A data Grid testbed environment in Gigabit WAN with HPSS

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For data analysis of large-scale experiments such as LHC Atlas and other Japanese high energy and nuclear physics projects, we have constructed a Grid test bed at ICEPP and KEK. These institutes are connected to national scientific gigabit network backbone called SuperSINET. In our test bed, we have installed NorduGrid middleware based on Globus, and connected 120TB HPSS at KEK as a large scale data store. Atlas simulation data at ICEPP has been transferred and accessed using SuperSINET. We have tested various performances and characteristics of HPSS through this high speed WAN. The measurement includes data access performance comparison between connections with low latency LAN and long distant WAN.

1. Introduction

For the Atlas Japan collaboration, International Center for Elementary Particle Physics, University of Tokyo (ICEPP) will build a “Tier-1” regional center and High Energy Accelerator Research Organization (KEK) will build a “Tier-2” regional center for the Atlas experiment of the Large Hadron Collider (LHC) project at CERN. The two institutes are connected by the SuperSINET which is an ultrahigh-speed network for Japanese academic researches. On the network a Grid test bed was constructed to study requisite functionality and performance issues for the tiered regional centers.

High Performance Storage System (HPSS) with high density digital tape libraries could be a key component to handle petabytes of data produced by Atlas experiment and to share such data among the regional collaborators. HPSS parallel and concurrency data transfer mechanisms, which support disk, tape and tape libraries, are effective and scalable to support huge data storage. This paper describes about integration of HPSS into a Grid architecture and the performance measurement of HPSS in use over a high-speed WAN.

2. Test bed system

The computer resources for the test bed were installed in ICEPP and KEK site. One Grid server in each site and HPSS servers in KEK were connected with 1-Gbps Ethernet through the SuperSINET. All resources including network were isolated from other users and dedicated for the test. Figure 1 and Table I shows our hardware setup.

Three storage system components were employed. A disk storage server shared its host with the Grid server each at KEK and ICEPP. The remaining HPSS software components were used in the KEK Central Computer system. The HPSS data flow is depicted in Fig. 2. The HPSS Servers including core servers, disk movers, and tape movers are tightly coupled by an IBM SP2 cluster network switch.

In the case of original pftp(parallel ftp with Kerberos authentication) server performance measurement, pftpd was run in the core HPSS server. In the case of GSI-enabled HPSS server which will be mentioned in the section 4, pftpd was run in the same processors with the disk mover. The disk movers were directly connected to the test bed LAN through their network interface cards. Two HPSS disk movers were dedicated to the test.

NorduGrid middleware ran on the Grid servers. Other computing elements (CE) acted as a Portable Batch System (PBS) [1] that was not required to install with the NorduGrid middleware.

The NorduGrid[5] is a pioneer Grid project in Scandinavia that added upper layer functionality, which is necessary to HEP computing, on the Globus tool kit. The middleware was simple to understand and offered functionality sufficient for our test bed study.

Table II shows the versions of middleware used in the test bed.

3. HPSS performance over high-speed WAN

3.1. Basic network performance

Before end-to-end measurement, basic Gigabit Ethernet performance between IBM HPSS servers and a
host at ICEPP through the WAN as well as a host on the KEK LAN was measured using netperf. It is shown in Figure 3 as a function of the TCP buffer size of the client. Round Trip Time (RTT) averaged was 3 to 4 ms. The network quality of service was quite good and almost free from packet loss ($< 0.1\%$). In this measurement, maximum TCP window size in HPSS server had 256kB (the buffer size of 256kB optimized to IBM SP2 switching network). The clients at both KEK and ICEPP had 64MB. Due to rather slower clock-speed processors on the HPSS servers the maximum raw TCP transfer performance was limited below 1Gbps. As seen in the graph, network access performance through both LAN and WAN became almost equivalent and saturated beyond 0.5MB buffer size.

