Development of a Process Control and Monitoring Platform for the Nuclear Power Plants

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1. Introduction

The NuRON-mc (Nuclear Reliable Operation Network – monitoring and control), a platform for the implementation of the process control and monitoring systems for the nuclear power plant, has been developed during the last 5 years, from 2002 to 2006, by KOPEC. The NuRON-mc is the fundamental model of integrated computer system equipped with all necessary features for the engineering of the nuclear power plant control and monitoring systems. The survey of the state-of-the-art technologies, derivation of design features, system design, detail design, and software implementation activities were performed.

This paper summarizes the major design and implementation features of the NuRON platform.

2. Design Features

At the first stage, the state of the art technologies of the commercial Distributed Control System(DCS) were evaluated. The designed features were established with the survey data of DCS technologies and the experiences from the KORI unit 2 Plant Computer System upgrade project and the development project of the Plant Monitoring and Annunciator System(PMAS) for the Shin-Kori 1 & 2 and Shin-Wolsong Unit 1&2.

In addition, the advanced technologies of the Information Technology(IT) regime is applied to development of the monitoring system. The COTS controller that shows robust control and data acquisition performances is applied to the control system. These two systems are integrated as the specialized development platform for the nuclear process control and monitoring system.

The major design features of the NuRON-mc are as follows:

- Design based on digital technology and network communication
- Adoption of Commercial Off-the-Shelf(COTS) to the maximum extent
- Open Architecture technology
- Redundant architecture of major components including server, network switches, controllers, etc.
- MMIS requirements were implemented per EPRI Utility Requirement Document(URD) and Korean URD
- Variety of enhanced operator support functions not provided by the DCS packages
- Conservative safety features in consideration of domestic licensing
- Advanced features for operability enhancement
- Use of standard C/C++ language in software implementation for portability

3. System Design

3.1 System Architecture

The NuRON-mc is comprised of the main computer server, Control and Data Acquisition System(CDAS), Operator Interface System(OIS), web server, printer, and data storage devices as presented in Figure 1.

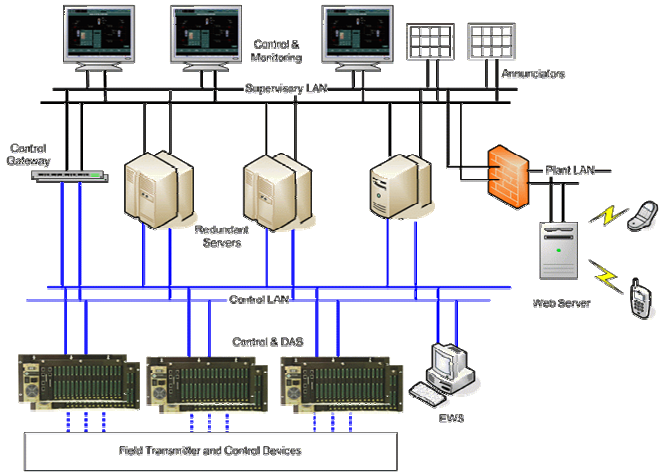

Figure 1. The Configuration of NuRON-mc

The CDAS performs control functions for the non-safety plant components, and also performs data acquisition via local I/O in the controller and/or remote I/O cabinets. The CDAS acquires the field data and performs specialized interface functions to other computer-based systems. The collected data is transferred to the servers once every second. The servers perform application programs and update the real-time database to provide necessary MMI functions and information for the plant operational status. The Historical Data Storage & Retrieval (HDSR) program saves the plant information to provide historical data for off-line analyses of operational events or accidents.

3.2 Human Factor Engineering Design

The Human Factor Engineering (HFE) activities were performed to develop, design, and evaluate the Human Machine Interface (HMI) features of the system per applicable human factors requirements. The

management of HFE program, operation experience review, analysis of functional requirements, analysis of system requirements, HMI design, development of HMI procedure, development of training program, and V&V of HFE are the detailed activities for HFE design.

