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Design and Analysis for an Operator's Action Sharing System

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1. Introduction

Advanced digital control rooms have lots of advantages compared to analog control room. They can integrate all process variables into more comprehensible forms. Advanced alarm processor can suppress trivial alarms, and P&ID based mimic displays can be integrated with context sensitive menu for referencing. Moreover computer based procedures have been introduced at more advanced MCR. Because all these display appears at flat panel display (FPD), they can be easily modified if necessary.

These days newly introduced MCRs are advanced types, and analog control rooms are no more built. In spite of this trend, advanced control rooms have shortage in view of team transparency. For example, shift supervisor cannot tell which devices reactor operator is manipulating.

APR1400 MCR has large display panel to share the same situation awareness among crewmember. Because LDP has fixed display comparing switchable display in FPD, situation awareness can be enhanced. However, even LDP cannot show the active device that crewmember are manipulating due to either limited number of devices in LDP or no demarcation for the active device. During construction of ShinKori 3/4, the demarcation box for the active device has been introduced and called an Active Control Box.

CPS of APR1400, however, has good features in view of crew coordination. RO and TO's procedure can be synchronized by shift supervisor's procedure.

HRP recognized the same issue and initiated a project on team transparency, published a report [1] saying that crew appreciated value of team transparency. HRP MMIS for team awareness sharing consists of LDP with Active Control Box around manipulating device, and additional FPD showing the display that other operator is working on.

In the paper, contrary to HRP approach, no more FPD is introduced because there is no room to install. The same workstation and the same LDP should be utilized for ream transparency.

2. Challenges and analysis

Fig.1 shows part of I&C architecture of APR1400 related to action sharing system. Main role is played by large panel display, and crew workstations. LDP consists of both variable and fixed sections. The variable sections are dedicated for SS, RO, TO and EO. RO dedicated section displays the same contents as RO's FPD.

SS workstation consists of 4 FPD labeled 1,2,3,4 in Fig.1. One of them can be projected to SS section of LDP. Because SS can use four FPDs from time to time for monitoring and controlling, active FPD should be defined as working FPD that SS is current focusing on with mouse. The active FPD can change every second. The active FPD can be projected to the fixed LDP section.

In addition to LDP sharing mechanism, workstation can be another destination of action sharing system. For example, SS FPD1 can be used to monitor RO FPD2. The same principle can be applied to RO, TO, and EO.

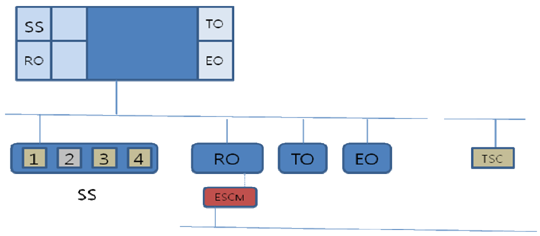

Fig. 1 I&C Architecture for Sharing System

Considering Fig.1 architecture, there are several challenges to solve during the project.

Traffic and CPU load is the first concern when additional system is introduced. Because contents of RO active FPD should be copied and pasted to SS FPD 1 more than 5 times per second, its traffic load could be estimated as 5 Mbytes per second. If TO and EO are simultaneously shared further, the traffic increases up to 15 Mbytes. This traffic load certainly has effect on the already installed control and monitoring ability, which is designed as 100 Mbyte/sec.

Therefore traffic load should be reduced. One solution is using vector graphics. All the graphics in FPD are drawn in vector objects such as device symbols and flowchart. Control and monitoring objects are drawn in ovation tool, procedures are in computer based procedure tool. The problem is that two tools are not same. Thus it is difficult to apply the same sharing mechanism.

Another solution is to use sharing video drivers of RO and SS. For example, when RO FPD draws its contents, the SS FPD (Destination) is simultaneously drawn in the video driver. This technique is utilized by lots of commercial software.

Final solution is a primitive technique that is RO FPD is captured, compressed, sent, and pasted to SS FPD. When the final solution is analyzed via traffic tool, the traffic load increases by about 200 Kbyte/sec. That can be acceptable even in emergency plant state.

