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General Man-Machine Interface used in Accelerators Controls: Some Applications in CERN-PS Control Systems Rejuvenation

M.Boutheon, F.Di Maio, A.Pace
PS Division
CERN CH 1211 Geneva 23 Switzerland

Abstract

A large community is now using Workstations as Accelerators Computer Controls Interface, through the concepts of windows - menus - synoptics - icons. Some standards were established for the CERN-PS control systems rejuvenation. The Booster-to-PS transfer and injection process is now entirely operated with these tools. This application constitutes a global environment providing the users with the controls, analysis, visualization of a part of an accelerator. Individual commands, measurements, and specialized programs including complex treatments are available in a homogeneous frame. Some months of experience in current operation have shown that this model can be extended to the whole project.

I INTRODUCTION

When the decision was taken to rejuvenate the computer control system operating the CERN-PS accelerators complex [1], it was felt that users should define their needs [2]. More precisely, the end users, i.e. the operation teams had to give their views on interaction principles and tools.

The framework of this study was of course delimited by the now worldwide accepted notion of G.U.I.[1] , integrating the concepts of windows, pull-down menus, pop-up menus, icons and objects selection, all these being driven by a powerful multitasking system [3]. Taking into account the dimension of the process - the PS complex includes 10 accelerators - a prototype had to be constructed in order to evaluate the new human interface proposed.

The hadron beam transfer line from the 1 GeV Booster synchrotron and the related CPS injection process were selected as guinea pigs. The principles and applications are described below.

II PROCESS STRUCTURING

In a very large process to be controlled from a centralized point, the first task consists in defining a structure allowing each member of an operating team to work in a quasi independent and secure way. These principles were already successfully introduced in the present control system [4] and are kept here. Moreover, the PS accelerators complex pulse-to-pulse modulation (PPM) working mode [5] imposes the notion of virtual machine: a parallel adjustment of concurrent beam types in the same accelerator is possible.

From the above the concept of an *Application* emerged: the whole lot of application programs needed to operate a logical part of an accelerator in an autonomous manner. We are talking here of the "CPS 1 GeV Injection Application" given as an example.

An Application includes:

- the complete access to the control/acquisition of the parameters set composing the sub process
- the controls of the dedicated measurement devices and associated presentation programs
- the temporary specialization of some general measurement devices (dedicated initialization of parameters)
- access to particular application programs developed for the specific sub process.

The term Application will be used in what follows to designate the working environment defined above.

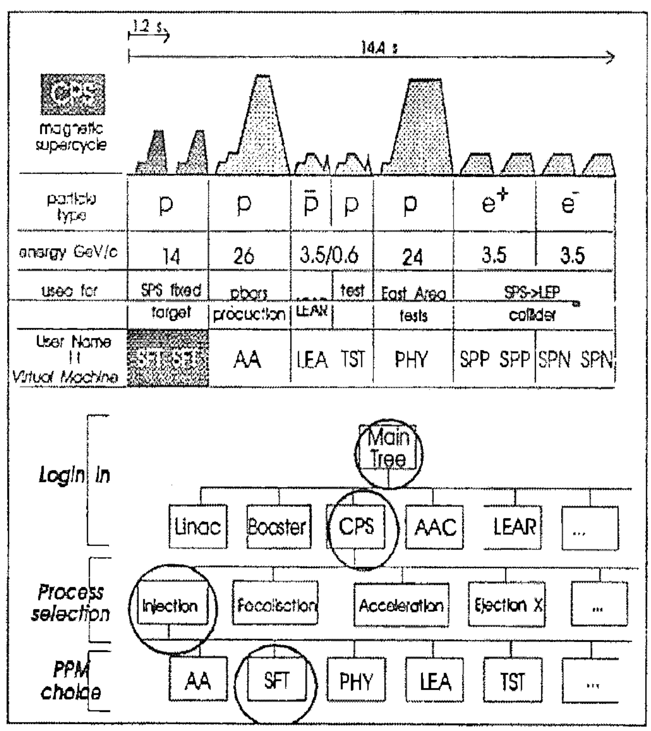

figure 1: a CPS supercycle showing the succession of beam types and selection structure scheme. Illustrated: The 1 GeV Injection Application addresses to the CPS parameters valid for the beam sent to the SPS accelerator.

