Smart Engineering of APR1400 MMIS Virtual Stimulation

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1. Introduction

Korea Hydro & Nuclear Power and Doosan Enerbility have been developing first-of-a-kind APR1400 MMIS simulator based on the virtualization technologies such as CPU emulation, hypervisor and virtual machine. The simulator type is a kind of virtual stimulation which is proposed at first in the world by our project. However, the simulator has two main goals. First is to build and operate virtual MMIS as same as the real plant's MMIS with virtual basic components such as virtual PLC (Programmable Logic Controller), virtual DCS (Distributed Control System) and virtual I/O with virtual networks. Second is to use the virtual MMIS with various purposes. Several applications were introduced to support the purposes [1]. In this paper, detailed functions of Smart Engineering Tool of APR1400 MMIS simulator are explained.

2. Methods and Results

Smart Engineering Tools is an exclusive software to be used within the APR1400 MMIS simulator. It has some main functions such as monitoring the virtual facilities at the levels of each cabinet and each rack including other kinds of devices, simulating the virtual facilities with specific conditions, and configuring each rack and cabinet. In order to develop the simulating function, it can be divided into sub functions. In this project, we have developed malfunctions for VPLC (Virtual PLC), VDCS (Virtual DCS) and other elements. And we have developed manipulation operations including overriding values.

2.1 Malfunctions of VPLC and VDCS

Malfunctions of VPLC and VDCS are shown in Table I and II. They are developed according to their FMEA results. All the modules of the real PLC and DCS platforms have been considered to be virtualized. Each malfunction can be executed within the Smart Engineering Tool as shown in Fig. 1. A combination of each malfunction with any sequence is possible and those are placed in a specific time. This means a time-based test scenario can be used. NCPU-2Q and CPM01A mean the processor module of each platform. Their malfunctions have been developed at the level of internal component of the module. Other modules' malfunctions have been developed as simple function.

Table I: Malfunctions of Virtual PLC

Module Type	Malfunctions
NCPU-2Q	A. Set NVRAM Error B. Set Flash Error C. Set DPRAM Error D. Stop CPU E. Set RTC Error
NQ-D43Q, NQ- D23Q NI-D43Q, NI-D23Q NQ-A24Q	A. Set GroupDiagonsis Error B. Set ChannelDiagonsis Error C. Set WDT Status
NHSC-1Q	A. Set Input Signal Error B. Set ChannelDiagonsis Error
NFD1-5/6Q NFD2-1Q	A. Set NFD1-5/6Q Status B. Set NFD2-1Q Status
NDA8-2Q	A. Set ChannelDiagonsis Error B. Set WDT Status C. Set Firmware Error D. Set EEPRAM Error E. Set DPRAM Error
NTC8-1Q NRD8-1Q NADF -1Q NAD8-3Q	A. Set ChannelDisconnect Error B. Set ChannelDiagonsis Error C. Set WDT Status D. Set Firmware Error E. Set EEPRAM Error F. Set DPRAM Error G. Set EEPROM CRC Error (only for NRD8-1Q)

Table II: Malfunctions of Virtual DCS

Module Type	Malfunctions
CPM01A	A. Set Power Status B. Set Temperature C. Fail Info. Network Port (m) D. Fail Info. Network Port (b) E. Fail Control Network Port (m) F. Fail Control Network Port (b) G. Fail Back-side 10M Port
AIM01A, AIM02A DIM24A, DIM24C DIM48A, DIM48C	A. Set Power Status B. Set Fuse Status C. Disconnect Input of TB
RTD03A, RTD04A TCM01A, TCM02A TCM03A, TCM04A	A. Set Power Status B. Disconnect Input of TB
AOC01A, AOV01A DOM01A, DOM02A DIOM01A-24 DIOM01A-48	A. Set Power Status B. Disconnect Output of TB
PFI12A, PFI24A PFI48A	A. Set Power Status B. Set Fuse Status C. Disconnect Output of TB
GSM, MBE	A. Set Power Status

Fig. 1. Typical display of malfunction editor in the Smart Engineering Tool.

