FIRST OPERATION OF THE WIDE-AREA REMOTE EXPERIMENT SYSTEM

Y. Furukawa, K. Hasegawa and G. Ueno*)
SPring-8/JASRI, Kouto, Sayo-cho Hyogo, 679-5198, Japan.
*SPring-8/Riken, Kouto, Sayo-cho Hyogo, 679-5148 Japan.

Abstract

The Wide-area Remote Experiment System (WRES) at SPring-8 has been successfully developed [1]. The system communicates with remote users on the basis of SSL/TLS with bi-directional authentication to avoid interference from unauthorized access to the system. The system has a message-filtering system to allow remote users access only to the corresponding beamline equipment and safety interlock system. This is to protect persons inside the experimental station from injury from any accidental motion of heavy equipment. The system also has a video streaming system to monitor samples or experimental equipment. We have tested the system from the point of view of safety, stability, reliability etc. and successfully performed the first experiment from a remote site, i.e., RIKEN's Wako campus, which is 480 km away from SPring-8, at the end of October 2010.

INTRODUCTION

Remote experiments brings many benefits to the users of a publicly opened experiment facility. One of the benefits is that the system frees users from travelling to and from the facility and users can spend that time on their creative work. Additionally, the system enables international collaboration during its 24-h operation: collaboration teams can operate their experimental equipment for 24 h, despite each collaborator working only during his or her day-time.

To realize a remote experiment system, we have to take into radiation and other safety and security issues. As previously reported [1], we have built a safe and secure Wide-Are Remote Experiment System (WRES) for remote experiment infrastructure. We have built a remote-experiment graphical user interface (GUI) and experiment control server for protein-crystallography experiments on the WRES, and after many tests, we have successfully completed the first operation from a remote site, i.e., RIKEN's WAKO campus 480 km far from SPring-8, at the end of October 2010. In this paper, we describe the remote experiment control system and summarize the first and following remote experiments.

WIDE-AREA REMOTE EXPERIMENT SYSTEM (WRES)

The wide-area remote experiment system (WRES) has been developed for safe and secure remote experiment at SPring-8 [1]. For safe and secure remote experiments, we have to take into account 1) radiation safety, 2) other human safety, i.e., human physical safety, and 3) security for access over the Internet.

During a remote experiment, the situation for radiation safety is no different from ordinary experiments at SPring-8; therefore, we do not require special treatment for a remote experiment on radiation safety issues.

If a remote experiment user, who has limited information on the experimental station, operates experiment equipment while SPring-8 staff is accessing the equipment, heavy or high-speed equipment might hurt the staffs. This leads to the issue of human physical safety. To prevent this, we use the fact that when an X-ray beam is introduced into the experimental hutch that covers the equipment to shield users from X-rays in the hutch, the radiation-safety interlock system ensures there are no people in the hutch. We built a local interlock for human physical safety. The local interlock system only permits remote experiments when the hutch is "normally closed," i.e., the hutch is ready for introducing X-rays.

For network security we use Secure Sockets Layer / Transport Layer Security (SSL/TLS) communication with bi-directional authentication (Fig.1). SPring-8 staff issues an authentication certificate including a beamtime ID for the remote experiment and sends it to the remote user by e-mail. The authentication certificate is an electric file locked by a randomly generated password. The password is also sent to the remote user by postal mail. The user who has both the authentication certificate and password can start the communication with the remote experiment connection server at the SPring-8.

The connection server verifies the certificate and passes the messages from the remote user during the beam-time. From the beam-time ID included in the certificate the connection server obtains the allocated beam-time.

The messages exchanged between the remote user and the SPring-8 station control system are formatted as SVOC which is used in the SPring-8 control system "MADOCA." The connection server filters the messages and passes only permitted messages to the station control system.

