NASA

Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Scalability Analysis and Use of Compression		5. Report Date 6. Performing Organization Code
7. Author(s) Daniel A. Menasce		8. Performing Organization Report No. 10. Work Unit No.
9. Performing Organization Name and Address George Mason University 4400 University Drive Fairfax, Virginia 22030-4444		11. Contract or Grant No. NAS5-32337 USRA subcontract No. 555-72-55
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, DC 20546-0001 NASA Goddard Space Flight Center Greenbelt, MD 20771		13. Type of Report and Period Covered Final December 1996 - August 1998 14. Sponsoring Agency Code

15. Supplementary Notes

This work was performed under a subcontract issued by
Universities Space Research Association
10227 Wincopin Circle, Suite 212
Columbia, MD 21044

Task 72

16. Abstract

The goal of this task is to analyze the performance of single and multiple FTP transfer between SCF's and the Goddard DAAC. We developed an analytic model to compute the performance of FTP sessions as a function of various key parameters, implemented the model as a program called FTP Analyzer, and carried out validations with real data obtained by running single and multiple FTP transfer between GSFC and the Miami SCF.

The input parameters to the model include the mix to FTP sessions (scenario), and for each FTP session, the file size. The network parameters include the round trip time, packet loss rate, the limiting bandwidth of the network connecting the SCF to a DAAC, TCP's basic timeout, TCP's Maximum Segment Size, and TCP's Maximum Receiver's Window Size.

The modeling approach used consisted of modeling TCP's overall throughput, computing TCP's delay per FTP transfer, and then solving a queuing network model that includes the FTP clients and servers.

17. Key Words (Suggested by Author(s))		18. Distribution Statement	
FTP and TCP		Unclassified--Unlimited	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 1	22. Price

NASA Form 1626 Oct 86

Scalability Analysis and Use of Compression at the Goddard DAAC and End-to-End MODIS Transfers

Daniel A. Menascé

During this reporting period, the work of the consultant was divided into the following two tasks: 1) Scalability Analysis of ECS's Data Server (DS) and a Cost/Analysis of the Use of Compression and 2) Analysis of End-to-End MODIS Transfers.

Task 1: Scalability Analysis of ECS's Data Server (DS) and a Cost/Analysis of the Use of Compression

This task comprises a scalability analysis on the use of compression using the sz (science zip) compression algorithm, developed by Pen-Shu Yeh, at the Data Server of the Goddard DAAC. The scalability analysis was carried out using the queuing-network based model developed by the consultant. Three types of compression parameters were obtained to carry out the analysis of the various compression scenarios: compression ratio defined as the ratio between the compressed and the original file, compression time, and decompression time. Compression ratios were obtained from real sensor data. Compression and decompression times were obtained by using both real sensor data and simulated MODIS data. The values obtained in the measurements were averaged in two different categories: level 1 data and levels 2-4 data.

Two compression scenarios were analyzed:

SZDC: use of SZ compression for ingest and distribution of data in compressed form.

SZUD: use of SZ compression for ingest and uncompression before distribution. Uncompression in this case is done by the data distribution process.

Figure 1 shows the results for the SZDC case and for two retrieval mixes: 20% large files (20L) and 80% large files (80L). The figure shows three sets of curves, one for each workload: Ingest (ING), Large Retrievals (LR), and Small Retrievals (SR). In each set one can see the results for the 20L and 80L cases. The first observation is that for each workload, the 20L case exhibits a higher response time than the 80L case. We can also see that for each file size mix, response time is higher for ingest, followed by LR, and then SR. Finally, with SZDC the system can easily support a flow of 3400 GB/day.

Figure 2 shows results similar to figure 1, except for the SZUD scenario. The behavior is totally different though. Response time is now higher for LR, followed by ING, and then SR. The results for 20L and 80L are undistinguishable in the graph. Also, the DS saturates at 800 GB/day. This is due to the fact that the data distribution server cannot handle the load of uncompressing the large files.

Since the bottleneck for the SZUD case is the data distribution server, we investigated the effects of using data distribution servers with higher capacity. We considered three cases: i) a data distribution server with a twice as fast CPU (2x case), ii) a data distribution server with two CPUs and each of them being twice as fast as the original CPU (2x 2cpu case), and iii) a data distribution server with four CPUs and each of them being twice as fast as the original CPU (4x 2cpu case). The results are shown in Figure 3.

