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Configuration of the virtual laboratory for fusion researches in Japan

T. Yamamoto*, Y. Nagayama, H. Nakanishi, S. Ishiguro, S. Takami, K. Tsuda, S. Okamura

National Institute for Fusion Science, National Institutes of Natural Sciences, 322-6 Oroshi, Toki 509-5292, Japan

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ABSTRACT

A virtual laboratory system for nuclear fusion researches in Japan known as SNET run by the National Institute for Fusion Science has been in development for the past seven years. Twenty-one remote sites have participated in SNET, which reached a speed of 1 Gbps in April 2009. The SNET is a closed network system based on L2 and L3VPN provided by SINET3, which is a national academic network operated by the National Institute of Informatics. SNET has been successfully supporting the remote participation of various sizes and types of experimental equipments and has also been supporting the remote use of a supercomputer. In this paper, we describe the configuration of SNET, which is overcoming the challenges that arise in virtual laboratories; we mainly explain the remote participation in the experiment. Remarks about the remote participation regarding the ITER activity, massive data transfer, and GRID are also discussed. A data transfer experiment between Japan and France was performed, with the average throughput reaching 880 Mbps on 1 Gbps of bandwidth.

1. Introduction

Information networks have begun to enable the remote use of supercomputers and have made the remote participation of the experimental equipments a reality in recent years. In an ordinary experiment, the equipment and its control room are located at the same site; in the remote participation the location of the user who controls the device is sited far from the experimental equipment. Participants in a large project can be scattered throughout the country. Researchers at the remote sites cannot directly handle the controlled device and cannot communicate face-to-face because of cost constraints. Such research is thus not as smooth as local experiments because of delays.

Information technology (IT) resolves those problems in the form of virtual laboratory. The growing use of the Internet has made our daily lives convenient, and its applications, such as e-mail clients and web browsers, are easy to use. However, suitable configurations and techniques are needed in the virtual laboratory. Necessary techniques include the high-speed transport of massive data over the long distances and solid computer security.

In this paper, we describe the configuration of SNET, which is the virtual laboratory for fusion research in Japan [1,2]. SNET has been operated by the National Institute for Fusion Science (NIFS) for the past seven years.

2. Outline of SNET

2.1. Virtual laboratory

The virtual laboratory is a system that resolves the requests of recent remote research activities by taking advantage of IT's characteristics. The virtual laboratory includes facilities, equipments, PC clients, and TV conference systems. Requirements for such research activities are as follows:

- The concentration of fusion experimental devices and supercomputers, owing to the high costs incurred by the improvements to enable high performance.
- An increase in data from measurement devices with high spatial and time resolutions. The volume of raw data used by supercomputers in calculations is growing rapidly alongside performance improvements.
- Larger projects, more collaborators. They may reside around the country or around the world.
- Growth in risks surrounding computer security, such as computer viruses and information theft.

The advantages of IT are as follows:

- The bandwidth of the wide area network (WAN) can grow to over 10 Gbps by means of the Ethernet technology.
- Virtual private network (VPN) technology on WAN has been established, which enables dedicated lines in the public network. VPN is a closed network with inherent high security.

* Corresponding author at: National Institutes for Fusion Science, 322-6 Oroshi-cho, Toki-city, Gifu 509-5292, Japan. Tel.: +81 572 58 2553; fax: +81 572 58 2666.
E-mail address: yama@nifs.ac.jp (T. Yamamoto).

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Research collaboration is very active at NIFS. The number of staff at NIFS is about 250, and the number of collaborators around the world is over 1200. The Large Helical Device (LHD) at NIFS is the largest superconducting helical machine for plasma confinement experiments [3]. NIFS also has an attractive supercomputer for research into plasma science [4].

An academic nationwide network in Japan, the Science Information Network (SINET), was provided by the National Institute of Informatics (NII), and each site connected to SINET had a bandwidth of 100 Mbps. SuperSINET was started in January 2002 to connect leading research universities and institutes, with a bandwidth of 1 Gbps having a backbone of 10 Gbps. SuperSINET was able to connect the edge nodes using layer-3 (L3) VPN, Multi-Protocol Label Switching (MPLS-VPN). In July 2007, SINET3, which is an integrated version of SINET and SuperSINET, began operations [5]. The bandwidth of its backbone is up to 40 Gbps and the number of edge nodes of SINET3 has increased to more than 60 sites. SINET3 has recently begun to provide among other services, an layer-1 (L1)/layer-2 (L2) VPN service and a multicast service.