Copyright © 2011 by the respective authors — cc Creative Commons Attribution 3.0 (CC BY 3.0)

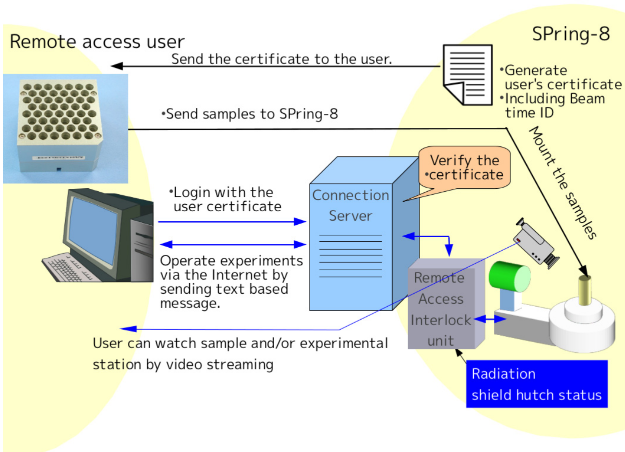

Figure 1: A schematic of the SPring-8 remote experiment system.

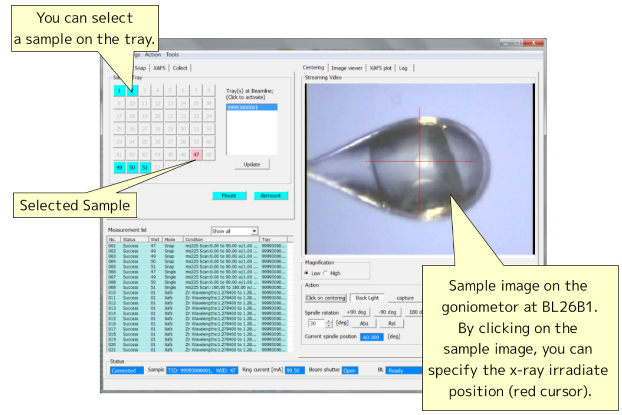

Figure 2: A graphical user interface for the remote user.

PROTEIN CRYSTALLOGRAPHY BEAMLINE BL26B1

In this section we briefly describe the SPring-8 protein crystallography beamline, BL26B1 [2]. The BL26B1 is one of the standardized protein crystallography beamline in SPring-8. The X-ray source is a bending magnet and the beamline optics consist of a double crystal x-ray monochromator, slits, X-ray mirrors. A monochromatized X-ray beam is introduced into the experimental hutch, which encloses the experimental equipment, consisting of X-ray slits, shutters, a goniometer, an X-ray CCD detector, and a sample changer. The sample changer is called SPACE [3].

The beamline and experimental station are highly automated, containing a sample changer. After users set their sample tray, which can contain up to 52 crystals on the sample changer, they can operate all their experiments from the software, called BSS [4], including sample screening, X-ray absorption spectra measurement, and automatically obtaining diffraction data.

Collected data are stored at a common data storage location for the protein crystallography beamlines and users can access their data via the Internet on the Web-based data distribution system called DCha [5].

Crystal growth becomes difficult as protein crystallography advances; therefore crystals become smaller and heterogeneous. It becomes important that the researcher who has grown the crystal specify the X-ray irradiated position for obtaining data because selection of the X-ray irradiated position determines data quality.

We focused on how a remote user can specify the X-ray irradiated position for the sample in a remote experiment. As shown in Fig.2, users select a sample number and SPACE mounts the selected sample. The sample image is then displayed on the remote user's GUI using a video streaming system, as shown at the top left on Fig.2.

By clicking on the video image, the remote user can specify the X-ray irradiated position. After taking several diffraction images, the user decides whether the sample quality is good enough for obtaining data. After the user sets the parameters for obtaining data, including the judgement of sample quality and the X-ray irradiated position, BSS starts automatic data collection. After all the data has been collected, the remote user can obtain the collected data using DCha.

FIRST OPERATION OF THE REMOTE EXPERIMENT

The first operation was made from RIKEN Wako campus, which is located 480 km from SPring-8 as shown in Fig.3. SPring-8 and RIKEN's Wako campus were connected to SINET-3 [6], which was the Japanese academic Internet backbone with 40-Gbps bandwidth[1]. RIKEN Wako campus was connected to SINET-3 at 10-Gbps bandwidht, and SPring-8 was connected to SINET-3 at 1-Gbps bandwidth.