2.2 Malfunctions of other elements

PLC and DCS are the main parts of the APR1400 MMIS, but there are also important components to be developed as a malfunction. These have been identified or determined to make a virtualization scope for the whole APR1400 MMIS. For example, a power supply, fan, thermostat, FGDC, circuit breaker, fuse, door open limit switch of each cabinet are controllable. OD/OLM devices have been simulated to be disconnected. FOT/FOR aren't considered as a malfunction because they depend on its associated terminal block malfunction. CIM/RMU have its own malfunctions.

2.3 Manipulation and Overridden Values

A function to manipulate the virtual equipment and insert intended values instead of current values on each input and output is necessary to make a specific status to test engineer's intention. Fig. 2 and 3 show the typical display of APR1400 MMIS. Engineers can manipulate possible operations on that display directly. Each operation is connected to its associated virtual element. The result of the operation can also be displayed with a status LED or separate display. And Fig. 4 shows the typical display to override a specific value into the virtual equipment. This overriding function is slightly different from the malfunctions. It is operated within the normal range of each controllable point. Therefore, an error can be possible after these kinds of operations.
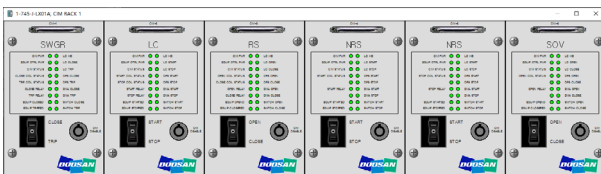

Fig. 2. Typical display of manipulation for CIM module.

2.4 Test Monitoring Display

All the operations and malfunctions in the virtual equipment should be shown in a separate display as a kind of list. So, on this display, we can deactivate the malfunction or remove some addition effects. And in order to check out a test result easily in terms of user friendly, a display is necessary to show the selected values on a page.
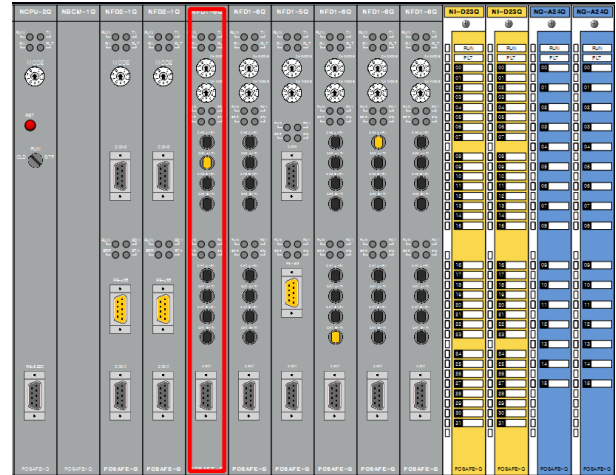

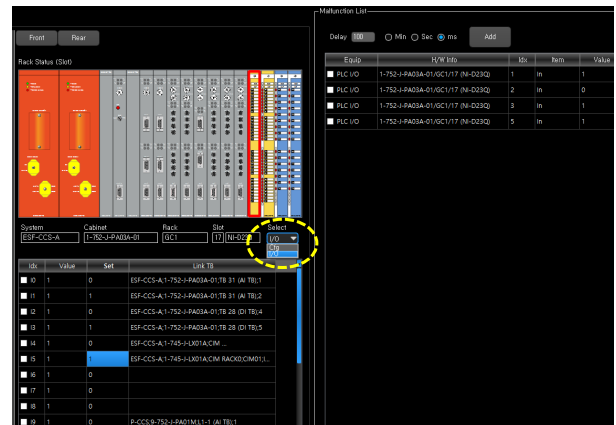Fig. 3. Typical display of overriding function.

Fig. 4. Typical display of overriding function.

3. Conclusions

Useful functions to test the virtual MMIS simulator have been shown in this paper. They can help improve the current engineering capability in the digital I&C field. It is a kind of draft version so far. It must be updated reflecting many stakeholders.

REFERENCES

[1] Sungjin Lee, "Applications of APR1400 MMIS Virtualization Simulator for the NPP's performance", Transactions of the Korean Nuclear Society Fall Meeting, 2022.
[2] "Virtual PLC Interface Design Document", Doosan Enerbility 2022.
[3] "Virtual DCS Interface Design Document", Doosan Enerbility 2022.