FIRST OPERATIONAL EXPERIENCE WITH THE DAΦNE CONTROL SYSTEM

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Abstract

The DAΦNE Control System has been fully implemented for the accelerator complex component already operative. The architecture has been improved both from the hardware and from the software point of view. Control application for magnetic elements, vacuum equipment, RF cavity and diagnostics have been developed and debugged on line. Tools to include HLS (High Level Software) application in the Control System have been developed together with a dedicated Real Time database.

1 INTRODUCTION

DAΦNE [1] is the Frascati Φ-factory project and DANTE [2] is its Control System.

DAFNE consists of an 800 MeV electron Linac, a 510 MeV damping ring, the Accumulator, and two colliding beam main rings. A Transfer Line, 156 m long, joins the different parts. At the present the Linac the Accumulator and the related Transfer Line are available and under commissioning.

DANTE is a three levels Control System, having a hierarchical communication structure and distributed intelligence. It is based on the VME bus and on the Macintosh personal computer, used as a console and as VME CPU.

2 SYSTEM OVERVIEW

The DANTE 3rd level, HELL, is made up by many different CPUs, DEVILs, each one controlling a specific class of element and updating the corresponding part in the RTDB (Real Time Data Base) [2]. The 2nd level, PURGATORY, includes two CPUs CARON and LOGGER. CARON forwards the command from the 1st level to the proper DEVIL and the 3rd level coming error messages and warnings to the running consoles. Moreover it checks continuously the DEVILs status. The LOGGER keeps trace and periodically saves all the communication between the 1st and 3rd level.

The 1st level, PARADISE, consists of several consoles providing a graphical access to the accelerator complex and of a Control System Server where the applications, the DEVIL start-up configuration and the DAΦNE data-set are stored.

The Link between PARADISE and PURGATORY is performed through the CES VMV bus interface (CES 7212-8250) [3], while between PURGATORY and HELL several optical point to point links have been implemented using the VME-VME LEXTEL LL2000 interface [4].

An Ethernet network connects all the Control System processors and it is used to download the DEVIL applications and the configuration data-sets. The Ethernet LAN is also used for debugging purpose.

It is worth noticing how using the same processor throughout the whole system permits to have the same Operative System [5] and the same development environment LabVIEW [6].

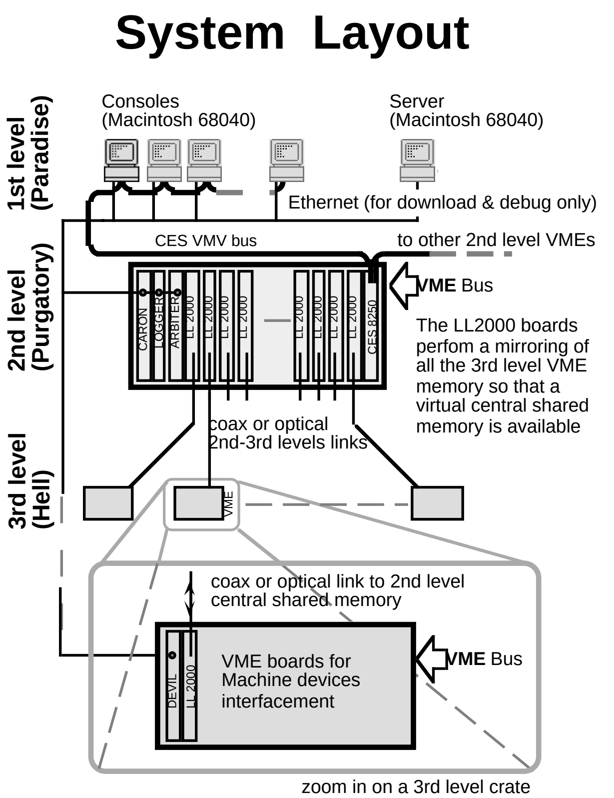

Figure 1 - General System architecture: all the distributed 3rd level VME crates contain one or more DEVILs (Macintosh LCIII with 68030, Math coprocessor, 8MB internal RAM, 4 MB VME RAM, Ethernet for diskless booting). All the DEVIL VME memories are mapped into the 2nd level VME address space. This virtual central shared memory is accessible from the consoles with a direct memory access.

3 DANTE IMPLEMENTATION

In this early stage of the DAΦNE complex commissioning the Control Group has been in charge of installing the hardware and providing the DEVIL applications for the primary devices. The first DANTE implementation, phase 0, started one year ago.

A control room was arranged in the Linac area, it has been used extensively to investigate in very deep detail the Control System main structure, and then also to commission the 20 m long first Transfer Line part. For this reason four consoles have been installed.

One month ago started the DANTE phase 1, it was supposed to control the Accumulator and the, 90 m long, Transfer Line, up to the Linac.

A new control room has been set up. This time all the efforts have been appointed in testing the Control System ability to drive the machine devices and defining the operating procedures.

The main Hardware components installed are listed in Table 1.

The total amount of software written and debugged for the controlled devices is greater then 150 Mbyte, 95% written in the native LabVIEW graphical language G and 5% written in a standard ANSI C and FORTRAN language.

