A Data Driven Graphical User Interface for Vacuum Control Applications

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Abstract

It is always a serious challenge to develop a synoptic based graphical user interface for the large installations due to inhomogeneous equipment distribution, large variety of equipment and huge facility size. The solution proposed in the report is based on automatic configuration of the graphical user interface using the description of the equipment and of the topology stored in the database. This approach was used to develop the applications for vacuum equipment control for the SPS and LEP accelerators at CERN. As a result, an impressive quality of synoptics was reached with very efficient maintenance procedure.

Introduction

The software described in this paper is intended to provide a uniform man machine interface (MMI) to the vacuum equipment of all main CERN accelerators (PS, SPS, LEP). The vacuum controls architecture is essentially similar for all three main parts of the CERN accelerator complex and employs a two layer model [1,2].

The control room layer provides the user interface to the system using graphics workstations and X-terminals. This layer also includes file and database servers. The front-end layer contains a number of front-end computers dedicated to a given geographical area and connected to the control room via the general control network. The front-end computers are used to run vacuum equipment servers: processes that allow access to the equipment over the network from the control room workstations.

The objective of this project is to provide the users with a flexible tool to monitor and control vacuum equipment using synoptic diagrams, pressure plots and other forms of graphical data presentation available on modern workstations. The main problems in developing MMI software for the CERN accelerators are due to the huge facility size, complex topology and inhomogeneous equipment distribution. Vacuum equipment of the CERN accelerator complex includes thousands of devices spread over many beam lines and accelerator rings and undergoes continuous modifications.

To achieve the required flexibility and maintainability of the MMI software, we decided to apply an approach based on automatic user interface configuration according to the accelerator description stored in the ORACLE database. The configuration data is read by the MMI software at run time and determines all equipment related aspects of the user interface, such as layout of synoptic diagrams, arrangement of pressure plots, etc.

The database and configuration data

Although the formats and structure of the information in the ORACLE database are quite different for different accelerators, the database can extract the following essential information for each piece of the equipment:

- Equipment type identifier.
  The type identifier determines the shape of the icon representing the equipment on synoptic diagrams and for controllable equipment allows the selection of the correct data acquisition and data handling procedures.

- Equipment position in an accelerator ring or along a beamline.
  This information is mostly used to place the icons correctly on synoptic diagrams. Several different coordinate systems are used to specify equipment positions in the database. They are bound by referencing some elements to their global coordinates in the site survey database.

- For controllable equipment:
  The equipment address and some other information which is required to reach the equipment in the control system network.

Also, the ORACLE database provides information on the grouping of equipment into sectors and larger partitions (sextants, octants, rings, beam transfer lines). Unfortunately, the existing database does not contain any explicit information on how the partitions are related to one another, i.e. which partition is next to which, where a beam injection line joins an accelerator ring, or where a beam extraction line "forks". This information is supplied in a separate text file describing the installation topology for the MMI purposes. An example of the topology description file is given in the Appendix.

Extraction of the information from the ORACLE database is done "off-line" by a special utility which preprocesses the extracted data, merges it with information from the topology description file and produces an indexed data file which is then used as the main source of the configuration data at run time for the MMI software. The purpose of this intermediate buffering is to provide:

- Guaranteed availability and fast access to the data.
  The data file resides on a control system file server and can be read within a fraction of second by any console workstation in the control network. This response is not guaranteed by the ORACLE database server which is not intended for real time control applications.

- Uniform interface to the data.
  Formats of the records describing partitions, sectors and equipment elements in the data file are identical for all accelerators. As far as possible, peculiarities of the original machine descriptions in the ORACLE database are removed during the preprocessing.

The user interface

The MMI software has been developed to run on a control room workstation using existing control facilities at the front-end level and below. Despite the general similarity of the controls architecture, methods to access equipment are significantly different in all three accelerators. Due to the inhomogenous equipment interface, the software has been delivered as three separate application programs, one for each main part of the accelerator complex.

All three MMI applications have been written to run under UNIX (HP-UX) using the Motif tool kit and have a large common part implementing the core MMI functionality. At start up, the applications read configuration information from the data file, perform various initializations and enter the main loop displaying a main window (Fig. 1).

The main window gives a general overview of the accelerator on a top level synoptic diagram. All main partitions are shown together with icons indicating the general status of vacuum equipment in the area. The main window is also a starting point for navigation through detailed data views provided by the MMI software (Fig 2). From the main window users can invoke synoptic diagrams, pressure profiles or device tables for a selected part of the installation.

The selected part may include any number of sectors in a contiguous viewing area that can be defined using the main window options. The viewing area is highlighted on an upper level synoptic diagram. The equipment in the viewing area is represented on synoptics by icons placed along a beampath (Fig. 3).

Both vacuum and non-vacuum equipment elements are shown on the synoptics; the non-vacuum equipment forms a background that helps users to locate the vacuum equipment of interest. Icon shapes for the non-vacuum equipment are derived from AUTOCAD drawings of the real equipment using a technique described in [3]. The size of non-vacuum equipment icons is roughly proportional to the real equipment size. The vacuum equipment is represented synoptically by fixed size icons according to CERN standards for icon shapes and colors.