4. Implementation

The detail design was performed to implement the platform and software package was developed with standard C++ language from scratch. The NuRON-mc software package consists of three software categories; system, operator aid, and application programs. These were implemented based on the following design bases:

- Application to all kinds of domestic nuclear power plants
- Allocation of the system server functions either to the centralized single host or to the distributed hosts
- Real-time task scheduling and real-time message transmission for control functions
- High portability by adopting the POSIX (Portable Operating System Interface for Computer Environment) standard APIs (Application Programming Interface) to the maximum extent

4.1 HMI Implementation

The operator interface graphics are implemented with ILOG Views development tool. Figure 2 shows typical operational display of the NuRON-mc.

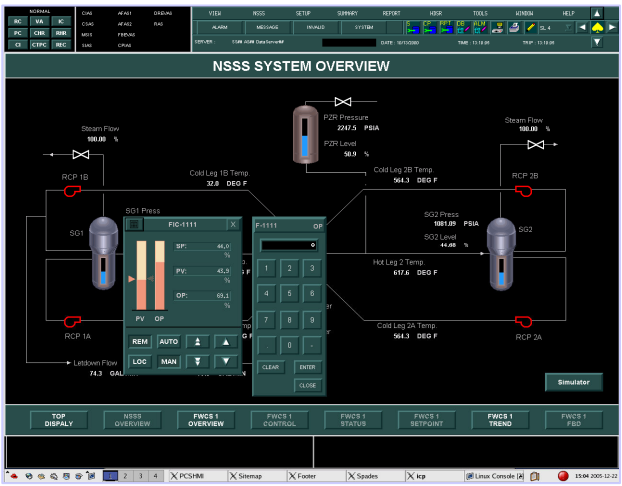

Figure 2. Typical Operational Display on OIS

The operational display shows integrated monitoring and control information on same page. To achieve fast response and reliable message transmission between soft control function on display and field actuators, private point to point connection (TCP/IP) is used based on the predefined information of the control database. The operator may interact with HFE designed soft control components for continuous or discrete controls.

4.2 Software QA(Quality Assurance)

The Quality Assurance (QA) process has been thoroughly applied to every steps of software design activites as follows;

- Software Development Plan
- Configuration Management
- Verification & Validation
- Tests
- Documentation

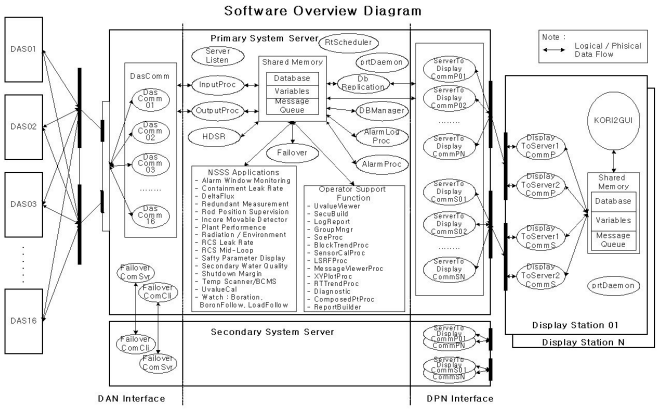

Figure 3. Software Overview Diagram

5. Equipment Qualification

The equipment qualification test has been performed under the environmental conditions of power plants to comply with the system requirements. The COTS equipment was selected to envelop the most harsh environment condition. The qualification tests have been performed in accordance with qualification test procedures such as type test, operational experience, analysis, and the combination of these. The reliability and operability have been demonstrated under the postulated conditions of the equipment qualification data and analysis.

6. Conclusion

An advanced platform, NuRON-mc, has been developed by KOPEC I&C based on the experience on the several replacement, construction, and development projects. This platform includes all necessary features for the process control and monitoring systems of the nuclear power plant.

The NuRON-mc was designed and developed with the specialized goals to achieve the nuclear specific features. If the NuRON-mc is applied to implementation of the process control and(or) monitoring systems of the operating plants, it will improve the operation of the nuclear power plant.