Virtual Simulation Environment for Loviisa Nuclear Power Plant Simulators

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EXTENDED ABSTRACT

This paper presents the virtual simulator environment for the Loviisa nuclear power plant simulators. Virtual technology is utilized in the IT infrastructure of the simulators, and the resulting benefits are discussed in this paper.

Loviisa nuclear power plant is located in Southern Finland approximately 100 kilometers east from Helsinki. It comprises of two VVER-440 type reactors commissioned in 1977 and 1980 which have operating licenses until 2027 and 2030, respectively. The plant is owned and operated by Fortum.

The original analogue I&C systems of the Loviisa plant are being partly renewed to digital I&C in a project that started in 2005. First stage of the renewal project have been supplied by Areva and Siemens and commissioned already in 2008. Rolls-Royce and Metso Automation will deliver the final updates during 2016-2018. The updates include a new reactor trip system, a neutron flux measurement system, and reactor power limitation and control systems.

The training simulator (LOKS) at the plant will be updated with the new automation systems. In addition, there are two new simulators developed during the automation renewal project: a new full-scope training simulator (LOKS2) and a development simulator (KESI). LOKS and LOKS2 will be utilized for operator training. KESI will be used for testing and development of process models /1/, assisting the HMI design, the development of operating procedures as well as for the testing of the new automation systems

The main components of the simulators are Apros simulation software, Instructor's Station, the automation components and the human-machine interface (HMI) components.

The process model of the nuclear power plant is implemented in Apros simulation software developed by Fortum and the Technical Research Center of Finland VTT /2/. The model covers the primary and secondary circuits of the plant and most of the auxiliary systems, totalling approximately 60 process systems. In addition, large parts of the automation and electrical systems are also modelled. Both simulators utilize the same process model which is a significant advantage with respect to maintaining the model. Due to the large scale of the model, it is divided into 12 Apros processes running on two virtual PCs in order to speed up the computation and to distribute it to multiple hosts. The sub models, the primary circuit, the secondary circuit, the 3D reactor model and the containment model, communicate with Apros communication library that is built on top of TCP/IP protocol.

Instructor's Station is a tool also developed by Fortum and VTT and it is the main user interface to running and managing the simulator system /3/. It is used by the instructor to start and stop simulation, manage test runs and to launch malfunctions, for instance.

The process model contains the majority of the plant's original automatics, whereas the automation systems to be updated during the renewal project will be connected to the model as external components. Those components comprise of the safety automation and the normal process control (NPC) systems. The safety automation systems include Areva's TXS system and Rolls-Royce's Spinline and are connected directly to Apros with dll-libraries. The NPC systems, Siemens SPPA-T200 and Metso DNA, are connected to Apros over network.

The HMI components of the simulators include the process monitoring system, the operator displays of the utility automation systems and the control panels. The new simulators will use touch panels instead of conventional hard-wired panels to operate the process. Although the touch panels do not possess the look and feel of the HW panels, they offer other remarkable benefits. The construction costs are lower and they are easy to re-configure. For example, the same panels can be used to represent the control rooms of both plant units and new panel prototypes can be tested easily.

The simulators' virtual IT infrastructures have been implemented with VMware vSphere environment /4/. LOKS2 and KESI have currently 4 ESXi hosts running over 60 virtual machines. The VMware vCenter server is used for the management of the virtual environment.

Virtual simulator infrastructure brings several significant benefits compared to using physical computers. Virtual machines can be flexibly configured and the computation resources are more easily managed. New virtual machines can be deployed on demand for testing purposes, for example. The use of virtual technology also improves the reliability of the system, since there is less aging hardware which is prone to malfunctions and failures. Furthermore, updating the hardware is straightforward and can be done without re-configuring the logical structure of the simulator system. Major benefits are also that the virtual infrastructure allows taking snapshots of the system state, to which the system can be restored, and the back-ups of the virtual simulator can be done in a centralized manner.

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