As it can be seen in Figure 3, the 2x case not only decreases the response time but also extends saturation from 800 to 1200 GB/day. The 2x 2cpu case extends saturation to 2000 GB/day. The 4x 2cpu scenario does not show signs of saturation even at 3400 GB/day.

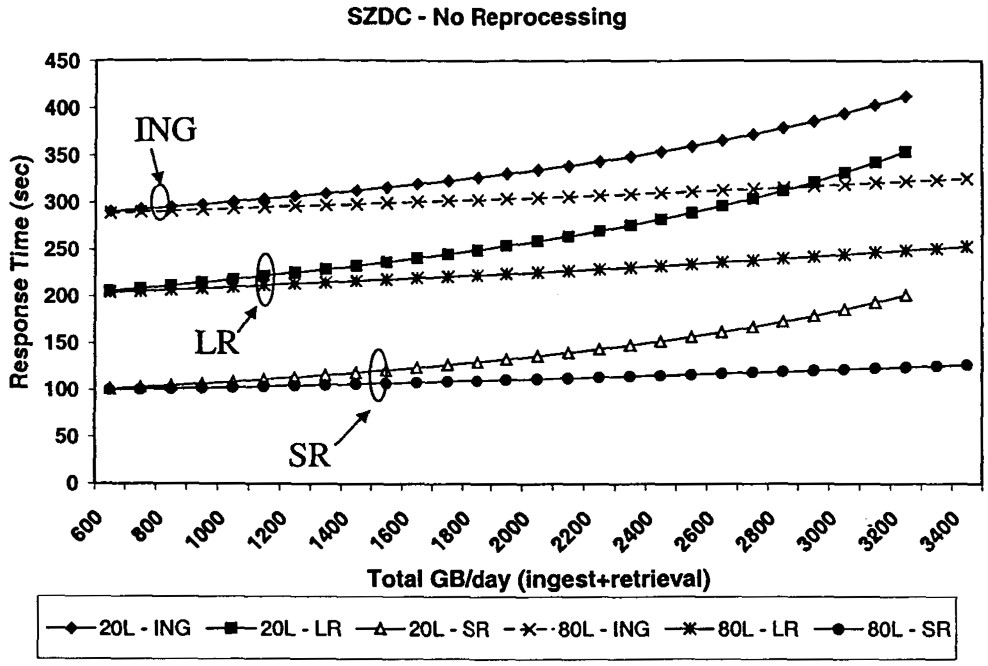

Figure 1 - SZDC with No Reprocessing

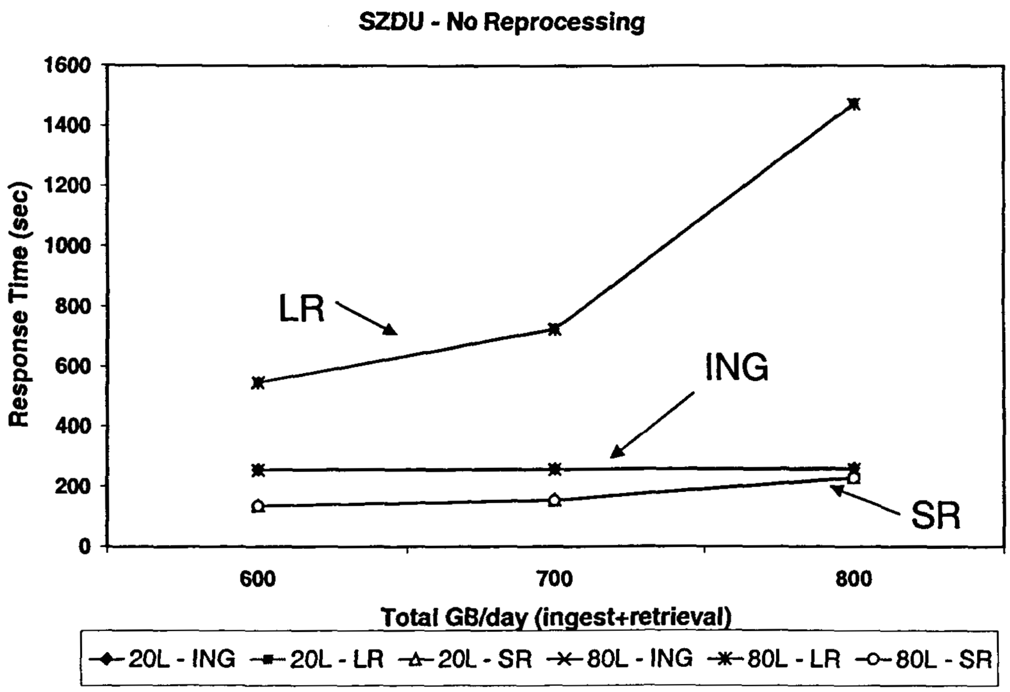

Figure 2 - SZDU - No Reprocessing

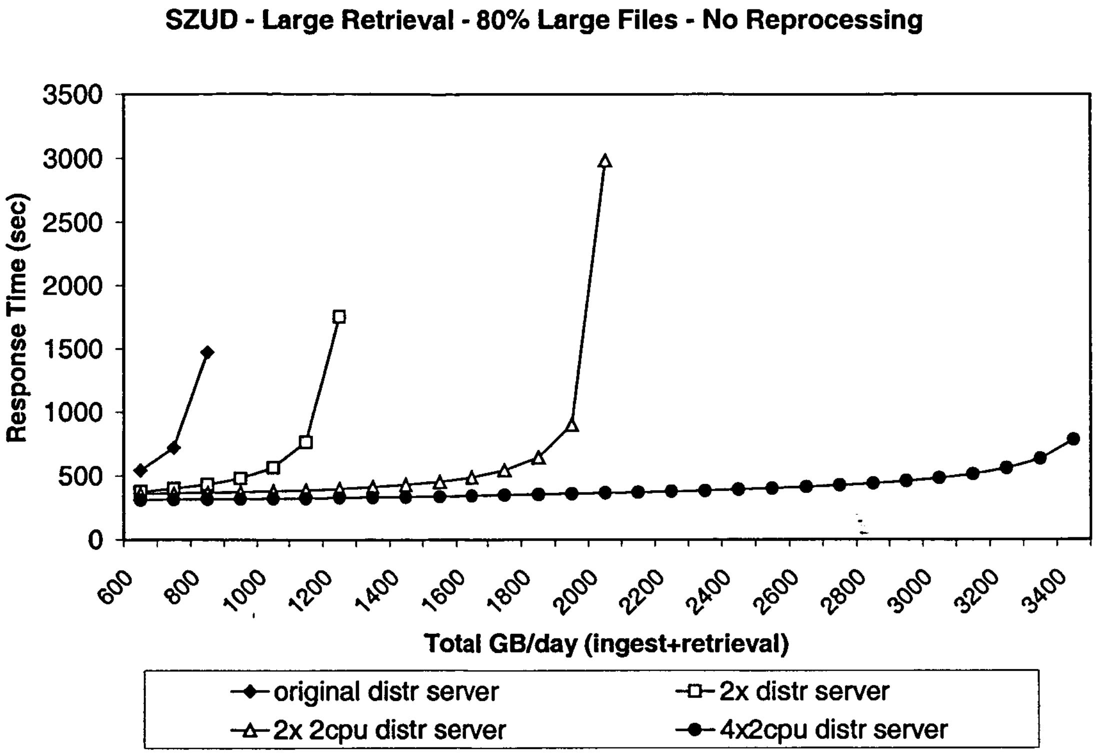

Figure 3 - Response Time for Large Retrieval for the 80L Case and SZUD for Various Data Distribution Server Scenarios

A cost analysis of the use of compression at the Goddard DAAC was carried out. The following assumptions with respect to compression were made: i) tape compression ratio: 1.5:1, ii) level 0 data is compressed by tape compression only, and iii) levels 1+: compressed by SZ but not compressed further by tape compression. The cumulative storage requirements and costs till 2007 are summarized in Table 1. It can be seen that the use of compression saves $1.5 million dollars. If data is distributed in compressed form, the network cost savings amount to $486 thousand dollars.

Table 1 – Cumulative Storage Requirements and Storage Costs.

	level 0	level 1	level 2+	Total
Volumes in TB (no compression)	424	1487	234	2146
Volumes in TB (with SZ compression)	283	577	67	926
Storage Savings TB	141	910	168	1,219
Costs in $K (no sz compression)	$ 786	$ 2,955	$ 493	$ 4,235
Costs in $K (with SZ compression)	$ 786	$ 1,698	$ 209	$ 2,693
Cost Savings in $K	$ -	$ 1,257	$ 284	$ 1,542

If compression is implemented at the Science Processor instead of the Data Server, one additional CPU has to be added to the current configuration assuming that CPUs become faster according to Moore's Law. In the worst case scenario where CPU speed remains constant over the years of the project, four additional CPUs will be needed to handle the extra compression/decompression load. This additional expense is negligible when compared with the cost savings of using compression.