2.2. Progress of SNET

Just as SuperSINET was begun, SNET activity was started with NIFS and three universities. The first category of SNET is “LHD experiment remote participation” [6]. Each university is connected to SNET with a bandwidth of 1 Gbps and the LHD network is now connected to SNET with a bandwidth of 5 Gbps based on L3VPN. Because SNET is a closed network, no firewall is installed between remote site networks and LHD network at NIFS. For example, Collaborators at Kyushu University control the ultrashort-pulse reflectometry system that is installed on the LHD, adjusts the position of the transmitter and receiver horn antennas from their laboratory room, collects the measurement data, and reconstructs the density profile [7]. Collaborators at Kyoto University also control the spectrometer system on the LHD and collects CCD data [8]. Their local agency at NIFS adjusts the device only at the start and end of the experimental period.

In the 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 uses the Plasma Simulator at NIFS; the Plasma Simulator had been NEC SX-8, and it was replaced with Hitachi SR16000 in March 2009. The remote site network is connected only to a gateway server for the Plasma Simulator through SNET. The researcher at the remote site first logs into the gateway, submits his/her job to the Plasma Simulator or transfers the data between the remote station and the gateway.

“All Japan ST research program” is a key category in SNET. Q-shu University Exp. with Steady-State Spherical Tokamak (QUEST), which began operating in June 2008 [9], is located at the Kyushu University. The data acquisition system (DAS) for QUEST is not present onsite, and the LABCOM data acquisition system [10] for the LHD at NIFS collects data from the QUEST experiment through SNET. Remote sites that belong to this category can request the data from QUEST by accessing the LABCOM.

In FY 2008, GAMMA-10 [11] and High Density Plasma Experiment-I (HYPER-I) experimental device [12] were added to the “All Japan ST research program” category. GAMMA-10 is a tandem mirror type of plasma experiment at Tsukuba University. The measurement data from GAMMA-10 are collected by the university’s DAS system, and the data are sent to LABCOM through SNET for distribution to other sites. HYPER-I at NIFS uses an the 80 kW microwave to excite the electron cyclotron waves in the plasma. Remote collaboration of HYPER-I is now in the test phase, and researchers at Kyushu University will soon be able to monitor the status of HYPER-I and discuss the results with collaborators at NIFS in the near future.

2.3. SNET activities and support

SNET activities are summarized in Table 1. Year by year, the number of remote sites has increased, and more than 50 researchers have now joined SNET from 21 remote sites, nine universities, and one research institute (April 2009). Currently, SNET offers various research resources for researchers at the remote sites.

The operation of SNET is supported by a SNET task team. The team connects the new remote sites to SNET with the cooperation of NII and network administrators of the remote sites. They register media access control (MAC) address of each researcher’s PC with the network device of the remote site. These details are described in Section 3.3. To prevent any problems, the team also monitors network conditions.

3. Configuration of SNET

3.1. Physical layer

To add a new remote site to SNET, the network of the collaborators’ laboratory is connected to the edge node device of SINET3. The best method is to use a dedicated line for the connection. This is the most reliable and enables relatively easy troubleshooting. As the distance between the network center and the site of the laboratory is usually more than 100 m, a multi-mode optical fiber is required for 1000BASE-SX (max. 550 m), or a single-mode fiber is required for 1000BASE-LX (max. 5000 m). If the network cable is passed near high-power lines such as an experimental device room, the use of a metal line is prohibited because of electromagnetic induction. The most inexpensive method would be to loan a dedicated line from the university or an institute. However, if such a line does is not available, it is rather expensive to lay down optical fiber and/or metal cable in a campus.

Table 1
Summary of SNET activities.

Category	Resource (location)	*Type* size or spec	Type of VPN	Number of remote sites
LHD experiment remote participation	LHD (NIFS)	*Heliotron* major/minor radius = 3.7/0.64 m *Video*	L3VPN L2VPN (Multicast)	10
Remote use of supercomputer system	Plasma Simulator (NIFS)	*Supercomputer* theoretical speed = 77 TFlops, main memory = 16 TB	L3VPN	6
All Japan ST research program	QUEST (Kyushu Univ.)	*Spherical Tokamak* major/minor radius = 0.64/0.36 m	L2/L3VPN	3
	GAMMA-10 (Tsukuba Univ.)	*Tandem mirror* axial length = 27 m, volume = 180 m^3	L3VPN	1
	Hyper-I (NIFS)	*liner plasma device* diameter/axial length = 0.30/2.00 m	L2VPN	1