Development and Demonstration of Remote Experiment System with High Security in JT-60U

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Abstract. Remote experiment system with high network security has been developed in JT-60U. The remote experiment system is produced by personal authentication with a digital certificate and encryption of communication data to protect the JT-60U supervisory control system against illegal access. Remote experiment in JT-60U has been successfully demonstrated from Kyoto University (Japan) in 2006 and internationally from IPP Garching (Germany) in 2007. The validity of the system was obtained. Results are great advances towards remote experiments in ITER.

1. Introduction

Development of a collaborative research environment is a crucial issue in large experiment facilities, such as ITER, JT-60U, etc., because the large facility is produced as a national or an international project. Therefore, it is important to unite researchers and research resources from around the world. In particular, by Information Technology (IT), a system for remote experiment and analysis is demanded to concentrate the wisdom to an experiment facility. Because of these backgrounds, National Fusion Collaboratory project [1] had started in US. Remote participation project [2] is progressing in EU. The VizGrid project [3-7] under the e-Japan project at Ministry of Education, Culture, Sports, Science & Technology (MEXT) has started in Japan. Based on the IT Based Laboratory Infra-Structure (ITBL-IS) [8] and Atomic Energy Grid Infrastructure (AEGIS) [9], the remote experiment system was developed in JT-60U, and the system is presented as the most promising candidate for ITER.

Key issue of the remote experiment system is to provide a stable high speed connection to get a quick response for setting experiment parameters and for monitoring the real time data of the facility and plasma discharge, keeping a high network security to protect the large fusion facility from an illegal invasion, simultaneously.

This paper describes the development and demonstration of the remote experiment system in JT-60U. In section 2, the development of a remote parameter setting system and a network security based on ITBL-IS and AEGIS are described. In section 3, the demonstration of a remote experiment from Max-Planck-Institut für Plasmaphysik (IPP), Garching (Germany) using the remote experiment system developed here was described. Finally the summary and the prospect for the future facility are mentioned.

2. Development of remote experiment system

To realize the remote experiment of JT-60U, the remote experiment server that sets plasma parameter remotely is developed [10] and the network security is made by the infrastructure of the security on effective collaboration technologies of ITBL-IS and AEGIS. The remote experiment server and application software are produced based on Java language in addition to the existing JT-60U experiment system, as shown in Fig.1. The system developed here has following advantages: development with Java does not limit the operation environment of the computer system. The remote experiment server is available without re-installation since this system is implemented with Java Applet. Because this system is designed as a web application, the loads on client computer and the remote experiment server can be reduced. The reduction of the unnecessary data transfer made a robust communication. This system utilized only the specified software such as the parameter setting and the data analysis, therefore, the method using Java applet has essentially higher security unlike Virtual Private Network (VPN).

The main functions of the remote experiment system include: a) the setting of discharge parameters, b) the function to browse an operation status of the facility, and c) the function to display plasma discharge experiment result data.

