FIRST EXPERIENCE WITH CONTROL AND OPERATIONAL MODELS FOR VACUUM EQUIPMENT IN THE AD DECELERATOR

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Abstract

Control and Operational models for Vacuum Equipment have been studied at CERN for several years [1]. A prototype implementation was tried out on ion gauges in LEP followed by a full-scale implementation for all vacuum equipment to be controlled in the newly built AD ring.

In order to meet the tight time schedule, the existing hardware and software infrastructure of the PS complex has been used. The model server was built on top of this infrastructure. This has introduced some restrictions with respect to a full implementation of the models, but made the server available for all vacuum equipment already installed in the various accelerators which are connected to this control system.

In order to test the server, a simplified man-machine interface has been created. This interface presents the available acquisition and control values in a very homogeneous way to the operator, making the advantage of the chosen model approach evident. It also makes additional diagnostic information, previously unavailable, accessible to the vacuum operators.

1 INTRODUCTION

Our Group is operating the vacuum systems of all accelerators in CERN since 1990. During this period, a significant effort was made to reduce the diversity in both hardware and software. For instance, the vacuum operators are offered a unified Man Machine Interface for the PS complex and the SPS and LEP accelerators. Nevertheless, despite the uniform operator interface, there still exists three different versions of the MMI because of the varying ways to access the equipment. For the same reason, alarm and data logging programs are different for each environment.

The objective of the work presented here was to try out a systematic approach using operational and control models of the vacuum equipment.

2 MODELS

The operational model may be considered as a kind of user requirement document, which specifies generic control procedures and related "control knobs and meters" for rather broad "families" of vacuum devices (e.g. ion pumps), without mentioning how the controls are, or shall be, physically implemented.

For each family, the model describes the functionality of the device in the vacuum system and the services which shall be provided for the users (vacuum technicians or accelerator operators) in order to monitor and control the operation of the device. This includes, in particular, the description of various physical variables in the device which can be observed and modified by the users, the states that the device can take during operation and the commands that it can accept to modify its state. In principle, formal modeling techniques (state diagrams, "use cases", etc.) can be used for definition of the operational model, but in our case it is basically a narrative description.

Although the operational model does not directly imply any particular implementation, its aim is to provide a control system designer with a set of guidelines for software development, as well as a thorough definition of the internal system interfaces - most notably the definition of the Application Programming Interface (API). At the API level, we speak about the control model which defines the application programmer's view of the vacuum equipment.

The control model defines in a formal way the procedures and data required for the application programs to implement the equipment control facilities described by the operational model. We apply object-oriented approach to define the control model: the vacuum equipment is organized in device classes; each class defines a control interface for a certain category of the vacuum devices. Devices of the same class have the same set of properties; a property typically corresponds to a physical variable in the operational model.

Several classes of properties have been defined to represent different kinds of the physical variables: analogue measurements, discrete command channels, boolean error indicators, etc. Each property has a value and, depending on its class, a number of other characteristics, such as units of measurement, time stamp, minimum and maximum values, resolution, etc.

Status	OK
Timestamp	Tue Mar 23 10:41:45 1999
Min	1e-12
Max	1e-6
Units	mbar
Resolution	1e-13
Format	2.1e
Access	Read-Only

Table 1: Characteristics of property "pressure"

As an example, table 1 shows the characteristics of property “pressure”. The values shown are applicable to an ionisation gauge. The values for the “Min”, “Max” and “Resolution” characteristics would be different for a cold cathode gauge, but the same characteristics would exist.

3 IMPLEMENTATION

In order to meet the tight time schedule of the AD project, the existing hardware and software infrastructure of the PS complex has been used. The implementation follows the three tier architecture shown in Figure 1, where the model server acts as an intermediary between the standard PS equipment access software and the model based applications.

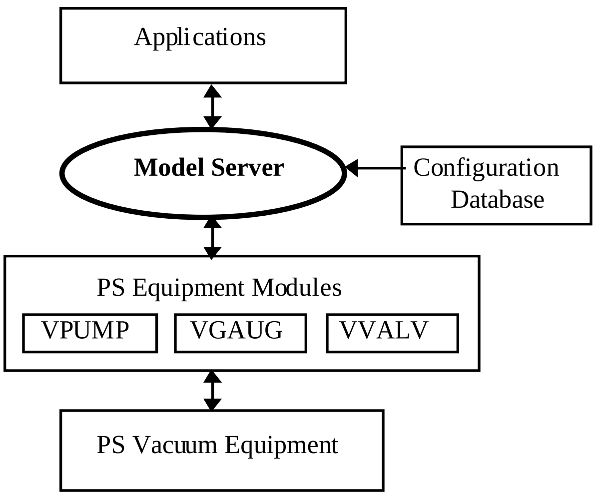

Figure 1: Implementation of the control models in the PS Control environment

Equipment access in the PS control system is organised through Equipment Modules; each Equipment Module is a collection of procedures and data allowing to drive certain type of equipment. The model server transforms the system specific view of the vacuum equipment provided by the PS vacuum Equipment Modules (VPUMP, VGAUG, VVALV [2]) into the model defined representation. In some cases, the model properties directly correspond to the Equipment Module data, but more often a dedicated procedure is required in the server to obtain "raw" equipment data and present it in the form defined by the model.

