PROGRESS OF THE VIRTUAL LABORATORY FOR FUSION RESEARCHES IN JAPAN*

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Abstract

SNET is a virtual laboratory for nuclear fusion research in Japan, it has been developed since 2001 with SINET3, which is a national academic network operated by National Institute of Informatics. Twenty one sites including major Japanese universities, Japan Atomic Energy Agency and National Institute for Fusion Science (NIFS) are mutually connected on SNET with the speed of 1 Gbps in 2008 fiscal year. The SNET is a closed network based on L2/L3VPN. Collaboration categories in SNET are as follows: the LHD remote participation; the remote use of supercomputer system; the all Japan Spherical Tokamak (ST) research program. ITER activity has started in 2007 and "The International Fusion Energy Research Centre" will be constructed at the Rokkasho village in Japan under ITER-BA agreement. One of the key to realize the international virtual laboratory is the high-speed data transfer. To reveal the problem, the data transfer experiment between Japan and France has performed on June 2009 and September 2009. On the latter case, a file of 86 GB was sent in 205 sec (3.3 Gbps) through the network limited to 4 Gbps. On the basis of the above, SNET would be useful for distributing the data of ITER to Japanese universities and institutions.

INTRODUCTION

The information network was begun to realize the remote use of the supercomputer and it has made the remote participation of the experiment equipments into a reality in recent years. On the ordinary experiment the equipment and its control room are located in the same site; on the remote participation the location of the user who controls the device is far from the experimental equipment. The participants in the big project are scattered throughout the nation. The researcher at the remote site cannot directly handle the controlled device and cannot communicate each other, face-to-face, or the great cost is needed for the move directly to do that. The research is not as smooth as the local experiment.

The information technology (IT) resolves those problems, "the virtual laboratory". Growing Internet has made our daily-life convenient and it is easy to use the applications such as e-mail client and web browser. However, the adequate configuration and technique are needed on the virtual laboratory. The required techniques are the high-speed transport of the massive data on the long distance, and the firm computer security.

In this paper, we describe the configuration of SNET, which is the virtual laboratory for fusion research in Japan [1], and the high-speed data transfer include the data transfer experimental between Japan and France.

VIRTUAL LABORATORY

The virtual laboratory is a system which supposes the remote research activities with the advantages of IT. The backgrounds of the recent research activities are listed as below;

- The concentration of the fusion experimental device and the supercomputer, due to the high cost by the improvement for the high performance.

- The increase of data from the measurement device with high spatial and time resolution. The volume of the raw data calculating the supercomputer is rapidly raised with its performance improvement, too.

- Larger project, more collaborators. They might reside around the nation, around the world.

- Growth of the risk of the computer security, such as computer viruses and the information theft.

The advantages of IT are listed as below;

- The bandwidth of the national wide area network (WAN) grews up to over 10 Gbps.

- The virtual private network (VPN) technology on WAN has been established and it makes dedicated lines in the public network. VPN network is the closed network native to the high security.

The research collaboration in NIFS is very active . The number of staff of NIFS is about 250 and the number of the collaborator is over 1,200 around the world. Large Helical Device (LHD) at NIFS is the largest superconducting helical machine for plasma confinement experiments [2]. NIFS has also an attractive supercomputer for researching the plasma science [3].

On the other hand, an academic national wide network in Japan was Science Information Network (SINET). SINET had been provided by National Institute of Informatics

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(NII), and each site connected to SINET with the bandwidth of 100 Mbps. On January 2002, SuperSINET was started to connect the leading research universities and institutes with the bandwidth of 1 Gbps and its backbone was 10 Gbps. SuperSINET was able to connect to the edge nodes by L3VPN, Multi-Protocol Label Switching (MPLS-VPN). On July 2007, SINET3, which is integrated SINET and SuperSINET, has started its operation [4]. The bandwidth of backbone is up to 40 Gbps and the number of the edge node of SINET3 has increased to more than 60. SINET3 newly provides L1/L2 VPN service, multicast service and so on.

PROGRESS OF SNET

Beginning of SNET

Just as SuperSINET was begun, the activity of SNET was started with NIFS and three universities. The first category of the SNET is "LHD experiment remote participation" [5]. Each university has connected to SNET with the bandwidth of 1 Gbps and LHD network has now connect to SNET with the bandwidth of 5 Gbps based on L3VPN. Because the SNET is a closed network, no firewall is installed between the remote site network and LHD network on NIFS. For example, the collaborator at Kyushu University controls the ultrashort-pulse reflectometry system which is installed on LHD, adjusts the position of the transmitter and receiver horn antennas from their laboratory room, collects the measurement data, and reconstructs the density profile [6]. The collaborator at Kyoto University also controls the spectrometer system on LHD device and collects CCD data [7]. Their local agency at NIFS adjusts the device only at the start and the end of the experimental campaign.

In financial year (FY) 2005, two categories, "remote use of supercomputer system" and "All Japan Spherical Tokamak (ST) research program" were added to SNET. The former is to use the Plasma Simulator at NIFS. It was NEC SX-8 before March 2009 and it is now Hitachi SR16000 after the replacement. Through SNET, the network of the remote site is connected only to the gateway server for Plasma Simulator, not the supercomputer's network. The researcher at the remote site should first login the gateway, then submits their job to Plasma Simulator or transfers the data between the remote station and the gateway.