Figure 4 shows the network performance with the number of simultaneous transfer sessions through the WAN. In the situation where TCP buffer size was 100KB, up to 4 parallel simultaneous stream sessions improved network throughput. Using greater buffer size than 1MB, multiple stream sessions did not improve the aggregate network transfer speed.

### 3.2. HPSS client API performance

Figure 5 shows data transfer speed by using the HPSS client API and comparison between access from LAN and over WAN. The transfer was from/to the disk of HPSS disk-mover disk to/from client host memory. The transferred file size was 2GB in all case. Disk access speed in the disk mover was 80MB/s.
It shows that even with a larger API buffer size in the client API, WAN access speed was about a half of LAN access both for reading and writing from/to HPSS server.

To increase HPSS WAN performance in future tests, the newer pdata protocol provided in HPSS 4.3 can be employed. This will improve pget performance. To get the same effect on pputs, the pdata-push protocol provided in HPSS 5.1 is required.

The existing mover and pdata protocols are driven by the HPSS mover with the mover requesting each data packet by sending a pdata header to the client mover. The client mover then sends the data. This exchange creates latency on a WAN. The pdata-push protocol allows the client mover to determine the HPSS movers that will be the target of all data packets when the data transfer is set up. This protocol eliminates the pdata header interchange and allows the client to just flush data buffers to the appropriate mover. The result is that the data is streamed to the HPSS mover by TCP at whatever rates it can be delivered by the client side mover and written to the HPSS mover devices.

3.3. pftp client - pftpd server transfer speed

Figure 6 shows data transfer speed by using HPSS pftp from HPSS disk mover to client /dev/null dummy device. Again as in the previous HPSS client API transfer, even with a pftp buffer size of 64MB, access speed from WAN was about a half of LAN access. In addition, enabling single file transfer with multiple TCP stream by using the pftp ‘pwidth’ option was not effective in our situation. In our server layout, two disk mover hosts each had two RAID disks. Therefore, up to 4 concurrent file transfers could effect higher network utilization and overall throughput, and was so seen in WAN and LAN access case. In the same figure (Fig. 6) data transfer speed was shown from HPSS disk mover to the client disks which had writing performance of 35-45MB/s. Though disks both in server and client hosts had the access speed exceeding 30MB/s and also network transfer speed exceeded 80MB/s, overall transfer speed dropped to 20MB/s. It is because these three resources were not accessed in parallel but in series.

Figure 7 shows elapsed time for accessing data in tape library. Thanks to HPSS functionality and an adequate number of tape movers and tape drives, the data I/O throughput scaled with the number of concurrent file transfers. However, since the library had only two accessors and could load up to two tape cassettes to drives simultaneously, in the case where data in more than three off-drive tapes is required to access, the throughput goes down.

Comparison of writing to HPSS disk mover from client over WAN and LAN is shown in Fig. 8. In the figure, ‘N files → N files’, for example, means that ‘reading’ N files simultaneously at client and ‘writing’ N files to the server. In our setup, HPSS server had 4 independent disks but client had only one. Reading multiple files in parallel from a single disk at client side degrades the aggregate performance by contention of disk heads.
4. GSI-enabled pftp

GridFTP[^3] is a standard protocol for building data GRID and supports the features of Grid Security Infrastructure (GSI), multiple data channels for parallel transfers, partial file transfers, third-party transfer and reusable and authenticated data channels.

The pftp and ftp provided with HPSS software was not required or designed to support data grid infrastructure. For future releases, HPSS Collaboration Members have introduced data Grid pftp requirements and the HPSS Technical Committee (TC) has convened a Grid Working Group to propose a development plan. As an interim and partial HPSS data Grid interface solution, the HPSS Collaboration is distributing the GSI-enabled pftp developed by Lawrence Berkeley National Laboratory (LBL). The HPSS TC is also working with the GridFTP development project underway at Argonne National Laboratory.

To acquire an HPSS data Grid interface necessary for our test bed, we requested and received a copy of the latest version of GSI-enabled pftp. The protocol itself is pftp but it supports GSI-enabled AUTH and ADAT ftp-command.

