteur
23, rue du Lœss,
67037 Strasbourg-Cedex2, France

Abstract

The new control system software of the Vivitron has been successfully installed since January 1997. Thirteen VME crates working at potentials from 0 to 20 MV concentrate the measurements and commands. They are linked together and to 4 display workstations, via a private optical Ethernet network. The challenge has been to simultaneously handle and display 1500 parameters, with fast and accurate rendering for the user. Other features like online archiving and fast spontaneous sampling (up to 1000HZ) were added to allow precise diagnostics. Another important aspect of this control system is its maintenance tool. An object-oriented database is used to handle all the parameter descriptions and to generate the code. Any change can easily be carried out by a non-specialist, by changing or adding a parameter, since the code is automatically generated and loaded to the target crate by the database. The performance of the object code generator and the use of standard hardware allows easy export to other accelerators. It has already been used to control the electrostatic accelerator CN at the IReS.

1 INTRODUCTION

In 1986, it was decided to start construction of a new kind of electrostatic ions accelerator: the Vivitron. The beam is accelerated by a central electrode at high electrical potential, where the ions are stripped. The beams provided are stable, continuous and easily adjustable in energy.

To control the accelerator it was decided to use crates working at several potentials, even at 20 MV on the central electrode. VME crates are distributed over the entire site federated with the control room workstation in an optical Ethernet network.

Special electromagnetic shields were designed to avoid breakdown when sparks occur.

To control these crates, specific software was developed by the IReS computer team. This was fully installed in January 1997 [1].

Given that numerous developments had to be made to the accelerator, the control system had to be designed so as easily facilitate changes. As such, maintenance is done by accelerator staff themselves and software corresponds closely to their requirements.

First we shall describe the way the maintenance tool works, and then the major characteristics of the latest system.

2 DESIGN OF THE SYSTEM

2.1 Overview

Given the several potentials present along the accelerator and to the number of measurements and commands, 13 crates are used. The connection between the crates is carried out by an internal Ethernet optical link.

All events are displayed using 8 Display Interfaces (DI) managed by 4 Unix workstations.

To achieve good display rendering on the screen (up to 5 Hz), the crates carry out a selection: they only transmit those measurements that change. In this way the bandwidth is optimised [2]. In other words, the crate decides which values have to be updated, according to initial settings and instantaneous values. The DI is **only** used as a passive display. Thus a better feeling for the machine is created.

VME crates working with VxWorks version 5.1 were chosen according to local experiments and technical standards. The software is based on 2 C language library layers: the lower layer contains the General Library (GL) and the upper layer contains the Specific Library (SL). Both are compiled to work on the VxWork **real time** kernel.

2.2 General library

The General library (GL) is unique, used by all crates and loaded at the crate boot. It lies at the heart of the crates because it describes the basic functions of all tasks and is the interface between the specific code and the hardware.

It describes communication between the crates and the screens, the operation of the acquisition loop, the operation of the measurement updating loop, the alarm actions, the log of all the parameters, etc. It also translates instructions from different sources (screens, users, …) into hardware changes (Analogue 0 to 10V, Digital change, serial link orders,...), and vice versa.

To sum up, the general library describes all services independent of the hardware configuration [3].

2.3 Specific library

The Specific library (SL) describes the crate environment. It takes into account the input and the output plugged into the crate. It contains the different calculations and also describes the **parameters**.

Parameters are descriptions of the commands or measurements onto the crates. The parameter describes the **C** function realised with the direct output/input (the C function describes the calculations to be computed,...). It also describes the calibration function, the update speed and the alarm threshold. Parameters are updated continually by the main control loop.

Automatic action can be managed by a crate. For that, specific servo loops are also described in the SL. Actions are functions of parameters managed by the crate and the programmed reaction.

Overall, the SL describes all services dependent on the hardware configuration.

Compiled specific libraries are loaded at the boot, following the general libraries. A link is then made between the hardware detected and the specific software parameters.

2.4 The Display Interface

To control the accelerator, 8 DI are used, each one having a specific function (e.g. 2 for the ion source, 1 screen for the Voltage Generator,...). The DI are X simple clients. They receive measurements as X events from the crates, and display them following the scaled set-ups. They receive commands as X events from the users, display them and re-transmit them to the crates.

SL-GMS software is used for the graphic animation. A development tool allows the drawing of the DI using a library of graphical submodels (for example a slider or a graph,...).

The connection between these submodels and the parameters is carried out inside the database that generates a link's description file.

3 THE MAINTENANCE TOOL: THE OBJECT-ORIENTED DATABASE

3.1 The choice of an object-oriented database

For maximum flexibility, it was decided to describe each parameter of the system with a C code function. That weakens the system because of the numerous links to manage.

