Application of Nuclear Application Programs to APR1400 Simulator

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1. Introduction

Advanced Power Reactor 1400MWe (APR1400) simulator has been developed and installed at Kori Training Center for operators of ShinKori #3, 4 nuclear power plant by Korea Hydro & Nuclear Power's Central Research Institute (KHNP CRI).

NAPS (Nuclear Application Programs) is a computer-based system which provides operators with past and real-time information for monitoring and controlling NSSS (Nuclear Steam Supply System), BOP (Balance Of Plant) and Electric system. NAPS consists of several programs such as COLSS (Core Operating Limit Supervisory System), SPADES+ (Safety Parameter Display and Evaluation System), CEA (Control Element Assembly) Application Program, and so on. Each program makes calculations based on its own algorithm and provides information available for operation.

In order to use NAPS programs with a simulator even though they are being used in a real plant, they should be modified to add several simulation functions such as reset, snap, run/freeze and backtrack required by ANSI/ANS-3.5[1] to the original NAPS functionality. On top of that, interfacing programs should be developed for the data communication between respective NAPS programs and simulator sever.

The purpose of this paper is to provide the overall architecture of the communication system between NAPS and simulator model, and to describe the method to apply NAPS to APR1400 simulator.

Fig. 1 APR1400 Simulator

2. NAPS overview

2.1 NAPS Software programs

The list of Software programs for NAPS is as follows in the Table 1. Each program receives data from simulator sever, performs run-time calculations and transmits the results back to simulator server. The data can be displayed on NAPS graphics.

Table 1. Software programs for NAPS

Module	Function	Remark
BuildFPList_gen	Interface between Simulator and NAPS server	Interface S/W
CpCalcConn	Interface between NAPS software programs and BuildFPList_gen	
CpCalc	System Support Program	NAPS S/W programs
Bop BopPrint	BOP Performance Applications	
Colss	COLSS Program	
CeaDemand CeaPrd	CEA Program	
Incore	Fixed Incore Detector Signal Processing Program	
Xrbp	Xenon Reactivity Prediction & Balance Program	
RpcCea	RPC CEA Selection Program	
Dspm	Deviation and Setpoint Monitoring Program	
Utdv	Update Time Dependent Variable Processing	
Cecor	CECOR Data Collector	
Midloop	Mid-loop Application	
PTCurve	RCS P/T Limit Curve	
RcsLeakRate	RCPB Leakage Program	
SpadeSvr	SPADES+	

2.2 Interfacing System Structure between NAPS and Simulator

A simulator sever loaded with process and logic models in a simulation environment, exchanges data and information with NAPS server using an interfacing program, BuildFPList_gen in TCP/IP networking protocol. The interfacing program exchanges data with every NAPS program via another interfacing program, CpCalcConn. Each NAPS and Simulator server allocates its own global memory for communication with each other. NAPS server communicates with MMI (Ovation), the actual plant I&C equipment in OPC networking protocol. The Ovation system present in the simulator to provide communication between the plant model computer and the stimulated Ovation equipment [2]. Fig. 2 represents the schematic diagram for the communication for data transfer between NAPS and Simulator.

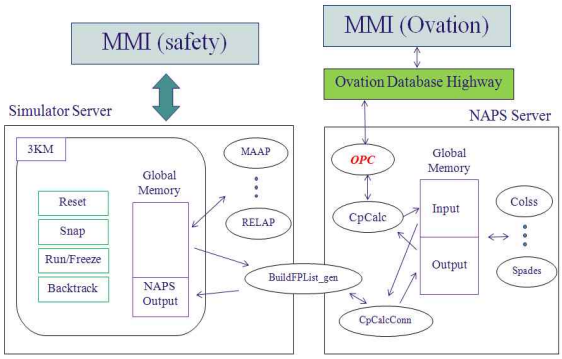

Fig. 2 Schematic Diagram between NAPS and Simulator

3. V&V of NAPS Application to APR1400 simulator

3.1 NIST

After the development of a system is completed, V&V (Verification & Validation) for the system should be done to prove its performance through NIST (Non Integrated Stand-alone Test). NIST is to be done according to the ATP (Acceptance Test Procedure). The test was carried out to check the interface between NAPS and Simulator that values on the both side of them were compared. An example of the result is shown in Table 2. Point alias is recognized in common even though corresponding variable names are different in its own system.

Table 2. Result of interface between NAPS and Simulator (Example)

Point Alias	Description	Simulator	NAPS
APJ0015	UAT TR01M POWER	36.2429	36.2429
APJ0016	UAT TR01N POWER	28.3943	28.3943
APY0128	SAT TR02M POWER	0.3415	0.3415
APY0129	SAT TR02N POWER	0.3415	0.3415
ASF0003	MN STM INLT TO AUX STM HDR FLOW	0.0000	0.0000
CDF0300	LP FW HEATERS DSCH HEADER FLOW	496.6130	496.6130
CDF0464	HW MU FLOW COND WATER FLOW	0.0000	0.0000
CDP0073	COND PUMP A PP01 SUCTION PRESS	296.7820	296.7820
CDP0074	COND PUMP B PP02 SUCTION PRESS	297.3880	297.3880
CDP0075	COND PUMP C PP03 SUCTION PRESS	302.6750	302.6750
CDP0085	COND PUMP A PP01 DSCH PRESS	38.7112	38.7112
CDP0086	COND PUMP B PP02 DSCH PRESS	38.7112	38.7112

3.2 Integration test between NAPS and Simulator

Integration test was carried out to check the result in NAPS which takes data from simulator sever and makes calculations in sub-programs. All the values represented on each NAPS display were evaluated. In this step, it is also checked whether unit conversions get done properly and adequate alarm signal is generated in the expected condition. An example of NAPS display is shown in Fig. 3.

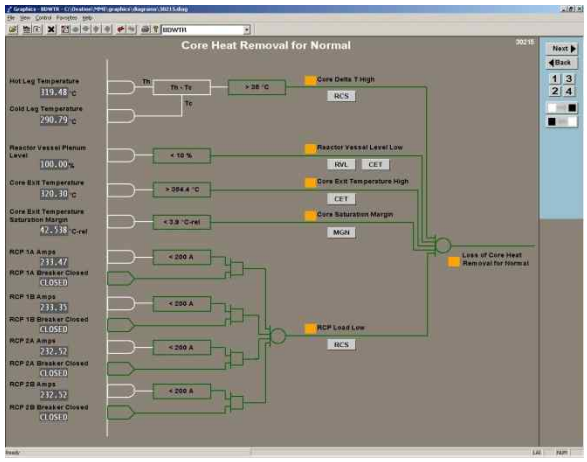

Fig. 3 Example of NAPS Display

4. Conclusions

The integration between NAPS and APR1400 simulator was completed and NIST and integration test was carried out according to ATP. The result of them shows that the interface between NAPS and simulator server is done properly.

The interface technology used in integrating NAPS and Simulator in this paper is thought to be able to be applied to other system, such as IPS (Information Processing System) and DCS (Digital Control System), connecting with a simulator.

The test for integrated system including Ovation system will be carried out after the development of stimulated Ovation is completed and provided by WEC (Westinghouse Electric Company).

REFERENCES

[1] ANSI/ANS3.5-2009, "Nuclear Power Plant Simulators for Use in Operator Training and License Examination", American National Standards Institute, 2009.

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[3] D. H. Hwang, M. S. Lee, J. H. Hong, "Stimulation interfacing method in APR1400 simulator", Transactions of the Korean Nuclear Society Spring Meeting, Gyoungju, Korea, May 29-30, 2008.