The first experiment was successful and all the functions required for the remote experiment mostly worked well. The video streaming went down several times but this was later improved by upgrading ffserver and ffmpeg, which were used for the video streaming.

Latency from clicking on the video image to sample motion was less than 1 s. This was not dependent on the geometric distance because most of the latency was result of video encoding.

Video streaming was VGA size, 10 fps and streaming data rate was up to 800 kbps. Message exchanging data rate was much smaller than the video streaming data rate.

We confirmed that the quality of the collected data was the same as that of the data collected during an ordinary experiment.

[1]SINET was upgraded SINET-4 in March 2011 and SPring-8 connection bandwidth to the SINET will be increased up to 10 Gbps later.

Copyright © 2011 by the respective authors — cc Creative Commons Attribution 3.0 (CC BY 3.0)

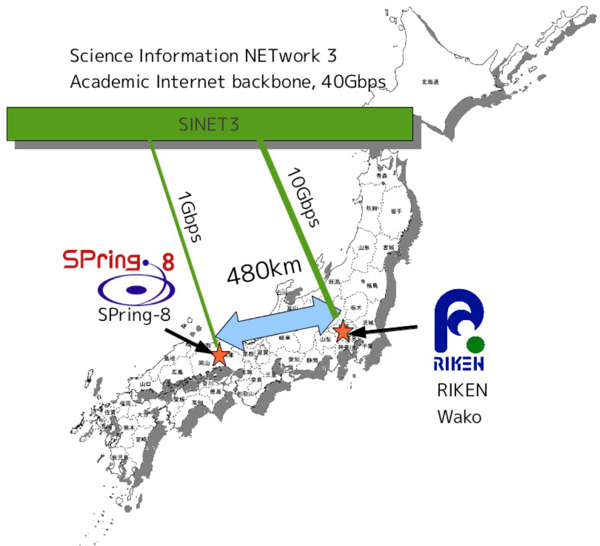

Figure 3: Location of RIKEN Wako campus and SPring-8.

CURRENT STATUS

The remote users interface was improved according to suggestions from the first experiment and opened for public protein crystallography users. We conducted training for the remote protein-crystallography experiment at the end of July 2011. We can now perform remote experiment on six beamlines.

We are now preparing for the first international remote experiment from Taiwan on BL12B2, which was constructed by the National Synchrotron Radiation Research Center (NSRRC) in Taiwan for protein crystallography.

We are also preparing a remote experiment for the another X-ray experiment field, X-ray Absorption Fine Spectra (XAFS) and plan to start testing coming April.

CONCLUSION

The first remote experiment based on the Wide-area Remote Experiment System was successful, and this indicates that the system is not only safe and secure enough but also efficient enough for conducting remote experiments. The SPring-8 remote experiment system will be expanded to include international remote experiments and other X-ray experiment fields.

REFERENCES

[1] Y.Furukawa, K.Hasegawa, D.Maeda, G.Ueno, "Development of remote experiment system", Proc. ICALEPCS 2009(Kobe, Japan) P.615

[2] Ueno G, Kanda H, Hirose R, Ida K, Kumasaka T, Yamamoto M, "RIKEN structural genomics beamlines at the SPring-8; high throughput protein crystallography with automated beamline operation" J Struct Funct Genomics. 2006 Mar;7(1):15-22

[3] Ueno G, Hirose R, Ida K, Kumasaka T, Yamamoto M, "Sample management system for a vast amount of frozen crystals at SPring-8" J Appl. Cryst. 2004 Dec;37(Pt 6):867-873

[4] Ueno G, Kanda H, Kumasaka T, Yamamoto M, "Beamline Scheduling Software: administration software for automatic operation of the RIKEN structural genomics beamlines at SPring-8" J Synchrotron Radiat. 2005 May;12(Pt3):380-4

[5] Okazaki N, Hasegawa K, Ueno G, Murakami H, Kumasaka T, Yamamoto M, "Mail-in data collection at SPring-8 protein crystallography beamlines" J.Synchrotron Radiat. 2008; 15:288-291

[6] http://www.sinet.ad.jp

[7] http://www.srrc.gov.tw

Copyright © 2011 by the respective authors — cc Creative Commons Attribution 3.0 (CC BY 3.0)