Integration of a PC based experiment in a Network based Control System: the TTF Optical Diagnostics Control System

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Abstract

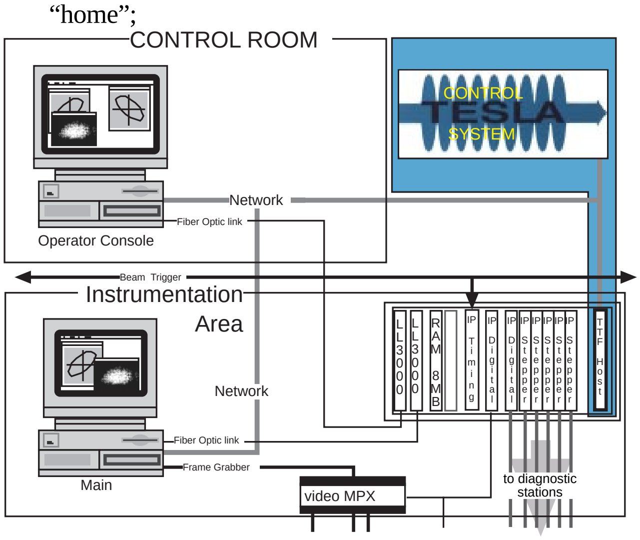
Optical Diagnostics for Tesla Test Facility at Desy Laboratory[1] have been provided by INFN groups of Frascati and Roma2. More than fifteen diagnostic station have been installed on the TTF beam line and Test beam line and operated with the Optical Diagnostics Control System (ODCS). ODCS is a stand alone system based on Macintosh computer and provides full control over the specific hardware while a network based Control System[2] takes care of the whole TTF.

This paper describes the ODCS system, its features and the solutions utilised to integrate ODCS with the TTF control system.

1 THE ODCS

When we started to design the Optical Diagnostic Controls we followed these main guidelines:

- the system has to be used for hardware control as well as for data acquisition and analysis: a common software environment should be preferred;
- the large number of heavy images continuously transferred between the computer hosting the Image Grabber and the Operator's Console shouldn't effect the network and moreover shouldn't be limited by the network's bandwidth and traffic on it;
- furthermore the transfer speed must be high enough to allow real time measurements;
- the system must be easily expandable in order to follow the further development of the TTF linac;
- remote control of the whole system must be allowed in order to permit operation and maintenance from "home";



- previous experiences [3] and well known hw/sw has to be preferred to reduce the efforts for development.

Our previous experience with Apple Macintosh for hardware and instrumentation controls and for data acquisition and analysis, defined the preference for the computers. The characteristics of MacOS and the need of VME modules for I/O defined requirements for the architecture. In Figure.1 is sketched the layout of the ODCS's hardware configuration.

The three partners of the system are shown: in the Instrumentation Area the main ODCS computer and the TTF host (VME-Sparc Computer), the Operator's Console in the Control Room. The two Macintosh are linked to the VME crate via a fibre optic link (Lextel LL3000 series); this ensure an high bandwidth for data transfer and moreover allows the Operator's Console to be located at quite long distance from the VME crate (approx. 80m.). The VME memory space is seen from the Macintosh as it was within its 32–bit address space and directly accessed. Main computer and Operator's Console have also a connection to the network to access the local services and to allow their remote control by means of Timbuktu (Farallon). On the Operator's Console runs an FTP server to allow downloading of images and measurements from any machine.

All the software tools have been developed using LabVIEW™ from National Instruments. For the low level communication routines C libraries have been written and imported into LabVIEW Vis using CIN (Code Interface Node).

The Image Grabber (a number of them have been successfully used) is hosted by the Main computer and controlled with LabVIEW. The beam trigger is used to synchronise the image grabbing with the beam pulses. For special measurements (low intensity radiation, time resolved measurements) an intensified camera from Princeton Instruments is used. Its interface to controller unit is installed directly into the Operator's Console and operated locally.

Input/Output with hardware is performed using IP (Industry Pack) I/O modules: digital IO, DAC, Step Motor Controller, etc.

2 DATA SHARING AND COMMUNICATION

2.1 *Shared memory*

Although the two Macs and their functionality can be merged into one, we decide to use the two computers configuration in order to avoid the Operator's Console to be slowed down from the operations related to the images acquisition and digitisation. With this splitting of functionality, the Main computer takes care of the Image Grabber and I/O controls while the Operator's Console is used to display data, to run automatic procedures for the measurements and for data analysis. Information about the system and the images are written from the Main computer into a RAM memory in the VME crate; the Main can be considered as the system's "server". The Operator's Console and the TTF Control System are hosts and they access information in the same way since they share the same VME RAM memory. Furthermore, since the two hosts don't control the hardware directly, a set of mailboxes have been defined in order to send commands to/from the server.

Because LabVIEW doesn't support C-like pointer variables, a C structure has been defined to map the shared VME memory and C routines have been written to read/write from/to this structure. They have been imported into LabVIEW Vis as CINs. At the same time the TTF host interface application includes the same C–structure (the same header file) for its read/write routines.

struct ODCS_mem {		
uInt32	SysInited;	/* Memory map inited */
mailbox	mbx[NumOfMbx];	/* mailboxes */
modules	mod[NumOfMod];	/* VME modules tables */
elements	ele[NumOfEle];	/* elements tables */
extele	xele[NumOfextele];	/* external elements */
images	ima[NumOfIma];	/* 512x512 8-bit image */ };

Table1: The C structure that defines the "real-time" database of ODCS

In Table1 is presented the C-structure defined to map the shared memory. The *mailbox* type is a container for commands strings to/from the Main computer and the other two partners: four unidirectional Mailboxes are implemented. Commands are coded following the format defined for TTF, i.e. "facility/device/location/property" and looks like: "ttf.diag/viewscreen/1bc1/screen=otr".

mod[] array (*modules* type) contains information about the hardware and is used by the Main to execute commands. Every ele[] array element contains information about the status of a diagnostic station and the I/O channels that uses; it is updated by the Main and continuously red by the Operator's Console to refresh data on graphic display. ima[] array is the container for the last image taken at every diagnostic station, its projections and RMS values (i.e. center of mass, sigmas) and total intensity. ima[] and ele[] are indexed in the same way (e.g. image for ele[n] is given by ima[n]).

