Architectures of Remote Monitoring Systems for a Nuclear Power Plant

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1. Introduction

Aina(Artificial Intelligence for Nuclear Applications) have developed remote monitoring systems since the 1990's. We have been interested in the safety of reactor vessel, steam generator, pipes, valves and pumps. We have developed several remote inspection systems and will develop some remote care systems for a nuclear power plant.

There were critical problems for building remote monitoring systems for mass data processing and remote user interface techniques in the middle of the 1990's. The network capacity wasn't sufficient to transfer the monitoring data to a remote computer. Various computer operating systems require various remote user interfaces.

Java provides convenient and powerful interface facilities and the network transfer speed was increased greatly in the 2000's. Java is a good solution for a remote user interface but it can't work standalone in remote monitoring applications. The restrictions of Java make it impossible to build real time based applications.

We use Java and a traditional language to improve this problem. We separate the remote user interface and the monitoring application.

2. Monitoring systems

We have developed several remote monitoring systems. We will introduce the systems and the common architecture of them briefly.

2.1 A reactor wall UT inspection

This system is a reactor wall UT(Ultra-sonic NDT) inspection system that has a robot working underwater [1]. This system consists of an inspection robot, a laser system that guides the robot's direction, an UT signal acquisition & analysis system and a main control system.

The original system used a serial communication protocol. Because the main board that we developed in 1996 for the robot and laser system, supports only serial ports. TCP/IP communication was only applied to the data acquisition part in 2000. Inspection was executed only on the main control system with CCTV. The inspection system must be beside a reactor because of the distant restriction of the serial communication. It wasn't a remote inspection system.

This project was finished in 2002 so we couldn't expand the main board into TCP/IP. But we modified this system to be a remote inspection system in 2004. We added the TCP/IP protocol into the main control system. We provided a Java interface to communicate with the main control system on the remote user's web browser and a web camera solution. We could execute the reactor wall inspection operation on a web browser.

2.2 A guide tube support pin inspection system

This system was developed to inspect the guide tube support pins. This system consists of a guide tube inspection robot, a robot control system, an image processing system to find the pins automatically, a remote inspection application server and a web camera server[2]. We improved the reactor wall UT inspection robot's main board with a bulk memory and a TCP/IP port.

The robot has two cameras, one for a web camera server to monitor the inspection situation and the other for the image processing system to calculate the central coordinates of the objective pins. The position information is transferred to the robot's control system and the robot drives the wheels to go to the pin. The robot control system manages the inspection robot and inspection manipulator to find the hole of the objective pin automatically.

The remote inspection application server provides web based remote user interfaces. And it works as a communication server for all components.

2.3 A remote data accessing system

This system is developed to monitor the remote inspection system to see whether it detects an abnormal condition at a instrument in a nuclear power plant. And it helps the remote user to access the acquisition data on the user's web browsers.

We applied JSP(Java Server Page) to the remote user web interface program to get the dynamic data information of the remote inspection system. When the remote inspection system detects an abnormal signal, this information is displayed on the applet window of the remote user's web browser. The remote users can retrieve the acquisition data of the remote inspection system. When an abnormal signal has occurred and new data is stored in the remote inspection system, the user's web browser reflects this modification automatically. This system is based on JSP and a network driver skill.

2.4 Common remote monitoring architecture

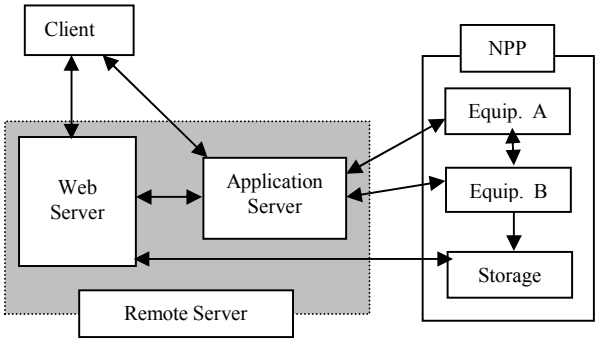

Figure 1. Common remote monitoring architecture

The common remote monitoring architecture that was applied to the remote systems we developed is shown in Figure 1[3]. The inspection mechanism looks like a black box to the remote users. The application server includes web applications and works like a communication server to control the inspection procedure. The error controls of an inspection are executed automatically in the application server and the equipment's processors. All the results must be announced to the remote users

3. An advanced architecture of the remote monitoring system for nuclear power plant

Indeed a remote monitoring system that includes a remote data acquisition based on the real time processing concept can't be made as yet. But this problem can be solved in couple of years. We suggest an advanced architecture of the remote monitoring system for a nuclear power plant as shown in Figure 2.

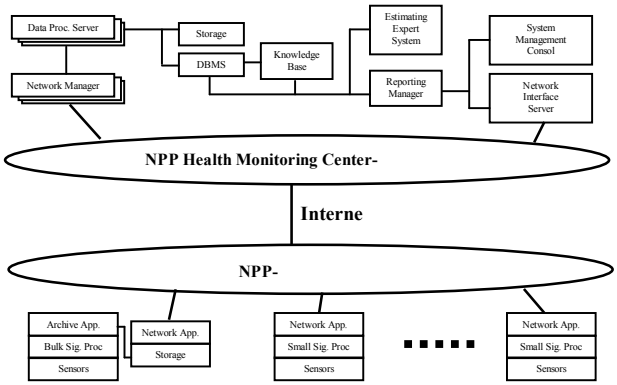

Figure 2. An advanced architecture of the remote monitoring system

There are a lot of sensors on the instruments. It contains the concept of a sensor network. The DAS(data acquisition system) will gather and transfer the data to the central monitoring computer in a real time. This computer will be constructed through a parallel processing. The transferred data and the processed data will be stored in the storage system and DBMS. The processed data can be used in a prediction part with an expert system. The remote users can share all the information via the network and web browser.

The monitoring systems we developed didn't include the remote data acquisition part. We tried to develop some remote data acquisition systems but couldn't make them. The data acquisition speed bands are out of the current network transfer capacity. 30~100MBPS data acquisition bands are required in the reactor UT and vibration monitoring parts. But the current maximum band of a network capacity is 100MBPS in the ideal state. When we use a commercial network system, the average network speed is within 50 MBPS. In addition to the network speed, the network switch performance is a critical problem. When we use a 100Base/T network card, it can't process 100MBit data per second. It spends nearly 30~40% times to receive and analysis the data packets.

Network venders developed the TBPS technique and they say that it can be serviced within a couple of years. In actuality TBPS technique was shown by Samsung in August 2006.

4. Conclusion

We described the common architecture of our remote monitoring systems and suggested an advanced architecture of the remote monitoring system in this paper.

Our conclusion is that the time restriction is the most important factor in the remote monitoring system. We have learned that the network speed is the unique unsolved problem of the remote monitoring system in a nuclear power plant, but it will be overcome within couple of years. We must pursue a remote monitoring system in the proper sense of the word.

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