Table 1 - Phase 1 hardware components

Console	2
Remote console	1
Server	1
Caron	1
Logger	1
Arbiter	1
Lextel coax link (pairs)	6
Lextel optical link (pairs)	4
DEVIL	15
Ethernet hub	1
VME crate	10

4 DANTE UPGRADE

The experience done with the DANTE phase 0 resulted in some modification of the Control System general scheme. An ARBITER has been introduced in order to rule the console data fetching from the 3rd level RTDB, because a 1st level VME access through the CES and LEXTEL boards produces seldom a time delay exceeding the NuBus time-out (25μs). This may result in a busError when two or more consoles try to get data from the RTDB concurrently.

The increasing number of installed DEVILs required a dedicated Server were to store the relative applications together with the start-up data-set files. The log files saved from the LOGGER, containing the list of command and error travelling between PARADISE and HELL, are housed on this server too.

A complete transition from coax LEXTEL point to point link to the optical one has been planned in order to face not only the problem of the long distance communication, but also the noise due to the harsh environment.

A description of the most important devices controlled by DANTE, in the phase 1, follows.

4.1 Magnets

All the accelerator magnets Power Supplies (more than 164 up to now) are *intelligent* devices. This means that they have an embedded micro controller which drives the current ramp with a pre-defined slew rate, monitors the interlock conditions and arbiters all the Power Supply status transitions.

The link with the Control System 3rd level (VME BUS) is done via many RS 422/485 4-wires multidrop busses at medium speed (from 9,600 to 57,600 bps). Not all the Power Supplies run the same communication protocol so that 4 different sets of drivers have been developed in order to control and read back all of them.

Dealing with "intelligent" devices made the control a matter of logic rather than of hardware. The concept of Power Supply element has been abstracted into a software object which contains virtual statuses and accepts always the same system commands.

The control applications running on the 3rd level DEVILs are in charge of updating continuously this software object representation into the RTDB and converting the system commands into a device dependent syntax.

The RTDB refresh rate depends on the baud rate and on the protocol going from 1 to 25 Hz.

All the 1st level user windows for the control of the Transfer Lines Power Supplies are completed and those for the Accumulator are on the way.

The control of the Accumulator and Main Rings *Kickers* magnets differs from the above general description. The *Kickers* magnets have been fully designed and built in house and required a strongly customised interfacement. In this case the command and control is performed through DAC, ADC, digital I/O and GPIB programmable delays. All this hardware is connected to the VME and controlled by a 3rd level DEVIL.

4.2 Radio Frequency

At this stage the Accumulator RF cavity control has been provided. It permits to visualise and to set the main cavity parameters.

An Industry Pack carrier, appointed for its reliability, has been used. It allows to house up to four, mixed type, I/O modules using a single VME slot. The carrier arrangement includes multiple channels DAC, ADC and digital I/O. The drivers for the hardware, the RTDB and the 1st level control window have been written and fully debugged. An operator window with less information and automatic start-up procedure is under development.

4.3 Vacuum

The Control System for the vacuum equipment has to deal with 24 SIP (Sputter Ion Pump) and 7 VUG (Vacuum Ion Gauge). Both of them are controlled, through the DEVIL serial port, using RS 485 4-wires multidrop busses.

Low level drivers, RTDB, 1st level control window and an overview window giving the vacuum general status at glance are available.

4.4 Diagnostic

The Control System for the diagnostic is in an early stage. Full remote control has been provided for the *Flags* and the related video camera, the (SEM) Secondary Emission Monitor and for a general purpose video and RF multiplexer.

VMEIO 1016 relai and VMEIO 1018 IO, by the OR Industrial Computer , have been used for the *Flags* control. A Video Multiplexer, controlled through the DEVIL serial port, permits the *Flags* remote view.

The 3rd level drivers, the RTDB and the 1st level control window have been written and are available for all the listed diagnostic element.

5 HIGH LEVEL SOFTWARE

The DANTE 1st level permits to include and to run HLS applications. They consist of codes, written using the FORTRAN compiler [7] available under the MPW development environment [8], integrated in the proper LabVIEW VI using the CIN (Code Interface Node) facility. A CIN allows to run a code written in C language which may itself calls a FORTRAN routine. To implement this mechanism a library to matching the C language data types with the corresponding FORTRAN ones has been developed.

Every HLS application must be able to access all the device read backs in the DANTE RTDB. Moreover it needs other information such as machine models, static lattice description, calibration and numerical constants. The last database part has been developed, it is housed at the 2nd level of the Control System on the LOGGER RAM. It is initialised by the 1st level main program at the Control System start-up. Data are grouped according to the DAΦNE functional areas they refer to and may be read and modified at run time.

A HAL (High level software Application Library), 1 Megabyte large, has been written and debugged. It provides the basic machine oriented routines and meets the CIN requirements. The HAL library has been used to write the basic applications for the accumulator commissioning. Their integration into the Control System is on the way.

6 CONCLUSIONS

The DANTE phase 1 is running. It has been fundamental to drive the beam from the Linac into the Accumulator and to optimise the Accumulator lattice in order to get a *circulating beam.*

The Accumulator commissioning is a powerful bench test for a continuos Control System refinement. Nevertheless its general structure and the implemented software have not shown, up to now, any relevant problem and will be easily extended to the main rings control.

7 ACKNOWLEDGEMENTS

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