§33. Fast Data Transfer to the LHD Off-site Data Archiving for Disaster Safety

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As shown in Fig. 1, the amount of the LHD physics data continues growing almost exponentially which fits well the famous Moore's law; 10 times growth in about 5 years. In the 17th annual campaign in 2013, it has renewed the world record of total data amount of 891.6 GB for a 40 min long pulse experiment. Nowadays, total storage capacity for the LHD is about 1 PB.

Since the LHD data amount grows very constantly, we have to consider the disaster safety more seriously. Even though we always stores at least three copies of the whole data with some redundancy, it is not enough safe against a big natural calamity destroying the buildings of the site. One of the possible measures will be to have an off-site data replica at the place being at least several hundred kilometers distant from the NIFS/LHD Toki site.

On the other hand, the Japanese academic internet infrastructure SINET has been upgraded to have 100 Gbps full meshed backbones since April 2016. The US oversea link is also upgraded as 100 Gbps, and a new EU link has been additionally established with 20 Gbps. To fully utilize the benefits of new SINET5, it is also required for the network users to innovate the application technology ceaselessly.

We has been continuing the technical verification on high-performance long distance data transfer methods for several years. It is because standard TCP/IP has a problem in high-bandwidth, high-latency data transfer, which is well known as "long fat pipe network (LFN)" problem. One of the effective solutions is the packet pacing which tunes the inter-packet gap (IPG) timing just below the effective bandwidth at every moment [1].

Collaborating with National Institute for Informatics (NII) and JAEA, we also test and verify another method for the recent several years. It is named as massively multi-connection file transfer protocol (MMCFTP) [2] developed by NII.

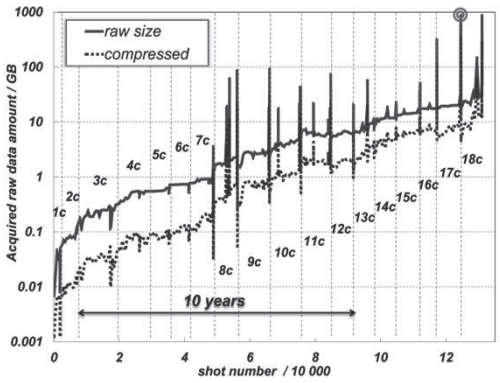

Fig. 1. Continuous data growth observed in LHD: Its exponential growth fits the Moore's law, *i.e.* 100 times in 10 years. Every Upper spike means the long pulse experiments, and the highest peak (double circled) corresponds to the world record of 891.6 GB/pulse.

In addition to R&D on the data transfer methods, we also examine the difference of network layers. The popular Internet communications are done through the Layer-3 connections; however, the virtual private network (VPN) technology gradually gets more and more popular these days. Especially, Layer-2 VPN (L2VPN) can connect even far long distant end points with a single Ethernet segment which is quite suitable for the dedicated use such as remote replication of massive data archive.

Actual verification tests between NIFS Toki and IFERC Rokkasho sites, MMCFTP has achieved over 8 Gbps effective speed by using SINET L2VPN [3], as shown in Fig. 2. For the next step, we plan to make a verification test for the LHD data replication to the far distant place, such as IFERC Rokkasho site.

1) T. Yamamoto, M. Emoto, H. Nakanishi, J. Plasma Fusion Res. **89**, 7 (2013) 474–478.
2) K. Yamanaka, S. Urushidani, H. Nakanishi, *et al.*, Fusion Eng. Des. **89**, 5 (2014) 770–774.
3) Nakanishi, H., Yamanaka, K., *et al.*; "Test and Verification of Fast Data Transfer methods for ITER-REC", 32nd JSPF Annual Meeting, 24–27 Nov. 2015, Nagoya, Japan (2015) 24pD51P.

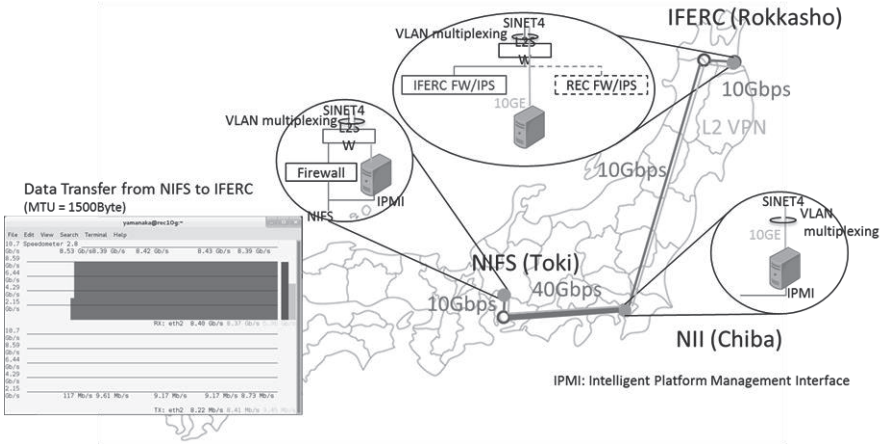

Fig. 2. High speed data transfer tests have been made through the 10 Gbps L2-VPN on SINET4 and 5 established between NIFS, NII, and IFERC REC sites. More than 8.5 Gbps effective throughput have been successfully achieved which is far beyond the Internet L3 communications passing through the firewall.