[1] Graphical User Interface

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The complete design of the user interface for the computer control system will consist of specifying all the Applications. The structure is Beam Oriented rather than Hardware Oriented as suggested by figure 1.

III TYPE OF CONTROL TOOLS

We considered in this study that the only interacting tools would be a mouse, and a keyboard. The (software) tools contained in an Application can be classified according to the different stages of a process. We have selected:

Synoptics

They are used to visualize the whole process covered in the Application, namely the pictorial display showing the pieces of hardware constituting the sub processes, on which the user can act. This figure gives on line the status of the apparatus, at least along the beam path if exact geographical representation is not possible. Moreover the synoptics is made of selectable objects through which other tools can be accessed.

Individual Controls

Each piece of hardware in the Application must be accessed, either to act on the beam itself, or to adjust measurement devices to obtain beam properties. This is done through "knob-like" tools which can be attached to any parameter, providing incremental actions, on/off type action, and several other moves, for ex. return to initial value. The refreshed acquisition value is also displayed.

Individual controls are also concentrated in a *parameter list* table which gives a complete information on status, control and acquisition values relevant for this Application area. Any line of this list is a selectable object calling a control knob.

This list is similar to the Synoptics, but gives other pieces of information: in that way List and Synoptics are complementary instruments.

The two classes above are entirely valid in any Application: they are what we called "generic application programs" [6].

Remark: we do not deal here with the question of data management (database use) which is entirely a part of the Control Systems specifications.

Physical Parameters

Some hardware variables like Voltage, Intensity... are hidden. So an accelerator physicist can adjust parameters directly in normalized position units, meters, radians, gauss, corresponding to the physics involved in the process [7]. Generally the two types of variables are linked by a linear equation system seen as a matrix which can be inverted to play in both directions. Going further this way [8] we can treat the synchronization of pulsed process (here the CPS 1 GeV Injection) with this method, the matrix being the cabling lay-out.

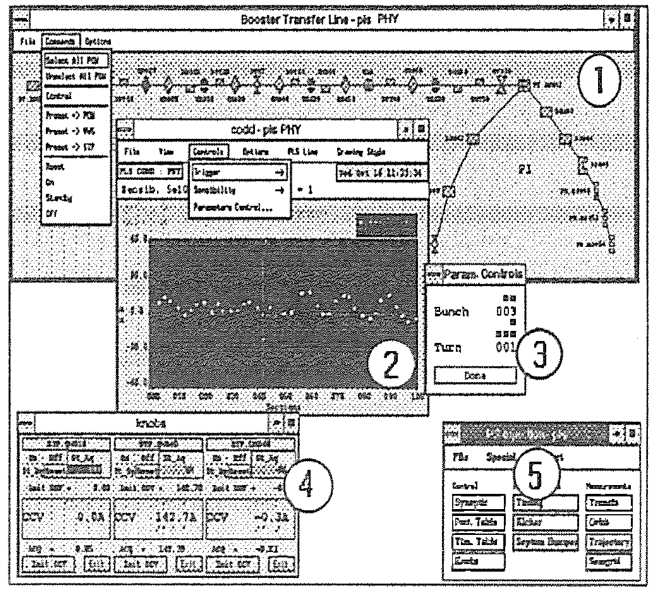

figure 2: one example of a Workstation screen showing some of the tools and presentation used for the PSB-CPS 1 GeV transfer and injection prototype.

1= the Synoptics window including all sub process elements, with Controls menu
2= Closed Orbit Display, in graphical view, and its Controls pull-down menu
3= the Closed Orbit Display sub window with the synchronization commands
4= three (5 possible) "knob-like" tools, controlling power supplies (hardw. units)
5= the main window - Application manager - giving total access to all programs

Measurements. Complex Treatments.