The server software is in a large part data driven. At start up the server reads a formalized control model description (devices, device classes, properties, characteristics) from the configuration database. The database also describes the equipment interface topology: where and how each individual device which is connected to the control system. This information is merely imported from the existing PS controls database.

3.1 Problems and constraints

Decision to use the existing controls infrastructure with minimum modifications has allowed us to speed up the development and to connect all vacuum equipment already installed in the various accelerators of the PS complex to the model server. But, at the same time, it introduced some restrictions with respect to a full implementation of the models.

Some features could not be implemented due to hardware and software limitations in the low level equipment controls. For example, only a limited subset of properties defined in the Ionisation-Gauge class is available because of the limitation on the number of parameters that can be passed in the internal software protocol frame [3].

Since equipment access via the Equipment Modules has to be preserved for existing applications, commands can be issued to the equipment bypassing the model server. It is not always possible to trace such commands in the server. As a result one can see, for example, an open valve with last registered command "close", but all other properties indicating normal operation.

The model server does not read values from the vacuum equipment directly; rather, it is using cached data from the Equipment Module data tables. Information in the data tables is updated approximately every 30 to 40 seconds - this cannot be done faster due to performance limitations in the low level equipment network and leads to a further limitation of the model server. In general, the update rate is sufficient for relatively slow changing measurement variables, but sometimes it is not fast enough to monitor status values. For example, when a sublimation pump goes for 30 seconds to the "sublimating" state, this very important event, from the operational point of view, can be missed between two consecutive updates.

However, despite the problems imposed by the implementation constraints, equipment representation provided by the model server essentially conforms to the operational models for all main categories of the PS vacuum equipment (pumps, gauges, valves).

3 USER INTERFACE

The graphical user interface program developed for the AD vacuum control basically performs direct visualisation of the model data. It also provides virtual knobs which allow the users to change the value of device properties and to send commands to the equipment. There are many possible ways of graphical representation of the control model - standardization at this level was not our goal at first instance. Rather, we tried to follow the same "non revolutionary" approach as in implementation in general and be as close as possible to the conventions and customary style of equipment control adopted in the PS complex [4].

Following these rules, we represent the vacuum equipment in a spreadsheet style tabular format. Devices are grouped in "working sets" which are represented as tables: a row per device and a column for a device variable (property). Property values are displayed in the table cells; clicking on a cell displays detailed information on a property (all its characteristics) or activates a control tool that allows to change the value of the property.

The main working set view is complemented by the detailed status display which shows the current state of all error indicators associated with the working set and a chronologically ordered list of all errors encountered since the program start-up.

The user interface application is based on a relatively small set of the software components (C++, Motif) which are combined and configured at run time using descriptive information on devices and their interfaces available on the model server. Given a device name, one can obtain a list of all properties supported for the device and for each property a full description of its characteristics. This run time interface discovery feature allows the application to easily adjust to changes in the equipment interface. For example, when a new device class is added to the model, it automatically becomes supported by the user interface application - as soon as the class description is entered into the configuration database.

4 OPERATOR'S EXPERIENCE

Although a number of compromises had to be done to adapt to the existing control system architecture, the advantages for the vacuum operators are numerous.

The first one is a coherent presentation of the data available from various types of equipment. Every value is systematically assigned a time stamp and status to allow for correct interpretation of the validity of the data. This allows to correctly handle and display values which have been taken right before a device changed state (e.g., a gauge was switched off) without loosing this last value.

A second advantage is the systematic way of signaling errors and warnings. Whereas it was common practice to encode an analogue value (e.g., a pressure value) to give some hints on problems (like returning -1.0 for under-range), the new approach defines a specific error-indicator property with an associated characteristic setting the severity (warning, fault, etc.). Another useful characteristic of these indicators is the availability of an associated plain text message which allows to clearly display the meaning of the error, like "Equipment error: offset too large". The systematic use of higher level indicators for such problems as communication errors, allows for quicker diagnostics than device specific "error bits" commonly used in present systems.

A final advantage from the user's point of view is that all properties for all devices can be documented in a database with adequate access tools. It makes it therefore easy to implement on line help features, for instance to guide the operators in diagnostic and repair activities.

5 CONCLUSIONS

We could successfully implement a model server for the vacuum equipment of the new AD decelerator on top of the existing controls infrastructure of the PS complex. It has been running for the commissionning of the decelerator and showed a number of useful features, both for the operators and for the application programmer.

However, the full power of the proposed approach can only be obtained in a new project or in a major reconstruction of an existing system. In this case, the models should serve as a conceptual skeleton for the system design from the equipment interface hardware up to the user interface level.

The operational model may serve as a core requirement document for selection, customization and integration of the industrial components, as well as for in-house developments. Internal system protocols and interfaces should be tailored to the needs of implementing the control model in a complete, consistent and efficient way.

6 ACKNOWLEDGMENTS

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