Study on the Application Method of Display Sharing System for the APR1400 Digital Main Control Room

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1. Introduction

The APR1400 digital MCR was applied for the first time in the Saeul units 1&2. APR1400 digital MCR has many advantages to reduce the physical and mental workload and to increase situation awareness through integrated Information Flat Panel Display (IFPD) of operator console, Computerized Procedure System (CPS) and Large Display Panel (LDP). But although digital MCR has many advantages, it has a weak point that operators cannot easily oversee the other operator's operational behavior like soft control action in the IFPD[1]. This environment makes it difficult to perform concurrent verification or peer review to prevent human error. Therefore, we have been developing display sharing system for Saeul units 1&2 digital MCR since 2013. This paper presents application method for display sharing system using LDP variable area and OA monitor included in an operator console.

2. Operators' Requirements for Display Sharing System

We have collected requirements from Saeul units 1&2 plant operators and I&C maintenance engineers to apply display sharing system for the APR1400 digital MCR[2]. Following requirements are summarized as Table 1.

Table 1 Operators' Requirements

No	Requirements
1	When developing display sharing function, operators have to be able to use that function using variable section of the LDP as well as IFPD
2	Configuration function has to be included for applying display sharing function considering the operation strategy of the plant.
3	When operators increase or decrease plant power using GOP, operators need to use display sharing function in each operator console.
4	When using display sharing function, operators have to oversee soft control action such as the action of the safety component control and non-safety component control.
5	When applying display sharing function, this function does not have to impact MMIS performance and reliability.
6	Original IPS, display and LDP design requirement have to be maintained in spite of the application of display sharing function.

3. Software Based Display Sharing System

First of all, S/W method was considered to implement display sharing system while minimizing the configuration change of MMIS. As shown in Figure1, additional hardware such as video extender should be applied to the ESCM(Engineered Safety Feature-Component Control System Soft Control Module) monitor to share safety grade soft control display, that is, ESCM display.

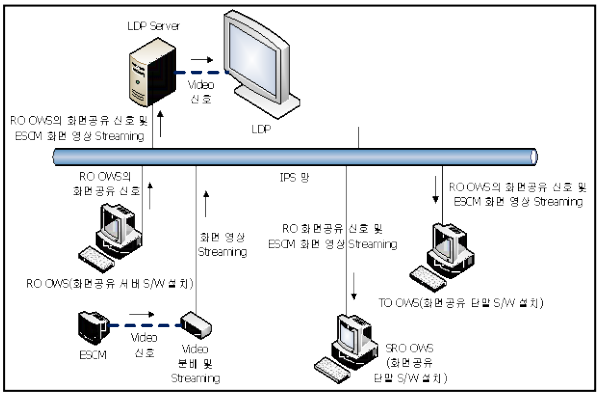

Figure 1 Software based display sharing system architecture

This video extender plays a role in distributing and streaming video signal. Also, independent server and application program for display sharing function have to be added. This method is very simple method to implement display sharing function. But, this method tends to affect DCS network load case by case. Operators and I&C maintenance engineers strongly request that it does not impact MMIS performance and reliability due to the application of display sharing function. Accordingly, we considered hardware method not to affect DCS network and performance at most.

4. Hardware Based Display Sharing System

To simply design display sharing function, we have introduced video extender, video scaler, and video matrix as shown in Figure2. Video extender such as video sender and video receiver has the function to send each operator's display to LDP variable area and receive shared display from the other operators. Video matrix has all of three (RO, TO and EO) operators' current display. Also, video matrix controller has the function to manage the shared displays which video matrix are storing from each operator's operator console.

