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Developing a Panelboard Trainer Using SIMVOX and PROVOX (U)

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A paper prepared for:
Fisher-Rosemount Systems Users Group Meeting - 1995
Developing a Panelboard Trainer Using SIMVOX and PROVOX

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DOE Contract No. DE-AC09-89SR18035
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Background

The Savannah River Site, located just south of Aiken, South Carolina, is a Department of Energy facility for processing nuclear fuel and waste products. The two major separations facilities at the site for processing this material had not been operated since March, 1992. A significant effort is currently underway to restart these facilities. The most crucial element in getting approval to restart these facilities is proving to the Department of Energy that they can be operated safely and efficiently. One of the most important items facing the restart effort is therefore having a well trained operations staff.

Several of the processes which are scheduled to be restarted are controlled by panelboard. This paper will address the efforts made to train the operators on the operation of one of the panelboard-controlled processes, specifically concentrating on the technical aspects of designing such a tool.

Introduction

Several challenges existed in creating a system that would be valuable for training operators: the robustness and accuracy of the process model, the operator interface to the process, and the communication between the operator interface and the process models. Cost and implementation time were also important factors.

Two possible implementation plans were examined. The first option was to develop a computer tool through which the operator could operate the process through interaction with the mouse and keyboard. The entire panelboard system could be created in computer graphics and a process model attached. The second option was to construct a complete replica of the control room panelboard in a training environment.

Operations personnel expressed a strong preference for creating the panelboard replica. Concerns were expressed about the comfort level of the operators training on a computer tool, and the value of the operators becoming thoroughly familiar with the physical location of the equipment in the panelboard was believed to be high. It was therefore decided to create a replica of the control room panelboard.
Overview

Three primary challenges faced the team in the construction of the panelboard trainer: the construction of the panelboard itself, the development of the model, and the data transfer between the panelboard and the model. The general design can be seen in figure 1. The inputs and outputs from the panelboard are connected to Fisher series-20 IO terminations. The IO terminations are connected to a Unit Operations Controller (UOC), as is an External Interface Card (EIC). An Envox workstation is used to configure the UOC. A Windows-NT workstation running SIMVOX software is connected to the EIC. The NT workstation is where the process model resides.

Panelboard

The panelboard was constructed from six forty-four inch steel sections which were fabricated on site from scrap material. A search for instruments was conducted at several decommissioned facilities at the Savannah River and at another Department of Energy site in Hanford, Washington. Wherever possible, an exact replacement for the equipment in the control room was utilized. If no exact replacement was found, the closest match in functionality and user interface was used. Finally, as a last resort, the few parts for which close matches could not be found were bought. The completed panelboard structure can be seen in figure 2.
Process Model

The process controlled by this panelboard is used to separate plutonium and uranium from other fission products. There are three separations units (a centrifugal contactor and two mixer-settler banks), various decanters, product tanks, feed tanks, head tanks, and heat exchangers in the process. The operator controls the process by manipulating the state of pumps, valves, and controllers.

The process model was developed using Simvox for Windows NT. Simvox provides a method of interfacing to the Fisher Unit Operations Controller (UOC) through an External Interface Card (EIC). Simvox also provides a rich tool set for construction of the process model. The Simvox tools were used to generate discrete tiebacks, control loop tiebacks, perform simple calculations, and to model analog and discrete values which needed to be displayed to the operator.

The tiebacks for the discrete devices (e.g. pumps, agitators, valves) were quite easily constructed. The method is the same as configuring the devices using Provox tools. A template for the actions of each type of device was created. Each individual device is then assigned a template and a set of input and output channels. Simvox then looks at the discrete outputs for the device and set the discrete inputs according to the template.
There are two ways that were used to configure control loops. Simvox allows for simple loops (e.g., some flow loops) to be tied back directly. These loops are configured in Simvox as control loops, analog input and output channels are assigned, and a valve gain is assigned. Simvox then multiplies the valve gain by the valve position to determine the appropriate process variable value. More complex control loops require the creation of an additional user calculation. For example, control of the outlet temperature of the process side of a heat exchanger by the flowrate of steam into the heat exchanger is a function of (at least) four variables: process side inlet temperature, process side inlet flowrate, steam inlet flowrate, and steam inlet temperature. A user calculation is set up to calculate this process outlet temperature and the control loop is configured to have the process variable track the result of the calculation.

Several discrete inputs for the alarm lights had to be modeled for this panelboard trainer. Simvox allowed the bulk of these to be done with very little effort. The configuration of a discrete input allows the developer to link the value of the discrete to any other point in the Simvox configuration. For an alarm light which is triggered by a high temperature, for example, the discrete is configured to illuminate the light if the temperature is above the high alarm limit.

Several analog input points which are not controlled variables also had to be modeled: tank levels, for example. Simvox functionality was fully utilized wherever possible. For the points which monitored the tank levels, this meant: configuring them as integrators, setting all input flowrates to the tank to be additions to the integrators, and the output flowrates from the tank to be subtractions from the integrator. Energy balances throughout the process were configured in much the same way.

