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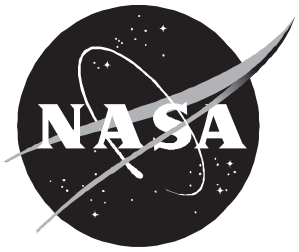

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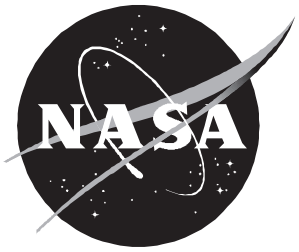

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Electronic Document Distribution: Design of the Anonymous FTP Langley Technical Report Server

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Langley Research Center • Hampton, Virginia 23681-0001

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Nomenclature

ASCII	American Standard Code for Information Interchange
DVI	device independent
FTP	file transfer protocol
HTML	HyperText Markup Language
ICASE	Institute for Computer Applications in Science and Engineering
LaRCNET	Langley Research Center Network
LTRS	Langley Technical Report Server
NAM	NASA Access Mechanism
NCSA	National Center for Supercomputing Applications
NELS	NASA Electronic Library System
PC	personal computer
SGML	Standard Generalized Markup Language
SunOS	SUN Operating System
TCP/IP	Transmission Control Protocol/Internet Protocol
WAIS	Wide Area Information Server
WATERS	Wide Area Technical Report Server
WWW	World Wide Web

Abstract

An experimental electronic dissemination project, the Langley Technical Report Server (LTRS), has been undertaken to determine the feasibility of delivering Langley technical reports directly to the desktops of researchers worldwide. During the first 6 months, over 4700 accesses occurred and over 2400 technical reports were distributed. This usage indicates the high level of interest that researchers have in performing literature searches and retrieving technical reports at their desktops. The initial system was developed with existing resources and technology. The reports are stored as files on an inexpensive UNIX workstation and are accessible over the Internet. This project will serve as a foundation for ongoing projects at other NASA centers that will allow for greater access to NASA technical reports.

1. Introduction

The goal of the Langley Technical Report Server (LTRS) project is to implement a proof-of-concept technical report server accessible from desktops of researchers worldwide. Economics and expediency mandated the use of existing technology and resources. As a result, the technical report server went from conceptual design to production in 5 months.

LTRS currently consists of a desktop UNIX workstation running an anonymous file transfer protocol (FTP) server (ref. 1), a widely used mechanism for transferring files over the Internet (refs. 2 and 3). The technical reports are distributed in PostScript format, a popular page description language from Adobe Systems, Inc. (ref. 4). Full-text searching on the reports is not available, but a Wide Area Information Server (WAIS) provides full-text searching of the report abstracts (ref. 5).

The FTP and WAIS servers are available to anyone with Internet access. These servers can handle many simultaneous users without impacting the workstation's primary use. For example, with LTRS, the workstation's primary use in the development and evaluation of system software was not impacted. This project does not directly address user-interface issues, but work in this area by others should provide additional interface methods (refs. 6 to 9).

This project was conceived in early September 1992. The FTP server first began production in mid-January 1993, and a WAIS server was added in February 1993. Existing tools, resources, and protocols were implemented to produce LTRS, which is currently used by hundreds of researchers worldwide. In addition, the FTP and WAIS servers will easily integrate into other NASA Internet access projects.

This paper discusses the background objectives for LTRS, its design and implementation, its use during the first 6 months, its integration with other developing systems that build upon it, and opportunities for future work.

2. Background

On-line libraries are the focus of many projects in library and information science (refs. 10 to 12). Libraries have vast amounts of information that is valuable only when easily accessed and utilized. A research laboratory's library provides services to experts in a variety of scientific disciplines. These researchers are the best in their fields and define the leading edge of their respective technologies. Thus, to provide the best possible service, the information source that these researchers depend on should be as sophisticated as the systems that they use in their laboratory.

2.1. Meeting Customer Needs

LTRS is an evolutionary step toward desktop document delivery. LTRS is the combination of existing technology and the continual application of new methods that facilitate technology transfer and help an organization maintain its competitive edge. Many library customers at Langley request the ability to perform literature searches in their office and receive the resulting documents at their desk. Before LTRS, Langley library customers typically experienced a wait of 1 to 2 weeks for Langley formal technical reports. Library customers now have the option of acquiring these reports in a few minutes without leaving their office.