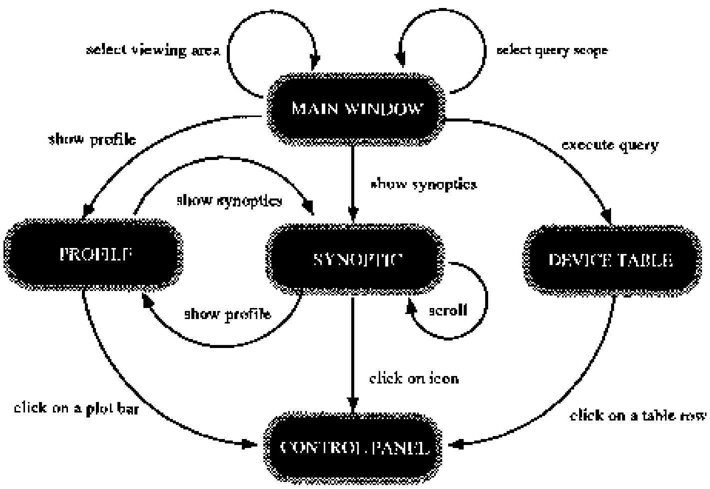

Figure 2. Simplified MMI navigation diagram

Relative positions of all icons in the synoptics are proportional to the real equipment positions, with the exception of some vacuum equipment elements which are located so close one to another that the correspondi icons overlap. In this case, a part of the synotic is expanded to accommodate all icons in that area.

All icons representing controllable vacuum equipment are active: the icon color corresponds to the current status of the equipment and clicking on the icon activates a device control panel (Fig. 4). The control panel displays all device parameters available in the control system and permits all device actions defined for a given equipment type (eg, open or close a valve).

Control panels can also be invoked from a pressure profile. The pressure profile is a bar plot of the pressure measurement data collected from all measuring devices in the viewing area (Fig. 3). The sequence of bars in the plot is the same as a sequence of the devices along a beampath in the viewing area.

Information on synoptics, profiles and control panels is periodically updated to reflect a current equipment state. The data acquisition is performed by the work procedure which is executed when the main loop is idle (not processing any X events). Only the data required to refresh a picture currently on the screen is read from equipment and the whole process of data acquisition and picture refresh is optimized in such a way that the user interface is not blocked for more then one second.

The MMI software provides the users with a capability to execute actions "globally": for many devices of the same type. This option, which is especially useful in large installations, is complemented by a possibility to search within a given scope for the vacuum equipment elements with real-time parameter values that match certain selection criteria. A special form is provided to set the query scope and selection criteria (Fig. 4).

The query option can be used in conjunction with global actions to check the action results, or independently to locate equipment of interest. For example, to select all ion pumps in sectors 110 and 130 that are not ON or read pressure above 10^{-5} mbar. When the query option is used to check a global action result, the last action scope is assumed and the selection criteria are set according to the action executed. For example, if a "close sector valves" action has been executed, the "check action results" option performs a search for the sector valves that are not closed within the last action scope.

Results of a query are displayed as a table where rows correspond to the devices found during the search and columns give values of the parameters used in the selection criteria (Fig. 4). Clicking on a row invokes a device control panel with the full information available on the device.

Figure 4. The query form and a device table produced as a result of the query execution

Conclusions

The MMI software has been used to operate the SPS vacuum equipment for over a year. All functional requirements has been met and the software has proven to be both reliable in outine operation and flexible to equipment changes. The database driven-design enables easy maintenance of the software. The only thing the users need to do to keep the user interface up-to-date is change the equipment database. A large part of the SPS-MMI application is accelerator-independent and implements general MMI functinality. As a result, it has become possible to produce similar applications for the PS and LEP accelerators in a rather short time.

References

1. P.M. Strubin, "Controls for the Vacuum System of LEP", J. Vac. Sci. Technol. A5(4), July/August 1987
2. W. Koelemeijer at al., "Upgrading the Controls of the SPS Vacuum System", EPAC, 1992
3. L.Kopylov at al., "Tools for Man-Machine Interface Development in Accelerator Control Applications", Proc. of ICALEPCS'93, Berlin, October 1993

Appendix - Topology description file

A part of the installation, or "beam line", is described in the file by a string containing the line name (preceded by keyword LINE) and coordinates of the first and last equipment elements in the line. A contiguous segment of the installation can be described by several consecutive LINE strings.

The installation topology is described in the file as a number of "root" lines from which other lines are branching. A root line description is delimited by keywords ROOT_LINE (followed by a name of the line and keyword CIRCLE if this line is a circular accelerator) and ROOT_LINE_END. Descriptions of connected lines are enclosed in keywords CONNECT and CONNECT_END and can be nested. Keyword CONNECT is followed by the name of the connected line, the position of the connection point and the connection type identifier. For example, beam injection line TT10 which joins the SPS ring from the left (LI) at the 735.4 meter point in the SPS coordinate system is described as follows:

```
CONNECT TT10        735.4   LI
```

A simplified (not all lines are included) example of the topology descritpion file given below describes a part of the SPS accelerator complex. Comments in the file are preceded by the '!' character.

```
ROOT_LINE SPS          CIRCLE  ! SPS main ring
LINE SPS                     0.0    6912.0
            ! Injection PS->SPS, line TT10
            CONNECT TT10       735.4          LI
            LINE TT10          0.0         876.05
            CONNECT_END        ! End of line TT10

            ! Injection PS->SPS, line TT70
            CONNECT TT70     6261.2           LI
            LINE TT70              0.0       665.0
            CONNECT_END      ! End of line TT70

            ! Extraction to T2, line TDC2
            CONNECT TDC2    1837.4       LO
            LINE TT20  0.0       633.23
            LINE TT22  0.0       89.0
            LINE TT23  0.0       153.16

                        ! Extraction to T4, line TDC2
                        CONNECT TDC2    722.23  RO
                        LINE TT24  0.0       142.74
                        CONNECT_END

                        ! Extraction to T6, line TT20
                        CONNECT TTT20   633.23  RO
                        LINE TT25  0.0       258.95
                        CONNECT_END

            CONNECT_END              ! End of extraction to TDC2

ROOT_LINE_END          ! End of line SPS
```