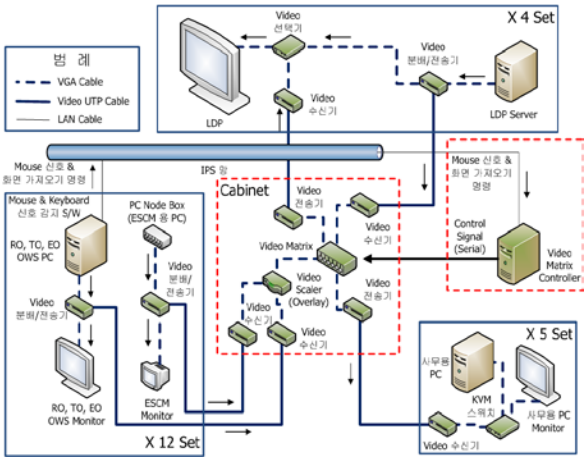

Figure 2 Hardware based display sharing system architecture

This hardware method has the characteristics not to affect DCS network load and OWS CPU load at most. But EQ tests have to be performed to the additional H/W component. The following Table 2 shows quality class and seismic class of the additional components.

Table 2 Quality and seismic class of H/W component

No	Additional H/W Component	Quality Class	Seismic Class
1	Q grade Video sender	Q	I
2	Video Matrix	A	III
3	Video Scaler	A	III
4	Video extender for LDP	A	II
5	KVM Switch for OA Monitor	A	II
6	Video sender	A	II
7	Video Receiver	A	II
8	Video Matrix Control Computer	A	III
9	Cabinet	A	III

5. MMI Design for Display Sharing System

We designed MMI display to manipulate display sharing function in the operator console.

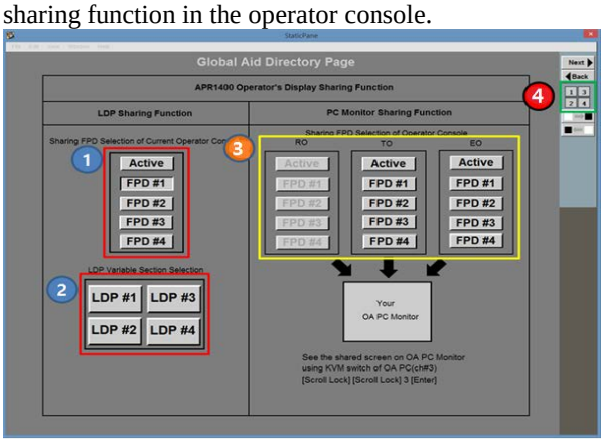

Figure3 MMI display for display sharing function

As shown in Figure3, there are two types to use display sharing MMI. One is fixed sharing function and another is automatic sharing function. An operator can also use fixed sharing function to share one fixed FPD of the other operators. Shared display is also shown on the LDP variable area or OA monitor through fixed sharing function. For automatic sharing function, the event on each OWS can be detected and the display used recently should be checked. When automatic sharing option is on, the display used recently should be displayed on variable area of LDP or on OA monitors of the other operators. If the operator who offers source display changes his control OWS, the sharing display should be changed with new control display automatically.

6. HFE V&V Result of MMI Design

We have tested display sharing system design in the light of HFE in June, 2016. One crew (5 operators) was participating in this test. We have no particular problem in view of usefulness and readability when operators use shared display in the LDP variable area using display sharing system. Operators evaluate that display sharing function is very useful in case that concurrent verification or peer review is required in all of the plant state.

7. FMEA of the Display Sharing System

We evaluated effect on the DCS and ESF-CCS due to application of the display sharing system through the FMEA. When performing FMEA, failure mode of each component was evaluated according to the architecture of display sharing system and connection with the conventional MMIS.

8. Conclusions

This paper describes display sharing system for the APR1400 digital MCR. We considered various methods to implement suitable system matching requirement from operators and maintenance personnel. Consequently, we adopted hardware based display sharing system and performed HFE V&V and FMEA. We collected good opinion from operators that display sharing system is very useful to easily detect operators' errors. We are planning to apply display sharing system into the APR1400 NPP and including UAE BNPPs.

REFERENCES

[1] HRP-952 Team Transparency in Near-Future Computer-Based Control Room(2009, HAMMLAB)
[2] A Study on the application of the Display Sharing System in the APR1400 MCR (ISOFIC/ISSNP 2014)