Some parts of the model were complicated enough that to get the level of dynamic simulation desired with as little effort as possible, C programming tools were utilized. For example, one of the process units is a sixteen stage bank of mixer-settler units. Modeling of this process unit to the desired accuracy level required that each of the sixteen stages be modeled, and for each stage: the level, the concentration, and the degree of separation of the organic and aqueous phases be calculated. While it might be possible to do this degree of modeling inside of the Simvox point configuration and user calculations, it is not the desirable way to proceed. Simvox does provide a set of library routines which may be called from inside a user-developed C language program and these were used extensively to model the two mixer-settlers, the centrifugal contactor and the decanters.

One of the most important parts of creating a successful training tool is the construction of a useful instructor interface. The instructor interface created for the panelboard trainer has two classes of functions: performing tasks done by personnel at the request of the operator, and instigating abnormal conditions. Very few processes are totally self contained and operated solely from the control room. This process is no exception. The instructor interface allows for heat exchangers to be valved in and for external headers to be pressurized. A series of abnormal conditions was also created for the instructor to initiate. The abnormalities consist of pump failures, valve failures, and the failure of key indications (temperatures, specific gravity).

The philosophy used to design the model is to keep the model as simple as possible, base the model on first principles wherever possible, and add fidelity where it is necessary to achieve the desired response from the model. We have used this philosophy quite successfully now on the construction of three different simulations at the Savannah River Site. The advantage in not setting an initial goal of extremely high fidelity is that it allows the developer to concentrate his efforts on getting a working prototype in front of
operations and training personnel early, and allows him to concentrate his efforts where the most benefit can be derived.

**Data Transfer**

The final design item to be discussed is the data transfer between the model and the panelboard. If this were a traditional Simvox model, with the operator controlling the process from a DCS console, Simvox would handle this data transfer seamlessly. However, since the operator's interface to this process is a panelboard, extra considerations must be made.

The IO definition in the UOC is divided into two sections: physical IO and simulated IO (see figure 3). Physical IO refers to the analog and discrete inputs and outputs which have physical terminations with wires leading to the panelboard. Simulated IO refers to those points which are configured to reside on the external interface card.

![Figure 3 - Physical and Simulated IO](image)

Every physical IO termination has a corresponding file-card-channel address on the external interface card. The UOC handles the task of copying the information between the panelboard and the model.

The panelboard is limited to setting (physical) analog and discrete inputs (relative to the UOC). The Simvox model is limited to setting (simulated) analog and discrete inputs (again, relative to the UOC). The UOC can only set analog and discrete outputs. The design for the data transfer is therefore to have all operator inputs from the panelboard input
to the Provox system as physical inputs. The UOC then copies the value of this physical input to the corresponding simulated output channel, which can then be read by the model. The model may then use this value to calculate a new value for one of its simulated inputs which would then be sent to the external interface card on a simulated IO channel. The UOC would then copy the value from this simulated input channel to its corresponding output channel (see figure 4).

Two methods were examined for copying the IO information between the panelboard and the model. The first method was to configure all of the discrete inputs in the UOC as "Action Dis" which set the PV of a discrete output. All analog inputs in this method would be configured with the "AO for Data Record" option, and would then copy the value received as the input directly to an analog output channel. The second method was to perform all of the copy operations inside of FSTs.

The method selected was using the FSTs. The advantages to the using the first method was that the Provox system would handle all the overhead and no FSTs would have to be written. The disadvantage of the first method was that every file-card-channel address would have to be configured as a point inside Provox. Since there is a hard limit of 320 points which may be configured per 20-series UOC, using the first method would have required us to use two UOCs. Using the FST method we were able to limit the number of UOCs to one. The point count was therefore the deciding factor in determining the method to be used.

Tool Selection

The tools selected for the data transfer and modeling for this effort were: Provox series 20 IO and UOC, Envox, and Simvox for Windows NT.

The selection of the 20-series IO and UOC was based on using the spares we had in our inventory. A project cancellation a few years back left us with several spares that could be used for this purpose. They were well suited to the task. Using this spare equipment also had a strong appeal to it because of the desire to keep the costs as low as possible. Envox was chosen as the configuration tool for the Provox equipment because of the familiarity we had with the product and the availability of the tools.

Simvox for Windows NT was chosen as the modeling tool because of its suitability to the task at hand. Simvox, in addition to its ability to communicate with the Provox system through the external interface card, provides a very useful tool set for creating process models. Previous experience using Simvox on the VAX platform was also taken into
account. Finally, the ability to become a beta site for the Windows NT version of Simvox, and influence the future direction of the product was also an important consideration.

Conclusions

The panelboard trainer has proven itself to be a very useful tool. Operator, trainers, and supervisors have all recognized its value. In addition to being used to train operations personnel, it has been used extensively to validate the procedures used to operate the process. The process trainer has enabled us to train the operators more quickly and more completely than would have otherwise been possible. One of the most visible ways the value to operations of the panelboard trainer has been displayed is that due to the success of the first system, eight more are either under development or in planning stages.