2.2. Objectives

LTRS is not intended to replace traditional library services but rather to complement them. Users

who do not want to use the system or who do not have the resources to use the system can still access the current searching and document delivery methods. The goal of LTRS is to provide researchers with easy, familiar, and efficient access to Langley formal technical reports. Providing technical reports electronically is also an opportunity for the library to expand into new service areas and increase its user base. LTRS allows Langley to easily provide information to nonlocal and even nonaerospace researchers.

While anonymous FTP servers have been in use for several years (ref. 2), the information in the Langley FTP server is its distinquishing feature. Many anonymous FTP servers exist, but the information is often of limited use or it simply duplicates information in other servers. The authors believe that LTRS is the first server to provide a significant number of technical reports concerning aerospace science and related disciplines. Anonymous FTP servers of technical reports have generally been maintained by computer science departments of universities or laboratories and have contained only computer science reports and information.

The FTP and WAIS servers are widely accepted and robust mechanisms that require little maintenance. Past the initial start-up costs of creating the servers, distributing a report has no direct cost. The report servers can simultaneously support many users without performance degradation. Users receiving reports are responsible for printing hardcopies or displaying the reports on their terminals. Either way, the integrity of the report is maintained, the library incurs no direct cost in providing the report, and unreasonable search or retrieval demands are not placed on the customer.

3. System Design and Implementation

The following sections details the design and implementation of LTRS. Design issues are discussed for the computer systems used for the servers, the format of the reports, and the addition of WAIS searching. Finally, the current limitations and their impact on these design issues are listed.

3.1. Document Server Implementation

Because a rapid prototype system was planned and no additional resources were available, existing resources were sufficient to create LTRS. These resources included a Sun Microsystems IPX SPARCstation workstation running SunOS 4.1.2, Sun's implementation of UNIX (ref. 1). The workstation is connected to the Internet via LaRCNET, Langley's local network (ref. 13). A workstation of this class and Internet connectivity are all that is required to install an FTP server. (See ref. 14 for instructions for adding anonymous FTP capability to a UNIX workstation.)

An FTP client on any architecture or operating system can access LTRS. (See appendix A.) UNIX was chosen for the implementation of the servers for several reasons. UNIX multiprocessing capabilities allow the machine to support any number of simultaneous FTP and WAIS sessions without severely impacting the local users of the machine.

Both FTP and WAIS are built around the client-server model (ref. 15). A server is a separate entity that provides services to any number of clients who request them. A real-world example would have bankers and grocers as servers and community members as clients. Depending on the service needed, the banker or grocer is chosen and the transaction processed. Figure 1 shows the FTP client-server model where client access can take place over both local and wide-area networks.

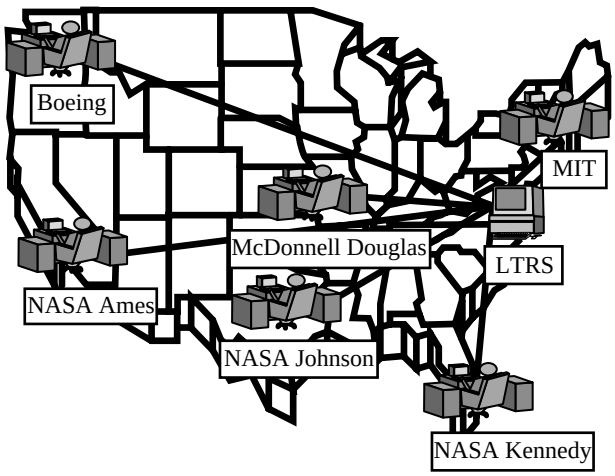

Figure 1. Sample session with LTRS simultaneously serving multiple clients.

Very little computing power is required to support FTP and WAIS servers. Neither of these services have impacted the workstation's capability to perform other computing tasks. The largest impact on the system is the disk space required to store the reports. Fortunately, high-capacity disk drives for workstations are readily available. For example, the current Sun IPX workstation, with 1.5 GB of storage, maintains 151 reports that consume almost 50 MB (fig. 2) and still has sufficient space to support local users. This storage would not be possible if the reports were not compressed. PostScript documents can become very large, especially when they contain

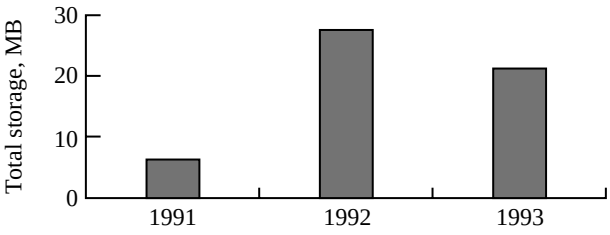

Figure 2. Total storage for technical reports by year.