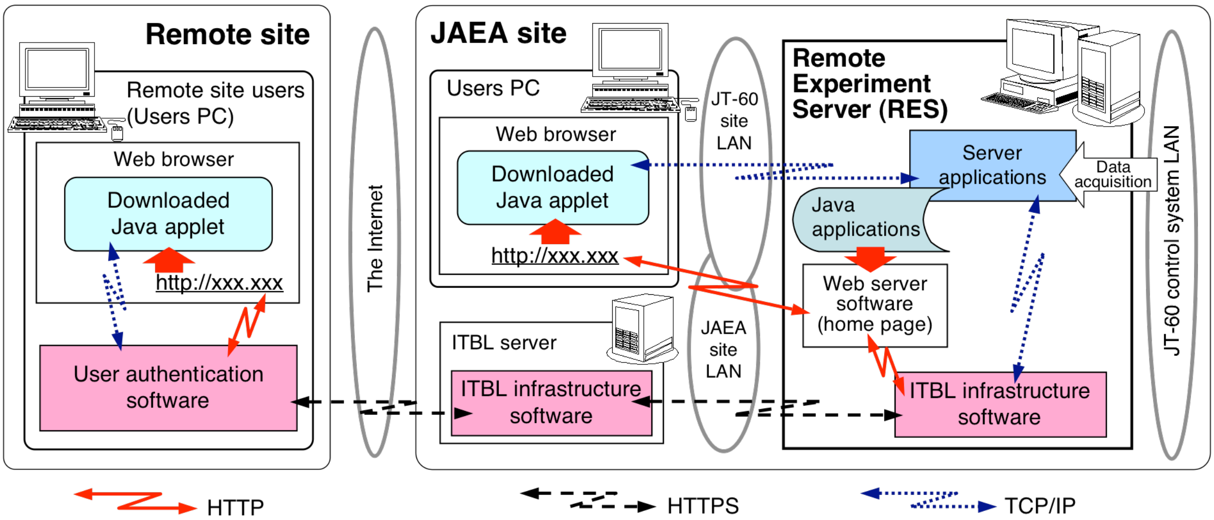

Fig.1 Remote experiment system: remote experiment server and application soft based on the Java language are developted. The user on the remote site can access using the downloaded Java applet through ITBL server.

The network security is produced based on ITBL-IS and AEGIS, and the gateway server validates a digital certificate of a remote researcher. The researcher who passed a screening of Certificate Authority (CA) is allowed to access the remote experiment server through an encrypted channel. Then, the remote researcher starts a web browser by specifying the Uniform Resource Locator (URL) of the remote experiment server.

After the authentication, authorization and creation of HTTPS tunnel by ITBL servers, the remote experiment system starts, and a menu-list of functions is displayed in the web browser. The off-site users can edit and set discharge parameters. The remotely set parameter is sent to the on-site file server through the remote experiment server. Finally, it is checked by the on-site security system for the protection of the facility and approved by the person in charge of the experiment. Therefore, multiplex defense system is conducted.