To manage and guaranty code coherence, the object database was the most effective way to produce a coherent code following rules.

Each object component is described in the database as an object with its own characteristics and code production rules. The description includes the C code function that can be generated automatically by the database, or changed manually.

3.2 Generation and update of Specific libraries

Each one of these objects has its own rules and properties.

For example, the Hardware Link (HL) objects. By HL, it is understood Analogue to Digital Cards, Digital to Analogue Cards, serial links, etc. Each of these objects has a different way of accessing the output or input "hardway " buffers. An object approach allows us to apply the same commands to display and to generate the links, the proper method being used at the lower layer, written in the object itself. This way, the database can integrate new, potential HL which are not yet defined.

A tool has been created to manage these objects, using "click and drop" software. You select the crate to be modified and access the parameters. For each parameter you can change the calibration, the trace (speed of display updating and log storage), or you can change the C function processed.

3.3 Upgrade of the General libraries

Access to the GL is very restricted because each change affects the operation of all crates. But low level changes can be very important for system improvements.

As these GL are hand-written in C code and as they have to be modified by staff familiar with C code, no specific tool is used.

3.4 Updates on the Display Interface

The DI are graphically designed by specific software SL_GMS. A library of submodels (buttons, graphics, displays) is available. These submodels are named and arranged on the graphical display. About 200 submodels currently exist, but others can be created using a special tool.

The connections between the submodels and the parameters are carried out using the O2 object-oriented Database. With a "click and drop" menu, attachment of the graphical submodel name with the parameter occurs, and simultaneously the configuration of graphical behaviour (e.g. the maximum value of the slider, the steps of each click, the speed progression of the graphs...) occurs.

The graphic building of the screen can be based on existent applications. That allows reusable styling and very fast application creation.

4 UPGRADES

4.1 Integration of new measurements and commands

As the installation or the modification of parameters is done almost every month, it is not possible to mention all of these upgrades. This is basically the normal use of the tool.

It should be remembered that with this maintenance tool, crate software has been developed and the corresponding user's display interfaces of 3 new experiment lines were very easily developed by the accelerator team. The CN control system is also done using this system The amount of parameters handled by the database and displayed on the screen is about 1500.

4.2 Serial links: the serial link generator

As each serial link has his own protocol, each RS232 device installed needs its own driver and integration in the Database.

Even though the C code driver between the crate and the device has to be hand-written, a serial link generator was set up to allow the easy integration of this new link as an new O2 database object.

Given the object structure, once a specific driver is developed, it is seen by the O2 database in the same way as all the other links.

4.3 The fast sampling tool

A special service uses the maximum speed available in a crate for the acquisition of 4 analogue channels with frequencies up to 1kHz in 30s (120.000 points stored). This fast sampling can be triggered by a belt position signal for accurate analysis of the causes of perturbation.

4.4 Pulsing

A GPIB link is used for pulsing frequency control devices.

4.5 Scan of the input Beam

A tool has been developed to allow a scan of the input beam. It is based on an internal servo loop launched by a normal command. Special submodels are used to allow a graphical x-y representation. This graphical representation will be used on the Emittance-meter soon to be installed.

4.6 HTML display of the database

A special module was installed allowing us to access the database using a classical web browser. It is available only in reading mode, but anyone can check specific points of the software from any computer.

4.7 The new CN control system

The 5MV CN accelerator is used as test bench for electrostatic studies. As it needs 24h supervision, a electronic control and command has been set up and for this, computerisation was necessary.

A VME crate with specifics Analogue to Digital input and Digital to Analogue output were installed. To the DI, an unused old Sparc 5 Sun workstation with 8Mo of RAM was installed.

The software development was carried out by students with limited knowledge of C language. About 20 parameters were scheduled.

Supervision has to be carried out from 2 places: locally during the day and from the Vivitron control room during night shifts. Two displays run simultaneously.

The DI was designed using the Vivitron pattern, and the database compiled.

Finally the software was completed in one working week - made possible because of object handling and reuse of the code.

The entire software was loaded from two 1.44Mb floppy disks.

Regular updates are done via one floppy disk.

5 CONCLUSION

As the Vivitron is a machine under continuous development, the software must also be developed.

These changes are done by accelerator staff themselves, who are not computer specialists. This allows use of tools corresponding to their requirements.

This is made possible with the use of an object-oriented database, although its development required much work.

This **system can be easily reused for other systems, using the same hardware**. This was achieved in one working week using a new software control system for the CN accelerator.

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