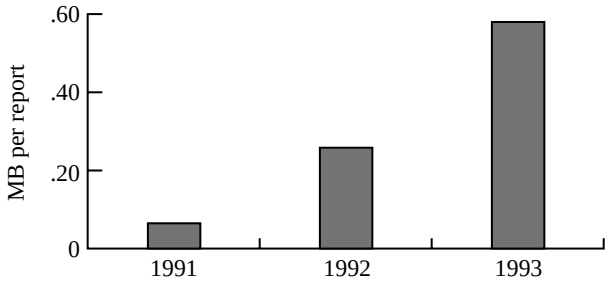

Figure 3. Average size of a single report by year.

graphics. Storage of uncompressed reports would quickly fill the system's disks. However, compression rates of roughly 70 percent are currently achieved and thus greatly reduces the storage requirement. Since the inception of LTRS, the average report size has increased (fig. 3) because more reports include PostScript figures.

3.2. Document Preparation

LTRS would not have been possible without a quality product to distribute. For several years, the Technical Editing Branch (TEB) has been producing Langley's technical reports using TEX, a typesetting system for mathematically oriented manuscripts (refs. 16 and 17). TEB has been storing the TEX source files of the reports in anticipation of the authors needing to reuse them. These TEX source files were assembled into PostScript documents and made available to researchers via anonymous FTP.

Using TEX to create electronically distributable reports can be summarized as a three-step procedure. First, source TEX files were processed into intermediate DVI (device independent) files, the only format TEX processors produce. A typical report could consist of as many as 10 to 15 separate TEX source files. Second, DVI files were converted to PostScript files. Third, the various PostScript files were concatenated in the correct order to produce a single file for each report. This procedure was used for the first 100 reports that were manually converted from TEX to PostScript. The output was checked with the corresponding hard copies to ensure that the integrity of the report was not compromised.

After the initial reports had been reconstructed, TEB agreed to verify and supply all future reports in PostScript directly to the FTP server. Because a PostScript file is produced in the normal publication procedure, little work is required of TEB. To make the report available on the server, the abstract is extracted for WAIS and the report is placed in the appropriate file system for FTP access.

Only PostScript versions of the reports were made available for the following reasons. Maintaining the integrity of the report is the top priority. The size and complexity of a PostScript version of these reports discourage casual alteration of the report. In addition, NASA could not distribute the reports in formats in which improper editing or printing of the file would compromise the quality and validity of the report. Because of the many locally developed TEX macros that are used to prepare the reports, the TEX source files were not suitable for distribution. Furthermore, distributing plain text (ASCII) versions is not feasible because the highly technical nature of the reports requires many equations and tables that cannot be represented in plain text.

3.3. What is Available

Currently, 151 NASA Langley technical formal reports are available: Technical Papers (88 total), Technical Memorandums (58 total), Reference Publications (4 total), and Technical Translations (1 total). All reports are approved for "unclassified, unlimited" distribution and represent Langley's technical output in aerospace science and related fields. The reports currently span 3 years: 1991 reports (10 total), 1992 reports (109 total), and 1993 reports (36 total). Newly published reports are added as they become available. Figure 4 shows the file hierarchy in which the reports are stored. ASCII abstract lists are available by year, and for each report contain the title, author, report number, funding number, and abstract.

3.4. Wide Area Information Server (WAIS)

Because PostScript files are not searchable with traditional text editing tools, the abstracts of the reports are available as ASCII files. Users can retrieve the abstract list and search it by using text editors or other standard utilities (e.g., the UNIX "grep" command).

Although using a text editor to search a list of abstracts was acceptable for the prototype server, a more flexible and sophisticated searching method was

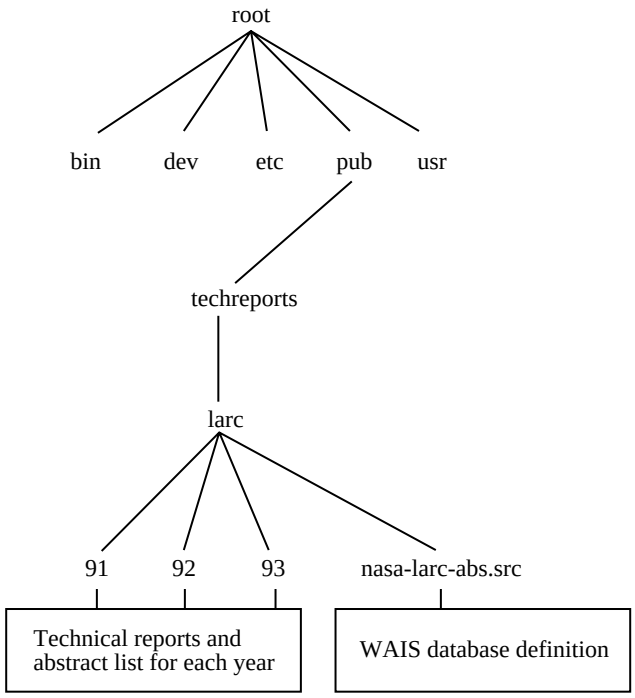

Figure 4. File hierarchy of technical reports on anonymous FTP server (`techreports.larc.nasa.gov`).

