Large volumes of data from ITER successfully transferred to Japan at unprecedented speeds

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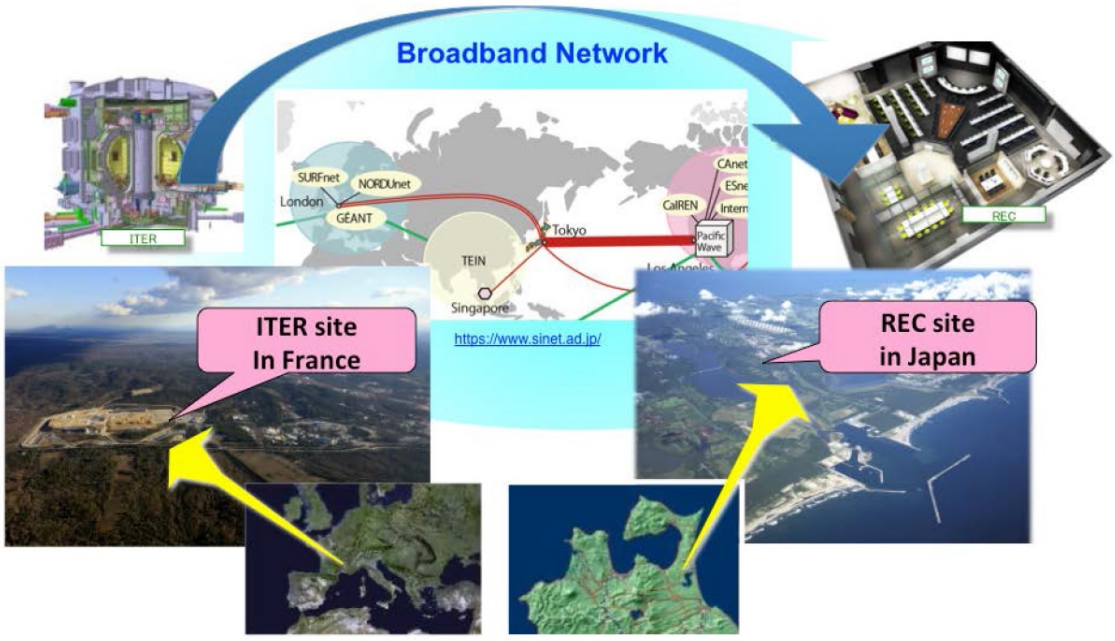


Data were transferred from ITER site in France to REC site in Japan. Credit: Hideya Nakanishi

The National Institutes for Quantum and Radiological Science and Technology (QST), in collaboration with the National Institutes of Natural Sciences (NINS) National Institute for Fusion Science (NIFS),

the National Institute of Information and Communications Technology (NICT) National Institute of Informatics (NII), and the ITER International Fusion Energy Organization (ITER), have connected a dedicated broadband network between one server in ITER and another in the ITER Remote Experiment Centre (REC) in Japan. Using this network they have repeatedly demonstrated the stable high-speed transfer (approximately 7.9 Gbps) of 1TB of data within 30 minutes, the assumed conditions in the initial experiments of ITER. This achievement is the result of a synergetic effect from collaboration in state-of-art information science and technologies and in remote cooperation for nuclear fusion research. These results are a big step towards the construction of the REC in Japan, 10,000km away from ITER. The amount of transferred data of 50TB per day is the world largest level inter-continental high speed data transfer from one site to another site.

The computer network technology of present uses the TCP/IP protocol, especially for the transfer of scientific technical data. In simple terms, with TCP/IP data is sent only after an acknowledgment is received. This means that as the distance increases, the data transfer rate decreases. This problem is solved with Massively Multi-Connection File Transfer Protocol (MMCFTP). Developed by NII, it is one of the world's fastest protocols for international cooperation in cutting-edge science and technology fields. In parallel, the SINET5 network, operated by NII, commenced operations in April of this year. This direct link between Europe and Japan reduces the communication distance between the two. A broadband dedicated link (10 Gbps) between the ITER and the REC site was also constructed. Using this dedicated line and data generated from the LHD device at NIFS, a large amount of experimental data, assumed to be 1 TB in the initial ITER experiments, was successfully transferred to the remote site. By transferring the data and constructing a data mirror site (duplicate site), there is hope that this mirror will help contribute to "big data" analyses in the fusion energy field and as a failsafe against natural disasters, serve as a remote backup.

The results will be presented at the IAEA Fusion Energy Conference in Kyoto from October 17th to 22nd, 2016.

