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Mobile Computerized Procedure System for the Improved Situation Awareness among Field Workers and Main Control Room Operators

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1. Introduction

Human errors can occur during the test and maintenance of the generator, safety injection system and reactor coolant inventory in nuclear power plants (NPPs). Most of human errors have been occurred by the omission of the prevention techniques such as the self-check, the peer-check, the concurrent verification and etc. Another important reason is the insufficient information sharing among main control room (MCR) operators and field workers. Various field service automation tools have been developed with recent information technology in many countries [1]. APR1400 computerized procedure system (CPS) has been developed for the MCR operators of Shin-Kori 3&4 units. Especially, the concurrent verification support design is applied in the construction project of Shin-Hanul 1&2 CPS. KHNP central research institute (CRI) expects that the extended application of CPS including the field activity, that is a kind of mobile CPS, can enhance the reduction of human errors. This paper explains the technical issues of the mobile CPS (m-CPS) in the conceptual development stage.

2. m-CPS Development

Since the m-CPS will be used for the field workers with a handheld device on wired and wireless integrated networks, the human factor engineering (HFE) review, the digital system architecture and environmental limitations should be considered to identify system requirements of the m-CPS.

2.1 Considerations for m-CPS Development

Portability, Durability and Usability : Since a field worker carries the m-CPS from his office to a local working area, the device of the m-CPS should have specific requirements. Battery capacity is, of course, enough to use. MCR operator uses a mouse and a keyboard to perform a computerized procedure in the APR1400 CPS. But, the field worker will use a finger or touch pen from the tablet PC for a long time. So the user interface will be different from the expected human usages of recent smart devices. A standard MS-Window style in the smart device can lead to confusion for m-CPS users who expect the exclusive style of an android application. Also, since MCR operators will use both APR1400 CPS and m-CPS from the different system simultaneously, some emergent features of APR1400 CPS should be maintained in m-CPS user interfaces and functions.

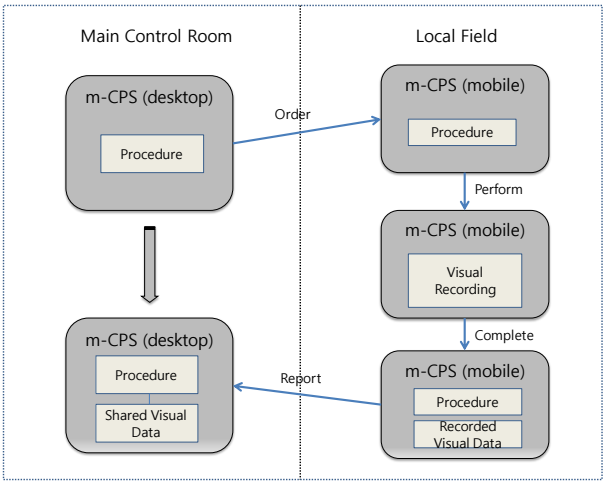

Fig. 1. Conceptual Diagram of m-CPS usage

Software Cross-Platform : The m-CPS should be running on various smart devices and the desk-top computer. The development of the m-CPS will be based on the cross-platform architecture. CRI CPS has been developed with QT which is a widely used cross-platform application framework [2]. Once an application is developed under the cross-platform framework, minimum time and effort is necessary to re-build the application.

Data Highway : Since the APR1400 CPS consists of server and client architecture, each software transfers computerized procedures, plant operating parameter and others on the DCS network. Frequency and size of transferred data have no effect to the performance of the DCS network. However, since the m-CPS will support big data sharing, multi-way communication and simultaneous users on wired and wireless networks, the adoption of data highway is essential for the m-CPS infra structure. Commercial solutions are available for the m-CPS such as MS Biz-talk™ and Giga-Space™.

Wireless Communication Network : Generally we can use the wireless communication in NPPs after ensuring that there is no effect on operating facilities in NPPs with EMI/RFI conditions. However some areas in NPPs can be available for the wireless communication. Once the m-CPS is run in the local field, the position of the m-CPS is almost fixed with little changes until the local work is done or some extra events occur. It can make the usability of m-CPS more improved. KHNP

has promoted how to mitigate the EMI/RFI conditions and how to apply the wireless communications in the NPP. Recent EPRI technical report states that when the frequency of a wireless device is more than 1GHz and the electric output is less than 10mW, there are no significant effects on facilities and devices of NPPs [3].