"All Japan ST research program" is the interesting category in SNET. Q-shu University Exp. with Steady-State Spherical Tokamak (QUEST), which has started to operate on June 2008 [8], is placed not in NIFS but in Kyushu University. The data acquisition system (DAS) for QUEST does not exist on its site, and the LABCOM data acquisition system [9] in NIFS collects the data of QUEST experiment through SNET. The remote site which belongs to this category can refer the data of QUEST with accessing the LABCOM.

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FY2008 and Now

In FY 2008, GAMMA-10 [10] and High Density Plasma Experiment-I (HYPER-I) experimental device [11] have been added to "All Japan ST research program" category. GAMMA-10 is the liner tandem type of the plasma experimental at Tsukuba University. The measurement data from GAMMA-10 is collected by their own DAS system and the data are sent to LABCOM through SNET for distributing to other sites. HYPER-I at NIFS has the 80 kW microwave for exciting the electron cyclotron wave in the plasma. The remote collaboration of HYPER-I is now the test phase and the researcher at Kyushu University will be soon able to monitor the status of Hyper-I and would discuss the result with his collaborator at NIFS in the near future.

The activities of SNET are summarized in Table 1. Year by year, the number of the remote site has increased. On April 2009, more than 50 researchers has joined in SNET from 21 remote sites which consist of nine universities and one research institute.

HIGH-SPEED DATA TRANSFER

LFN Problem

ITER is a next-generation experimental tokamak reactor and it is a key for realization of the fusion. After the negotiation in 2005, it was decided that ITER reactor would be constructed in France and "the International Fusion Energy Research Centre" (IFERC) would be built in Japan within a framework of ITER Broad Approach (BA). The experimental data which is produced by ITER and the video information at the control room would be sent to the ITER parties.

In the case of Japan, SNET is a good scheme to distribute the massive data of ITER experiment to the related universities and institutes. The collaborator of the remote site could refer the data of ITER with the same method on LHD or QUEST. However, long fat-pipe network (LFN) problem will occur because the distance between Japan and France is so long [12]. If the long network has the bandwidth of 1 Gbps, but the real speed of the file transport does not reach to 1 Gbps without the adequate adjustment. TCP protocol requests the sender waits the the acknowledgment of the received data for error recovery, such as packet loss. If the round trip time (RTT) of the network is so large, the effective throughput is decreased because the waiting time of the sender is increased. To overcome this problem, there are various researches about TCP mechanism. The precious study of the data transfer is discussed in Ref [13].

The domestic wide area network (WAN) is wide enough to be influenced by LFN problem. For example, the file transfer is very slow (under 100 Mbps) between NIFS and Kyushu University; its RTT is about 30 ms. In the case of SNET, the WAN accelerator, Fujitsu WANDIRECTOR A100, has been introduced and it sustains the bandwidth of about 300 Mbps.

Table 1: Summary of SNET Activities

Category	Resource (location)	*Type*	Type of VPN	Number of remote sites
LHD experiment Remote participation	LHD (NIFS)	*Heliotron*	L3VPN	10
		Video (Multicast)	L2VPN	
Remote use of supercomputer system	Plasma Simulator (NIFS)	*Supercomputer*	L3VPN	6
All Japan ST research program	QUEST (kyushu Univ.)	*Spherical Tokamak*	L2/L3VPN	3
	GAMMA-10 (Tsukuba Univ.)	*Tandem mirror*	L3VPN	1
	Hyper-I (NIFS)	*liner plasma device*	L2VPN	1

Data Transfer Experiment

To reveal the LFN problem on the real network, the data transfer experiments between Toki in Japan and Cadarache in France had performed two times in 2009.

The first experiment was performed on July 2009. The servers which located at both ends were connected to 1 GE ports. No special hardware was required to build the server; the server at Cadarache was standard note PC which has 1 GE network interface card (NIC). RTT between Toki and Cadarache is about 320 ms. The path was the shared line, most of the bandwidth of the path was 10 Gbps. Through the experiment, the path was clean, no packet loss was observed. More than 1 TB of data had been transferred in three hours from memory to memory with the technique of avoiding the packet loss. The average throughput was 880 Mbps.

On September 2009, the second experiment has performed. In this case, 10 Gbps lines were used and the target was not only memory-to-memory transportation but also disk-to-disk one. The servers for this experiment were built with the commodity items only; the CPU is Intel Core i7, the memory is DDR3-1333, the file system is SSD RAID and 10 GE NIC is Chelsio S310E. The servers were connected to both the shared line and the dedicated line (L2VPN). The bottleneck of 4 Gbps existed in Europe on the both line. The file of 86 GB has been transferred in 205 seconds between the disk at Toki and the disk at Cadarache through both the shared line and the dedicated line. The average throughput was 3.3 Gbps, which was more than 80 % of the limitation. These experimental results encourage us to prepare the next step of the virtual laboratory.

CONCLUSION

SNET is the national-wide network for the fusion research based on VPN technology operated by NIFS. SNET has been successfully supporting the various activities of fusion research which include both the experiment and the simulation for several years. In the near future, ITER would be a big challenge for the remote participations around the world. To investigate the high-speed data transfer on the real long-fat network, the data transfer experiments were carried out between Toki in Japan and Cadarache in France and those were successfully performed. SNET is the catalyst for the fusion research activity in Japan and continues to contribute to that as the informational logistics.

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