Design of Information Processing System for Research Reactor

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1. Introduction

As Man Machine Interface System (MMIS) of commercial power plant is fully digitalized, that of research reactor is also changed from analog to digital system. Thus, research reactor is furnished with Information Processing System (IPS) conducting the role of information layer between control layer and operation layer of MMIS. Basically, the IPS acquires and processes reactor data from other I&C subsystems. The goal of IPS is to provide reactor status information to operator personnel in control room. In this paper, we define functional roles of IPS in research reactor and describe an applicable system models to the IPS. Finally, we propose adequate system architecture for the IPS by taking account of economic feasibility and effectiveness factors.

2. System Design with High Availability

In this section, a design concept for high availability is described and an architecture meeting the concept is proposed. Furthermore, some redundancy features applied to the architecture are explained in detail.

2.1 System Reliability and Availability

The important two factors in system design, reliability and availability, are similar concept, but quite different in the operation aspect. Reliability is the conditional probability that a system operates correctly throughout the interval $[t_0, t]$ given that it was operating correctly at the time t_0. Availability is the probability that a system is operating correctly and is available to perform its function at the instant of time t.

The nuclear safety class systems of MMIS should be furnished equipments with high reliability for robustness because failures of them can cause critical accidents and are not repairable normally. Contrarily, the IPS considers the system availability than reliability because it is possible to maintain its components and it prevents the reactor protection system from performing its function.

2.2 System Models for High Availability

The IPS in research reactor requires lower performance than power plant. The reason is that overall input points and interface subsystems are small relatively. Besides, it does not control instruments directly but process information. Thus, the IPS in research reactor does not require high cost DCS (distributed control system) product. That is, off-the-shelf server class can be supplied as the IPS sufficiently.

Traditionally, several models for high availability are applied to the industrial world. The major three models [1] are summarized in table 1. The Active/Standby model is configured as an active server and a standby server. That is a symmetric configuration and the standby server is ready to back up the active fully. The Active/Active model is called asymmetric model, two servers perform each mission and can back up for the other respectively. *N*-Active/*1*-Standby model is that only one server is ready to back up for *N* servers. This model is used for providing more complex and various services in the IT industry.

Table 1: System Models for High Availability

Models	Adv.	Disadv.
Active/Standby	High readiness	Low utilization
Active/Active	High utilization	Low readiness
N-Active/1-Standby	Highest utilization	Low readiness

2.3 IPS Configuration

The IPS provides reactor status information to Main Control Room (MCR). The information is derived from other I&C subsystems, such as Reactor Protection System (RPS), Reactor Regulating System (RRS), Process Instrumentation and Control System (PICS), etc. The IPS provides information both on a real-time and historical basis on demands of the operator in the control room. The IPS communicates with other systems via a data communication network which transfers all data periodically. Figure 1 shows the system concept of IPS and the interface subsystems.

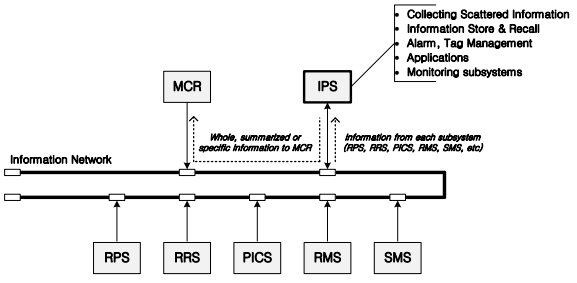

Fig. 1. System concept of IPS and interface subsystems.

As shown in figure 1, the IPS is responsible for collecting scattered information caused by distributed design of I&C system and providing whole, summarized, specific information to MCR. Moreover, it manages whole reactor information and tag configuration for instrumentations, processes alarms to be configured with various signal status in I&C system, monitors functional integrity of subsystems and executes various applications.

Detail functions of IPS are defined as follows:

1) In/out Processing: Input scanning, I/O task scheduling, communication.
2) Real Time I/O DBMS Function: Database management.
3) Applications Processing: Execution of required application program, such as critical functions monitoring application.
4) Alarm Processing: Alert the operator the abnormal conditions.
5) Data Archival Function: HDSR(historical data storage and retrieval).

These functions should be continuously served to MCR for the safe operation of reactor. If IPS is not work, the reactor will be shut down manually. That is why the IPS should have high availability.

Basically, our design follows the Active/Standby model, but the standby server performs as 'hot-standby' mode according to the conservative design criteria. In this mode, the standby server processes all input data as the active server, but just does not output. This enables the backup server to take current status in real time and data of active server over without loss.

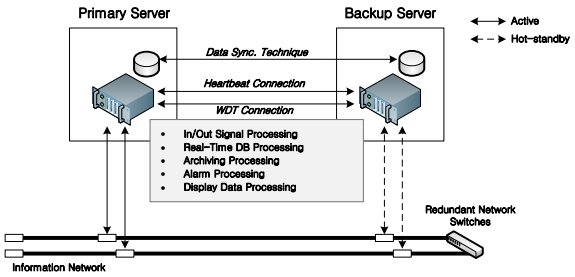

Fig. 2. A brief configuration of IPS.

The proposed configuration has three redundancy features for high availability. The first is hardware redundancy feature. Redundant servers are employed basically and they are connected together as heartbeat connection and watch dog timer (WDT). The interconnections are used to identify aliveness of opposite server. Redundant network switches and multiple communication channels are employed for network redundancy. The next feature is information redundancy. Storage media stores various dataset including setpoints, processing variables, intermediate results, etc. The redundant servers include storage media respectively and a synchronization technique is applied between the storages. The last is software redundancy feature. The IPS performs consistency check and capability check. The input processing function performs input range validation on received inputs from other I&C subsystems. Diagnostics function monitors H/W and S/W to check its functionality continuously.

2.4 Failover

The IPS has monitoring and recovering functions to provide high availability because it is important system providing reactor related all information to operator.

The diagnostic function is able to check component integrity of IPS, such as CPU, memory and so on, on power-up. Also, it is able to surveil the working status of IPS components on normal operation periodically. Furthermore, this function is able to monitor communication status with other I&C systems, such as RPS, RRS, PICS, etc.

The failover function copes with any malfunction or performance deterioration. It is the most important function to maintain the functional system integrity continuously. This failover function equipped with the redundant servers and components provides high availability of IPS.

3. Conclusions

The non-nuclear safety class IPS is designed to be available for normal operation of reactor because it provides base information to operator personnel for operating reactor. By taking account of economic feasibility and effectiveness factors, off-the-shelf servers can perform the role of IPS in research reactor sufficiently. However, more conservative design versus commercial system is required for availability improvement.

This paper proposes a system architecture that exploits several redundancy features, hardware, software and information redundancy for enhancing system availability.

REFERENCES

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[2] Seong-Jin Kim, et al., An Efficient Method to Search Real-Time Bulk Data for an Information Processing System, Transaction of the Korean Nuclear Society Autumn Meeting, pp. 1061-1062, 2005.