Cyber Security : Communication networks, devices and software of the m-CPS are proper for the cyber security and information integrity according to the associated regulatory codes and standards. It is possible to provide communicated information to uncertified application by recent hacking methods. If there is a strong protection against abnormal software, a potential risk about loss of certified devices is existed without the human and physical security.

Human Error Prevention : Preliminary task analysis about periodic and surveillance testing procedures and associated activities has been performed by KHNP CRI. It is probable that the m-CPS is helpful for supporting and strengthening the prevention techniques of human errors as shown in the Figure 2. After developing the m-CPS, KHNP CRI will evaluate its operability according to the HFE V&V process.

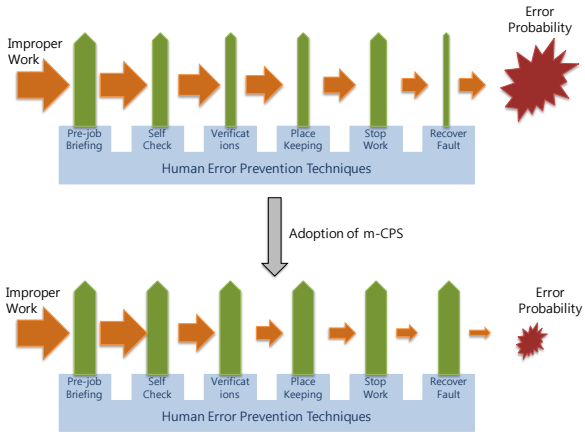

Fig. 2. Reduction of Human Error by m-CPS

APR1400 CPS Compatibility : APR1400 CPS is applicable for normal, abnormal and emergency operating procedures. KHNP has established a standard XML schema for a computerized procedure. Supplementary information such as recorded image is necessary for the surveillance and periodic testing procedure in the m-CPS. It is possible to be included in the standard XML schema. Also a unified procedure editor will be used to write a MCR operating procedure and a local testing procedure.

Scalable User Interface : Some of graphic user interface (GUI) applications have a fixed size layout such as 1024*768 px, 1280*1020 px and etc. It is difficult to change the display resolution of the GUI application. CRI CPS was developed with the fixed size layout [4]. As previously mentioned, the m-CPS is possible to apply for various devices. Some of user interface components in the MCR CPS may be not essential for the small and wide display of the m-CPS.

2.2 Design Features of m-CPS

Previous considerations are useful for the m-CPS design. Based on the design of APR1400, CRI CPS has been developed and operated for SKN 3&4 HFE V&V and license test for the reactor operator and the senior reactor operator. Therefore the m-CPS will be developed by upgrading the CRI CPS with improved features as shown in Table I.

Table I: Improved features of m-CPS from APR1400 CPS

	As-Is	**To-Be**
Type of Users	Shift Operator in MCR	Operating and Maintenance Staff
No of Users	More than 20	More than 500
Available Location	MCR, RSR, TSC and LOR	Most of Areas
Available Plant Units	Shin-Kori 3&4 Shin-Hanul 1&2 BNPP 1~4	Most of NPPs in South Korea
Support Procedure	Plant Operating	Plant Operating, Surveillance and Test
Integrated Information	- Procedure - Operating Parameter - Attached Image	- Procedure - Operating Parameter - Attached Image - Recorded Image - Job Status - Real-time Communication
Operating Device	Desktop	Desktop Labtop Smart Pad
Network	DCS Network	OA Network
Vendors	WEC Doosan Heavy	KHNP
Cyber Security	Plant Level Security	Software Secure Coding

3. Conclusions

The proposed m-CPS can be developed with many recent technologies in the various industry fields based on CRI CPS. Performance and stability of CRI CPS have been tested several times until now. It is expected that more human errors can be reduced by the m-CPS through improved situation awareness and human performance tools for local workers and MCR operators. Some considerations as well as mentioned ones will be reflected in the m-CPS development.

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