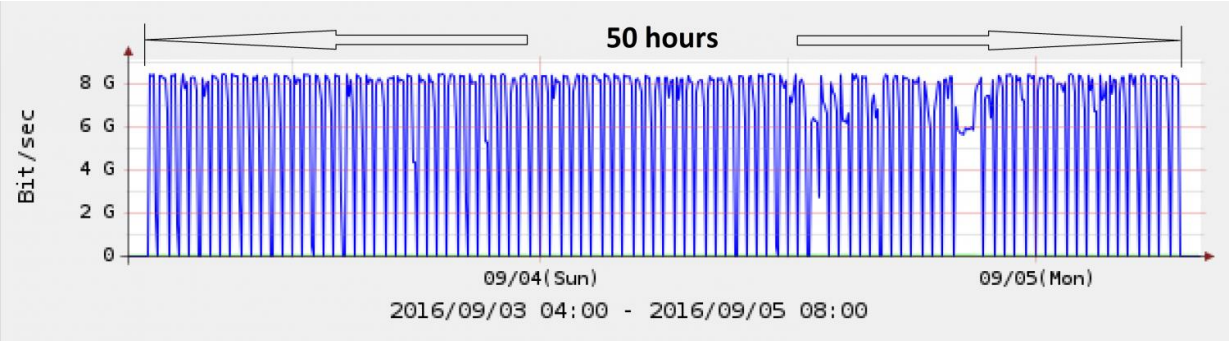
Background and purpose of research development

As part of the BA activities, the ITER Remote Experimentation Centre (REC) is being prepared in Rokkasho, Aomori, Japan (Fig. 1). The REC will be able to participate remotely in experiments at ITER from Rokkasho. In addition, by transferring and storing ITER's experimental data and creating a database locally, it will be possible for researchers around Japan to access the data with a lower latency and analyze the experiments more effectively.

This requires all experiment data from ITER to be transferred to REC in its entirety, however, transfer speed decreases drastically when the transfer distance increases, such as with the distance between EU and Japan, because of the limitations of the TCP/IP protocol and the bandwidth of the network.

NIFS conducted high-speed data tests between ITER and Japan in September 2009, and a transfer speed of up to 3.5 Gbps was maintained for 205 seconds (86 GB of data was transferred). However, this was not enough to transfer the entire amount of data per day generated from the experiments at ITER.

The amount of data generated from each experiment in ITER is massive, and it must be analyzed rapidly between experiments at a pace of about every 30 minutes to an hour. This means the data must be transferred to REC within that timeframe.



Data of 105 TB were transferred repeatedly every 30min at a high speed (average of 7.2 Gbps) from ITER (France) to REC (Japan) for 50 hours. Credit: Hideya Nakanishi

Method and results of research

The 5th generation of the SINET network "SINET 5", developed and operated by NII, is a game changer. A direct link 20 Gbps broadband network between Japan and Europe has been established, and the distance of the network line has become shorter than ever (Fig. 2). In addition, by constructing a dedicated virtual private network (L2VPN) between Rokkasho and ITER, a stable, highly-secure broadband network was created in collaboration with GÉANT, that operates the pan-European network for the research and education community, and RENATER, that operates the national research and education network in France.

Moreover, in order to simulate the experimental data including various data generated in the actual fusion device, these tests used data generated from actual fusion experiments from a real fusion device, the LHD operated by NIFS.

With the TCP/IP protocol, data is only sent after an acknowledgment is

received in order to confirm that each packet being sent is correct. Over long distances, it takes a long time for the confirmation of each sending packet to arrive. As a result, the data transfer speed for large amounts of data decreases drastically. Massively Multi-Connection File Transfer Protocol (MMCFTP), developed by NII for transferring big data in the interest of international cooperation of science and technology, is one of the world's fastest protocols for transferring data over long distances. In MMCFTP, the high-speed data transfer of massive amounts of data is done by splitting the data file, creating multiple connections simultaneously, and balancing the amount that is sent over each connection to keep a steady speed. MMCFTP was adopted for the nuclear fusion field so the full capability of the network connection could be exercised. As a result, the entire amount of data estimated to be generated in the initial experiments at ITER (1TB) can be transferred within the limited time window between experiments.

By connecting the servers in ITER and REC with a dedicated broadband network, the massive amount of data, around 1.05 TB, can be transferred every 30 minutes at high speed (7.9 Gbps at maximum and 7.2 Gbps at average measured from the ITER side server) for 50 hours. This is the first time that the total amount of data estimated to be generated at ITER per day, around 50 TB, was successfully transferred. (Fig. 3). These results are a big step towards the construction of the REC in Japan.

This achievement shows that the data estimated to be generated in the initial experiments in ITER (1TB per experiment) can be transferred in their entirety to the REC in under 30 minutes, which is consistent with the estimated interval between experiments of about 30 minutes to an hour. Further development of this technology will allow the massive amounts of data expected to be produced when ITER is in full operation (about 50 TB per experiment).

The massive amount of data obtained from experiments in ITER will

become an important database. By transferring the data and constructing a data mirror site (duplicate site), there is hope that this mirror will help contribute to "big data" analyses in the fusion energy field and as a failsafe against natural disasters, serve as a remote backup.

Provided by National Institutes of Natural Sciences