Development of a Prototype of Digital Maintenance Support System for Research Reactors

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1. Introduction

The use of the latest digital technologies in nuclear facilities such as nuclear power plants and research reactors should be preceded by satisfying stringent rules and regulations applied to design, construction, and operation of those facilities. In spite of the continuing improvement in digital technologies and information technologies, maintenance works undertaken inside the reactor building stay with the conventional paper-based ways due to strict regulation issues for reactor safety.

There have been many studies scrutinizing the effects of digitalized human-system interfaces on the performance of control room operators [1-3], and Park and Kim [1] found that new design features implemented in the digital control room seem to be effective for reducing the likelihood of human errors overall using empirical data in nuclear power plants. Also, it is obvious that more supportive features could be provided to operators

To reduce the workload imposed on the filed operators and improve the overall effectiveness of maintenance services, we developed a digital maintenance support system for research reactors based on a real-time closed network and implemented a prototype system to verify the applicability to a real research reactor. This paper explains the detailed design of the maintenance support system and various functions implemented on the prototype system such as visual communication, computerization of procedures, provision of real-time process variable information, database management, and electronic approval for maintenance work process.

2. Design of a Real-time Maintenance Support System for Research Reactors

In consideration of the strict restriction on the use of wireless communication inside the reactor building, the power line networking was employed for real-time data communication with main control room. In addition, to minimize the concerns over cyber security for nuclear facilities, the maintenance support system uses a dedicated closed network that is separated from existing I&C systems for reactor operation. The communication network for the proposed maintenance support system is typically organized as shown in Fig. 1 in research reactors.

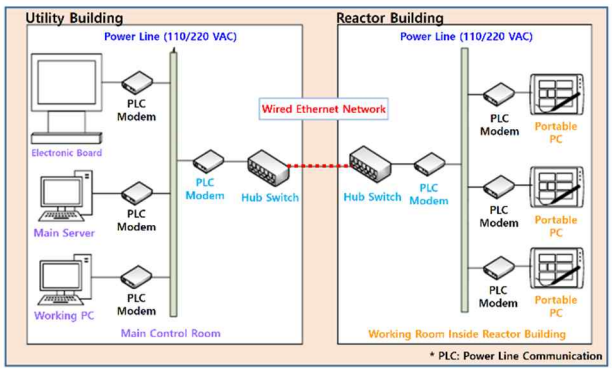

Fig. 1. Communication network architecture for the digital maintenance support system.

The digital maintenance support system mainly consists of a main server for database management, portable PCs for field operators' maintenance works, a working PC for desk works, and an electronic board for real-time communication between control room and field operators. To improve the efficiency of field maintenance works, the maintenance support system was designed to be featured with following functions.

- Use of tablet PC for maintenance works inside reactor building
- Computerization of maintenance procedures
- Real-time transmission of maintenance data to main server and database management
- Display of real-time process variable information to field operators
- Visual communication with operators in main control room
- Online sharing of documents, drawings, photos, etc.
- Electronic approval for maintenance work process

3. Implementation of a Prototype System

Based on the detailed design requirements of the digital maintenance support system, a prototype system was developed to be operated on a dedicated closed network. The main functions implemented on the prototype system and screenshots of main pages are as shown in Fig. 2 and Fig. 3, respectively.

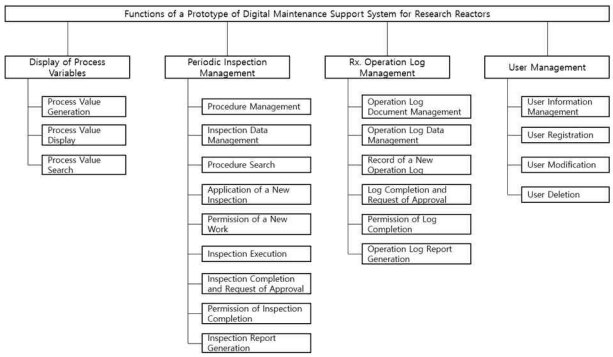

Fig. 2. Functional structure of the prototype system.

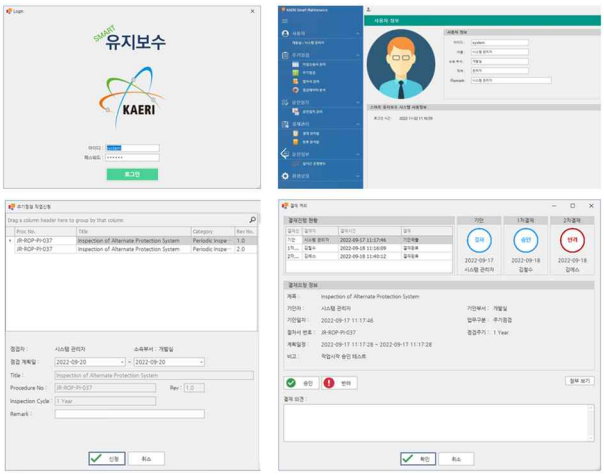

Fig. 3. Screenshots of main pages of the prototype system.

3.1 Periodic Inspection Management

Field operators carry out periodic or surveillance inspections of structures, systems, and components at predetermined intervals to verify that they continue to function or are capable of performing their functions appropriately. The periodic inspection is performed using paper-based procedures in the existing research reactors, so that the operators have to bring lots of documents and drawings. Through the developed prototype system, to enhance the efficiency of the periodic inspection, the procedures were computerized and all the tasks could be executed on the portable PC connected to the main server. This allows field operators to retrieve required information from the main server and transmit the inspection data to the main server in real time.

3.2 Reactor Operation Log Management

In research reactors, the reactor operator documents operation log for main operating parameters every predetermined time (e.g. every 3 hours) to keep operational records of each operating shift and detect abnormal reactor status. The recording work of operational log was computerized using the portable PC in the developed prototype system. The operators can monitor real-time process variables on the portable PC, which can reduce errors in writing the operational log. In addition, the recorded log data is transmitted to the main server in real time and stored.

4. Summary and Conclusions

As digital technologies have progressed, the use of up-to-date digital technologies is an inevitable trend in nuclear facilities even with strict regulation issues. In this regard, we developed a digital maintenance support system based on a real-time closed network to improve the existing maintenance practice drastically, and implemented a prototype system to verify the applicability to a real research reactor. Through the development of the prototype system and functional tests, we could confirm the practical applicability of the proposed digital maintenance support technology. After the ongoing functional improvement and optimization, the developed system is planned to be applied to a newly constructed research reactor. We expect, consequently, that it will enhance the efficiency of commissioning and periodical maintenance tasks, and reduce the potential for human errors.

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