This class of tools has no special structure, being too linked to the particularities of the process. Nevertheless, two types of measurement tools are distinguished :

- *special measurements:* the apparatus used, the diagnoses, the parameters involved are present only in the process covered by the Application. These tools are developed (sometimes using complicated computations) according to specific needs. They only obey the presentation rules: e.g. the Transverse Emittance measurement.

- *dedication of general interest measurement:* here the measurement is performed through a tool with conditions related to the Application (synchronism, sensitivity, ..etc..) from which the tool is called. Then, this measure is "generic", i.e. usable from several Applications but each of them sees it as if it was specially written. In the prototype, the Closed Orbit Display serves as an example [9].

One other class can exist:

Optimization

Of course, these programs are specially designed for an Application; each of them depends only on the process analyzed. In the prototype the Betatron Oscillations Minimization [8] was developed; others are foreseen. There again no standards are anticipated, only the interactions and presentation rules are adopted; the only decision taken was to

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propose computed corrections to the user : no automatic closed loops were introduced.

These five types of tools will be present in any Application of the man-machine interface. Their relative weight will depend on the sub process characteristics.

IV Screen Management

The different tools from the 5 classes above constitute a working environment. The user is facing a Workstation screen: we had to define some standards of data presentation which could be used in the whole control interface [10]. We are not talking here about the Standards selected for the Computer Controls System: for screen picturing, X-Windows™ and Motif™ were used (see [6]) and their standards accepted.

Data presentation

We concluded from past experience that in any display exists a dichotomy of data presentation: graphics or tables . Due to the user personality, or the type of data, or the mode of operation ...etc.. it is difficult to eliminate one of them. We tried to keep at will the two displays (example: Closed Orbit Display). The *synoptics* and *parameter lists* are themselves applications of this concept.

Windows use

Each type of controls tools is running in a proper window with a menu bar and its associated pull-down menus. We intend to propose at this level a common choice which can be enlarged according to the sub process. In the prototype FILE, VIEW, CONTROLS, OPTIONS.. HELP are the common factor; it is too early to freeze the proposal, but the subject is important.

Another point of interest consists of the windows movements. Experience has shown that windows must be opened at the same place every time they are called, and, hardly ever need re-dimensioning. It is a task for a man-machine interface study to define an Application in order to verify that this request is satisfied. If necessary, the freedom of re-dimensioning a window is not given. Whenever possible sub windows should not mask present windows.

Icon use

Such facilities are powerful tools for screen management. Here also, to make an efficient use of time in an Application we imposed some rules, and introduced a hierarchy on the icon transformations.

With the exception of some windows waiting for a specific response or being the last of a tree structure, each window can be put into an icon. The latter is kept itself in a window (bottom of the login screen) and can be re-opened to its full scale. By the way, we decided also that no window should occupy the whole screen.

When opening an Application, a main window is opened and proposes the list of available programs in this sub process. At any time, even with a screen full of running displays, you can clean the entire screen by storing this main window into an icon . And the reverse action puts back on the screen all your Application working environment, exactly as it was, in one go. This facility has been found extremely useful, allowing a fast glance at another subject without interrupting our main task.

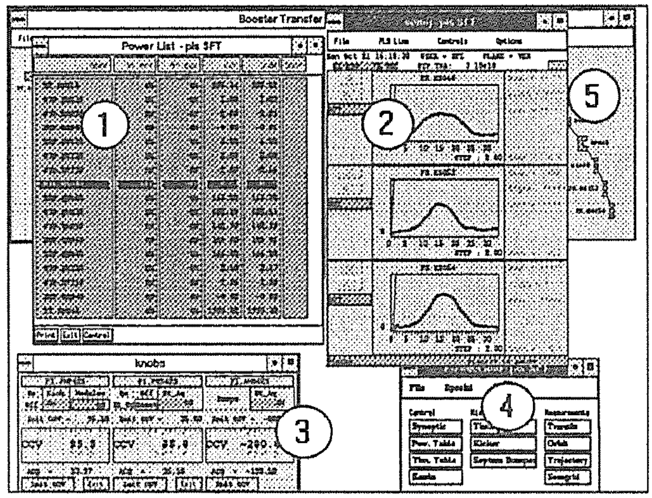

figure 3: another Workstation screen including tools showing other views and means of controls associated to the PSB-CPS 1 GeV injection process, and complementing the figure 2. All these tools can be activated together or successively by the way of icons.