Sharing Interface is to trigger the sharing functions. Goal of sharing mechanism is not producing secondary workload. It function should be easily accessible. The first alternatives is shown in Fig.1

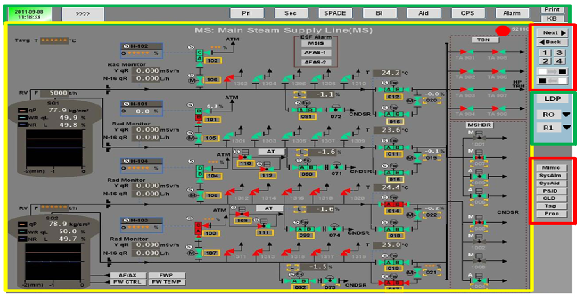

Fig. 2 An Interface for action sharing

A sharing menubar is inserted at the right frame on FPD. The menubar holds 3 buttons that are labeled as LDP, crewmember selection, and FPD selection. LDP pushing can be achieved one click away, FPD pulling can be achieved two clicks away. The challenge for this design is to modify the right frames which are drawn in graphic builder and CBP, and alarm specific tool.

The second interface is designed by considering that the copied FPD can be regarded as the same display pattern as mimic display. Thus the copied display can be grouped and accessible from the aid button. Aid button is clicked to invoke the Fig.2 directory. This interface has an advantage that no more software can be modified for sharing. Addition graphic page is enough.

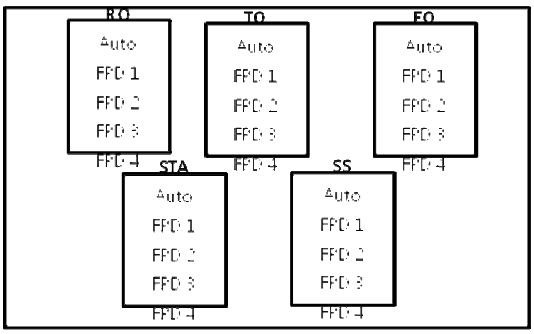

Fig. 3 Another Interface for action sharing

Human error prevention tools are modified to utilize this action sharing system. Affected tools are concurrent check, peer check, and independent check. In advanced digital room, these tools are difficult to apply.

When the action sharing system are introduced, RO, TO, and EO are pushing their active FPD into their respective LDP. Then other crewmembers can check the other operator's actions. Another scenario is that SS is pulling RO active FPD into SS FPD1 to pear check RO's action.

Design Change will occur after testing the sharing software. Since ShinKori 3,4 has not been permitted for commercial operation, design change shall occur after commercial operation permission in order not to influence present permission process. The design change process includes audit by regulation authority.

Software V&V is inevitable activities in order to assure that action sharing system is free from bugs and that SW handles all potential exceptions. Usually handling all exceptions needs systematic approach and the source code becomes 5 times bigger.

V&V activities include analyzing algorithm, checking source codes, unit test, and integration test. All exceptions could be injected to the system to assure its reliability.

Safety Soft Control would not be scope of action sharing system because safety control is one of function on the safety system. Safety system should be isolated from non safety system, and simpler and more reliable than non safety system. Note that non-safety soft control dialog can be pushed into LDP and other operator's FPD.

If safety soft control images were captured, third party program should be developed and inserted into the safety system. Then the third party program should be graded as a safety system. Another problem encountered is network link to send the captured images.

Human Factor Engineering Program will be applied to action sharing system. HFEP consists of 12 elements which are selectively applied according to graded approach. Motivation of action sharing system occurs during V&V of ShinKori MCR. Thus OER is one of the the most important elements of HFEP. Usability test will be performed.

3. Conclusions

A action sharing system will be introduced at ShinKori3,4 MCR, and further applied to other APR1400 plant if necessary. The project started and applied by the end of 2014.

Despite benefit of action sharing system, there are lots of challenges to overcome such as traffic load, and interfaces. The challenges have been analyzed thoroughly. Traffic load can be reduced through vector graphics, video driver, and capture and compressing techniques. Furthermore interfaces for action sharing system are developed and evaluated to reduce secondary workload.

REFERENCES

[1] Work Practices 2009 HAMMLAB Study: Team Transparency in Near-Future Computer-Based Control Rooms, HRP-952, Stine Strand, Magnhild Kaarstad, Håkan Svengren, Tommy Karlsson, Christer Nihlwing, 2010