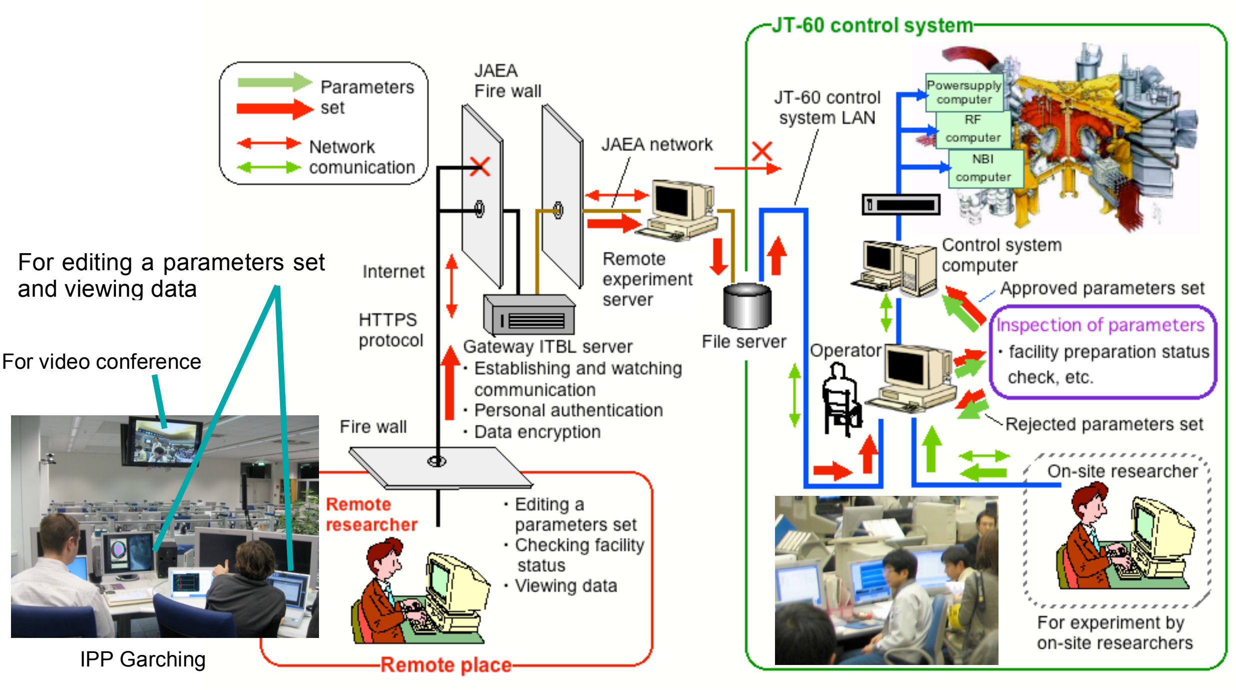

Fig. 2 Overview of remote experiment system in JT-60U.

3. Verification and demonstration of remote experiment system

Remote experiment in JT-60U was first demonstrated from Kyoto University in 2006 to investigate the onset condition of an NTM. It was also demonstrated internationally from IPP Garching (Germany) in 2007 on the occasion of an NTM stabilisation similarity experiment between JT-60U and ASDEX Upgrade. Schematic view of the remote experiment in JT-60U are shown in Fig.2.

The remote experiment started by the access to the gateway server of ITBL to establish the secure network connection, and the off-site researcher accessed the remote experiment server. Based on the discussion of both on- and off-site researchers by using the video conference system, experiment parameter was produced in IPP by using the menu-list of functions displayed in the web browser (Fig.3.1). The produced file for the next discharge parameter was sent to the on-site file server. After the safety check in the JT-60 facility and the approval of the person in charge of the experiment, the discharge was carried out according to the remotely set parameter. During the operation, the status of the facility was checked by the plasma movie (Fig.3.2). The plasma movie is able to provide various useful information in real time to the physicists; hot spots due to heat flow from a plasma on the vacuum vessel

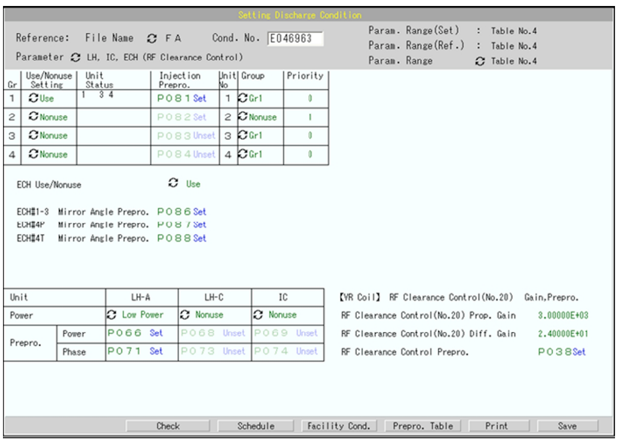

Fig. 3.1(a) Menu of parameter setting for ECH system on the web browser.

wall, time-evolution of plasma position and shape, etc.[11]. Change of macroscopic plasma rotation is also indirectly provided by magnetic probe fluctuation using the ”sound” channel.

After the experiment discharge finished, the diagnostics data were collected to the on-site server. The data of experiment results was displayed on the remote side terminal. A time trace of the input NB and EC power and the obtained normalized beta and the fluctuation is shown in Fig.3.3.

The remote experiment system was successfully verified on its authentication, encryption and turn around time. The gateway server blocked all access except the ITBL-IS and AEGIS client certificate, and we confirmed that its authentication mechanism was working properly. The use of packet capture software proved that packets were encrypted. The amount of communication data to display a discharge condition reference page was measured with packet capture software. Throughput was calculated from the window size and the measured Round Trip Time (RTT), and the turn around time was measured from the amount of communication data and throughput. When RTT was 290 milliseconds, the turn around time was 4.13 seconds for the initial setup of remote experiment from IPP Garching, i.e. the download of the applet. This gave the applicable response to the remote participants, and it provided mostly the same environment as the on-site researcher.