1= Parameter List of the power supplies, giving complete numerical information
2= the Beam Profile Measurement window and related Emittance computation
3= several knobs, linked to normalized coordinate units here (physical units)
4= the main window - Application manager - see figure 2
5= the Synoptics view kept in background, e.g. giving instantaneous status info.

Workstation use

Every Workstation will be independent, see Chap. V.

It is foreseen that only one Application will be opened (i.e. "alive") at the same time on a Workstation screen. This is not introduced as a rule, but a suggestion. The hierarchy principle implemented in icons use will ease the fast exchange between several Applications on one Workstation.

Updating data

As said in Chap.I, an Application is related to an accelerator cycle providing a user with a beam; it was requested that all the programmes belonging to an Application display a set of coherent data, i.e. presenting values acquired on the same machine cycle. At least a warning sign must indicate clearly if it is not the case for whatever reason. In principle, several Applications could co-exist on a Workstation, and updating rate problems could be anticipated. This is why we considered that probably only one Application will be "full screen" at a time on one Workstation.

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V ANTICIPATED CONTROL CENTER

Workstation relationship

Every Workstation will be independent, i.e. can open any Application (as defined in Chap.I), and there will be no mutual interaction between any other Workstation. If needed, several Workstations will (the system will allow it) open the same Application in order to get a larger screen surface. Controls will be granted on the basis of first in - first served, and the command values will be refreshed with the last updating (see [9] more precisely).

Numbers

The prototype gave us an idea as to the needs arising from the operation of an accelerator complex, and how the present central control room - from which ten machines are driven - will be rejuvenated. Thanks to the non-dedication of any tools (the present consoles), the PS accelerators complex has been operated from 8 simultaneously active entry points for several years.

For reasons of screen surface we concluded from experience that we need 3 stations to replace one console, making what we call a "work place". For the time being, the general analog signal multiplexing system will be kept; however it is foreseen [11] in the Computer Control Rejuvenation project to construct a digital system using Workstations as display terminal.

We think that the central control room of the PS complex will include at least 25 Workstations, with a mean value of three logged on one accelerator at a time. One extra improvement will be to increase by a factor of 3 the number of entry points.

Assignment

At a work place, it is foreseen that two workstations will support the Applications defined here, and the third one will be mainly used to cope with the generalities: Alarms, Messages, Radiations Survey, Statistics, and so on.

VI CONCLUSION

The Man-Machine Interface specifications summarized here and introduced in this prototype are not final. Other important points are still being debated. For instance spreadsheet techniques (like the EXCEL^{TM} product available in our Personal Computer network [12]) could replace some development programs if not operational tools. WINGZ^{TM} is currently under evaluation [9].

On the other side a few topics were left aside but will have to be defined correctly before the user environment definition will be abandoned. Designing the Data Archiving and Error Handling and Presentation systems is a must.

For several months the Booster-to-CPS transfer and injection process at 1 GeV has been operated through one Application, built from the specifications given above. This Application constitutes a global environment providing the users with the controls, analysis, visualization of a part of an accelerator. This was defined as a prototype for the new era in man-machine interface using graphical displays associated with a distributed network of powerful workstations. The fact that this prototype was readily accepted by the operation teams without a long training period encourages us to extend the principles used. A second beam line is already treated in the same way.

The PS complex Computer Controls Rejuvenation project will now take care of an ensemble of three machines: the LEP pre-injectors (2 Lepton Linear accelerators + 600 MeV collecting ring) [13]. A large part of the prototype programs will be used for that slice, to the benefit of users.

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