Table III shows commands in each FTP protocol. While GSI-enabled pftp and GridFTP have different command set for parallel transfer, buffer management and Data Channel Authentication (DCA), the base command set is common. Fortunately unique functions of each protocol are optional and the two protocols are able to communicate. Installing and testing the GSI-enabled pftp, we proved that the GSI-enabled pftp daemon from LBL could be successfully accessed from gsincftp and globus-url-copy with no dcau option (standard globus client utilities). From NorduGrid, the server was accessible as well. The below is a sample XRSL (Extended Resource Specification Language) which utilize GSI-enabled pftp server as a storage element (SE) of the NorduGrid.

A sample XRSL

```bash
&{(executable=gsim1)
(arguments='-d'')
(inputfiles="Bdata.in" "gsi://protelv://width0pt//protelv//hreft://ftp://dt05s.cc:281"
(stdout=datafiles.out)
(join=true)
(maxcpus="36000")
(middleware="nordugrid")
(jobname="HPSS access test")
(stdlog="grid_debug")% (ftpThreads=1)
```

In the performance measurement with 2GB file being accessed from 'pftp client', GSI-enabled pftp server and normal kerberos pftp server had equivalent elapsed data transfer time in any situation. Accessing from 'Grid-FTP client', GSI-enabled pftp server and normal pftp server, as well, had equivalent transfer time in usual. However, in the case where multiple disk movers were utilized and accessed data and GSI enabled-pftpd server resided in separated disk movers, transfer speed was halved. Figure 9 shows aggregate transfer speed over the number of independent simultaneous file transfer and shows the situation. After investigating the detailed communication between client and server, we found the difference behaviour of the two servers. In original pftp where pftpd running in HPSS core server, data path is directly established between pftp client and disk mover. On the other hand, GSI-enabled pftp, data flow was from disk mover, via pftpd to client host. When the disk mover and pftpd server do not reside in the same host, two successive network transfer are incurred.
Table III Commands in FTP protocol

| GridFTP               | GSI-enabled pftp          |
|----------------------|---------------------------|
| SPAS,SPOR,ETET       | PBSZ,PCLO,PORPN,         |
| ESTO,SBUF,DCAU       | PPOR,PROT,PRTR,PSTO      |
| AUTH,ADAT            |                           |
| RFC959 commands      |                           |

Data access performance was measured with several system configurations in comparison between LAN and WAN access. From that, we found that network latency affected data transfer speed with HPSS pftp and client API. The “GSI-enabled pftp” developed by LBL was successfully adapted to the interface between Grid infrastructure and HPSS.

Our paper is a report on work-in-progress. Final results require that the questions relative to raw TCP performance, server/client protocol traffic, and pftp a protocol be further evaluated; that any necessary modifications or parametric changes be acquired form our HPSS team members; and that measurements be taken again. Further understanding of the scalability and the limitation of multi-disk mover configurations would be gained by measuring HPSS network utilization and performance using higher performance network interfaces adapters, system software and infrastructure, and processor configurations.

5. Summary

ICEPP and KEK configured NorduGrid test bed with HPSS storage server over high speed GbE WAN.

References

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2. [http://www.netperf.org](http://www.netperf.org)
3. [http://www.globus.org/datagrid/gridftp.html](http://www.globus.org/datagrid/gridftp.html)
4. [http://www.sdsc.edu/hpss/](http://www.sdsc.edu/hpss/)
5. [http://www.nordugrid.org](http://www.nordugrid.org) You can find NorduGrid papers in this proceedings too.
6. S.Yashiro et. al., “Data transfer using buffered I/O API with HPSS”, CHEP’01, Beijing, Jul.2001
Client disk speed @ KEK = 48MB/s
Client disk speed @ ICEPP = 33MB/s

Aggregate Transfer speed (MB/s)

- KEK client
- ICEPP client

TCP buffer = 64MB

# of file transfer in parallel

Client disk speed to /dev/null
Client disk speed to client disk

pftpd → pftp HPSS mover disk →