Results are great advances towards the remote experiment in ITER.

4. Summary

The remote experiment system with the high network security was developed in

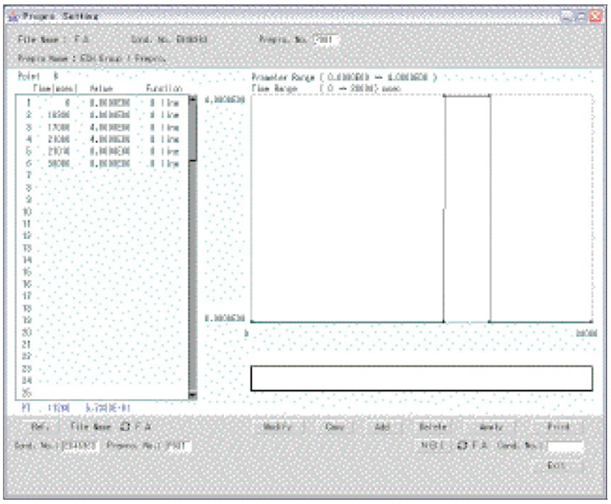

Fig. 3.1(b) Parameter setting display for the injection time of ECH system on the web browser.

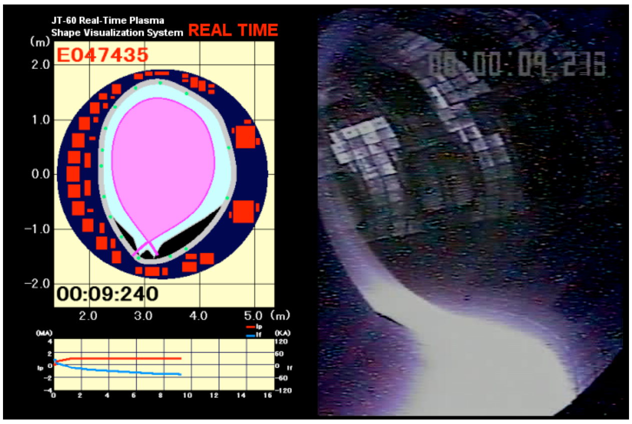

Fig. 3.2 Real time display of the plasma shape computer graphics (CG) calculated by the plasma shape reconstruction system and TV camera image on the remote site.

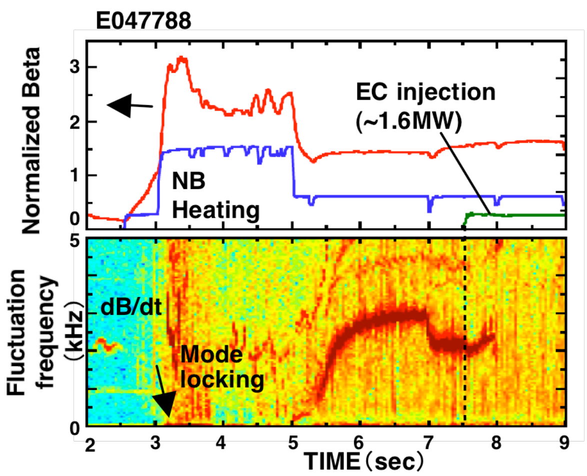

Fig. 3.3 Normalized beta, NBI and EC power and the magnetic fluctuation monitored on the remote site.

JT-60U. Using the developed system, the remote experiment was successfully conducted from Kyoto University in Japan and from Max-Planck-Institut für Plasmaphysik in Garching. The remote researcher can carried out the experiment in the same environment as the on-site researcher. They also have consciousness similar to the on-site participation of the experiment. This success provides a technological base to enforce the establishment of the ITER remote experimentation center based on Broader Approach project.

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