When the Image Grabber is set in order to digitise the image seen from the camera at station "n", ima[n] is continuously updated from the Main computer. The operator can configure its display to update either the full image, or the projections, or just the RMS value, or even all of them. Projections and statistics of images are calculated while writing to VME to improve the speed.

2.2 Commands and Readout

Figure2 shows a flow chart outlining the execution of a command. The operator clicks a button on its graphic display to, for instance, insert an OTR screen at station "n" named "1exp3". A command is written into the mailbox to be executed by the Main and when it is completed, the variable ele[n].screen is updated to value "otr". The display software of the Operator's Console detect this change and update the graphic display accordingly.

Commands from the TTF host are executed in the same way. The interface program use the same C routines to read/write the mailboxes while data are directly read from the ODCS_mem shared memory and sent through the network to a console running a display application.

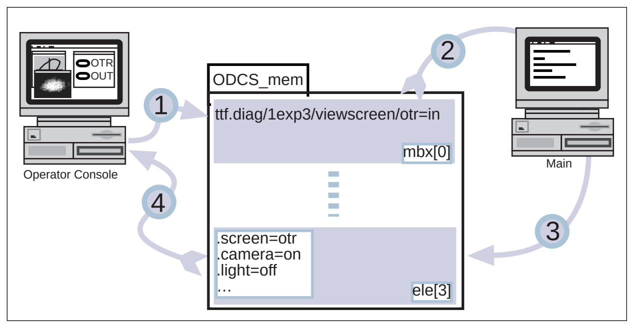


Figure2: Execution of a command from the Operator's Console and readout from Shared Memory

2.3 Data from TTF Control System

ODCS has been also designed to send commands and receive information from the TTF Control System. This is very important when some procedures have to be executed automatically as, for instance, the emittance measurement. In this case the current of one or more quadrupoles must be set to change the beam optics and read during the measurement. For this purpose the xele[] array of type *extele* is used. Type *extele* mainly consists of a string and a float variable: in the string the ODCS writes the name of the item whose values is needed (e.g. a quadrupole current: TTF.MAGNETS/DOUBLET/F2EXP1/PS.RBV) while the TTF host continuously check this list and update the values of listed item in the correspondent float variable. When the quadrupole's current has to be changed, the procedure running in the Console write a command into the TTF host's mailbox and waits for the reply message that confirms the completion of the command.

3 PERFORMANCES

The present configuration of the ODCS still consists of a Macintosh 7100/66 and a Macintosh 8100/110 computers. The first one is the Main computer and hosts the Image Grabber; the second is the Operator's Console.

The Main can digitise and transfer to the VME half-size images (384x256 pixels) at more than 1Hz; full-size images are refreshed at 0.5÷1Hz. Execution of a command takes approximately, but usually less, than 1sec. This is mainly due to the time needed to execute the routine that reads the images from the Image Grabber boards and the one that writes it to the VME. These routines, being LabVIEW CINs, prevent LabVIEW and the MacOS to run other tasks in parallel. At 1Hz beam repetition rate the Maintosh CPU is then "occupied" running these routines for some hundred of milliseconds. Actually, the increase of speed of commands execution is not a critical issue since the typical command, i.e. the insertion/extraction of a view screen in the beamline by means of a stepper motor, needs some seconds to be completed from the actuator.

4 COMMENTS AND FUTURE DEVELOPMENTS

Since 1997 ODCS is used daily from TTF operators to help the transport of the beam and for measurements. New tools are continuously developed and controls for new diagnostic devices are implemented as they are added. For normal operation the diagnostic stations are usually operated from a TTF Control System console via the interface to ODCS while measurements are performed using automated procedures on the ODCS console.

Because new and much faster computers are now available, we planned to upgrade the two Macintosh. The Main computer will be the one to be replaced first and we have three open options:

1- a new MacG3 will be installed beside the actual Main. The latter will continue to host and run the Image Grabber while the new one will take care of the communications and commands execution;

2- the new MacG3 will completely replace the existing Main;

3- the new MacG3 will be used to host and run the Image Grabber and a new embedded VME Sparc computer running LabVIEW will be the new Main.

It is likely that the three options will be implemented in the order as successive upgrade stages.

If option 3 will not be realised we planned to install "network mailboxes" to allow execution of commands from a remote computer. These have been successfully tested already with a TCP/IP server VI (based on LabVIEW TCP/IP tools) running in the Main computer that receive commands from authorised hosts on the network. Another TCP/IP server VI will interface the VME shared memory and will send data for remote display.

We have also tested a LabVIEW http server that we planned to install to distribute measurements and real-time data to members of collaboration.

5 ACKONWLEGMENTS

I'm grateful to all the colleagues of INF-LNF in Frascati for their work developing part of the software for ODCS. Many thanks also to the DESY colleagues and their continuos collaboration and support especially to K.Relich and O.Hensler that implemented the interface to TTF Controls.

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