Task 2: End-to-End MODIS Transfer

The goal of this task is to analyze the performance of single and multiple FTP transfers between SCFs and the Goddard DAAC. We developed an analytic model to compute the performance of FTP sessions as a function of various key parameters, implemented the model as a program called FTP Analyzer, and carried out validations with real data obtained by running single and multiple FTP transfers between GSFC and the Miami SCF.

The input parameters to the model include the mix of ftp sessions (scenario), and for each FTP session, the file size. The network parameters include the round trip time, packet loss rate, the limiting bandwidth of the network connecting the SCF to a DAAC, TCP's basic timeout, TCP's Maximum Segment Size, and TCP's Maximum Receiver's Window Size.

The modeling approach used consisted of modeling TCP's overall throughput, computing TCP's delay per FTP transfer, and then solving a queuing network model that includes the FTP clients and servers.

Publications

"Scaling for E-Business: technologies, models, performance, and capacity planning," Menascé and Almeida, Prentice Hall, May 2000, 449 pages.

"Business-oriented Resource Management Policies for E-Commerce Servers," Menascé, Almeida, Fonseca, and Mendes, *Performance Evaluation*, September 2000.

"A Reference Model for Designing a Curriculum for E-commerce," Menascé, *IEEE Concurrency*, March 2000.

"Challenges in Scaling E-Business Sites," Menascé and Almeida, *2000 Computer Measurement Group Conference*, Orlando, FL, December 10-15, 2000.

"Design and Performance Modeling of Component Interconnection Patterns for Distributed Software Architecture," Gomaa and Menascé, *Proc. 2000 Workshop on Software and Performance*, Ottawa, CA, September 17-20, 2000.

"Web Performance Modeling Issues," *International Journal of High-Performance Computing Applications*, Volume 14, Number 4, 2000.

"A Method for Design and Performance Modeling of Client/Server Systems," Menascé and Gomaa, to appear in the *IEEE Transactions on Software Engineering*.

"E-representative: a scalability scheme for e-commerce," Meira Jr., Menascé, Almeida, and Fonseca, *Proc. Second International Workshop on Advanced Issues of E-Commerce and Web-Based Information Systems (WECWIS 2000)*, Milpitas, CA, June 8-9, 2000.

"Peformance of Client/Server Systems," Menascé and Almeida, in ``Performance Evaluation - Origins and Directions," eds. Guenter Haring, Christoph Lindemann, Martin Reiser, LNCS Series of Springer-Verlag, 2000.

"Analytic Modeling of Distributed Hierarchical Mass Storage Systems with Network-Attached Storage Devices," Pentakalos, Menascé, and Yesha, to appear in *IEEE Transactions on Parallel and Distributed Systems.*

"Design and Implementation of a Tool for Measuring the Performance of Complex E-commerce Sites," Paixao, Meira Jr., Almeida, Menascé, and A. M. Pereira, *Tools'2000 Conference*, Chicago, IL, March 2000.

"Planning the Capacity of a Web Server: An Experience Report," Menascé, Peraino, Dinh, and Dinh, *Proc. CMG'99 Conference*, Reno, Nevada, December 1999.

"An Analytical Model of a Bandwidth Allocation Scheme for a Network Service Provider (NSP)," Menascé, Wang, Steele, and Weidman, *Proc. CMG'99 Conference*, Reno, Nevada, December 1999.

"A Methodology for Workload Characterization of E-commerce Sites," Menascé, Almeida, Fonseca, and Mendes, *1999 ACM Conference on Electronic Commerce*, Denver, CO, November, 1999.

"Resource Management Policies for E-commerce Servers," Menascé, Almeida, Fonseca, and Mendes, *Second Workshop on Internet Server Performance*, in conjunction with ACM SIGMETRICS 99/FCRC, Atlanta, GA, May 1st, 1999. Also published in the *ACM Sigmetrics Performance Evaluation Review,* Volume 27, Number 4, March 2000.