clearly needed. WAIS was chosen for searching the abstracts because WAIS is public domain software, is easy to use and maintain, and is increasingly popular (ref. 5).

On February 10, 1993, a WAIS server was added to LTRS to allow keyword searching of abstracts. WAIS provides an easy-to-use interface that is accessible to both local and remote users. Building a WAIS database definition can be easily accomplished by using the indexing program included in the standard release of the WAIS software. Although only the ASCII abstracts were indexed for this project, WAIS can index many non-ASCII formats.

3.5. Current System Limitations

To test these experimental services as quickly as possible, trade-offs were made. When the first author posted a USENET news article (ref. 3) to determine the level of interest in accessing technical reports via anonymous FTP, the response was overwhelmingly in favor of making the service available despite certain limitations. Users wanted access to the reports immediately, and they were willing to have the service undergo refinements while in production. The initial limitations and constraints are discussed in the following sections.

3.5.1. How "automatic" is it? Full automatic desktop document delivery is the goal. Although LTRS makes significant strides toward this goal, it is not fully automatic. That is, the users are still responsible for the successful retrieval, decompression, and printing of the desired report. Figure 5 presents a sample FTP session. While a more automated system is desirable, LTRS is designed to provide only the basic system functionality. Because only widely accepted methods and protocols are used, the current services will serve as a core that other projects can build upon.

```
fiddler%ftp techreports.larc.nasa.gov
Name (techreports.larc.nasa.gov:mln): anonymous
Password: {type your e-mail address here}
ftp> cd pub/techreports/larc/93
ftp> ls -FC
ftp> get README
ftp> get abstracts.93
ftp> binary
ftp> get tp3302.ps.Z
ftp> exit
fiddler% ls
fiddler% uncompress tp3302.ps.Z
fiddler% lpr -Pmyprinter tp3302.ps
fiddler%
```

Figure 5. Sample FTP session transcript.

3.5.2. System implementation constraints. The current implementation of LTRS imposes some limitations. For instance, providing the technical reports in PostScript limits the usefulness of this service for those who do not have access to PostScript previewers or printers. While these resources are common in the scientific computing community, their use is not yet universal.

Because PostScript files can become very large (e.g., several MB) especially if they contain figures, disk storage becomes an issue. For LTRS, the UNIX utility "compress" was used to reduce the storage required for the reports. The utility "uncompress" is needed by the user to restore the reports to PostScript format after they have been retrieved. Although UNIX systems have the uncompress utility, it may not be available on some non-UNIX systems. However, public domain versions of uncompression utilities exist for IBM PC and clones, Apple, Macintosh, and DEC VMS platforms. (See appendix B.) In addition to the storage benefit realized at Langley by compressing the reports, compression results in greatly reduced transfer times when retrieving reports.

3.5.3. Document completion. Perhaps the most limiting factor of the system is that not all reports are complete. The reports vary in the percentage of included figures. While all text, equations,

and tables are present, not all figures and no photographs included in the hardcopy are present in the PostScript version. However, all figure legends are present, independent of the figure itself.

Document completeness is more of an issue with older reports. Given the increasing popularity of sophisticated graphics and visualization tools, recent reports often have figures in PostScript format, which makes for easy inclusion into current reports. However, many older reports are incomplete. Scanning the hardcopies of older reports and producing PostScript output is a possible solution, but this method is labor intensive and beyond the scope of this project. Scanned images and photographs are also storage intensive and would require several orders of magnitude more storage than what is currently available.

3.6. Security Issues

Because the FTP server is available to anyone with Internet access, security concerns are paramount. The anonymous nature of the service prevents validation of remote users. Two security concerns are the unrestricted access to government computers and the classification or limitations of the technical reports.

As previously stated, only reports approved for "unclassified, unlimited" distribution are available. The authority for deciding which documents are eligible to be placed on the server rests with the manager of the Technical Editing Branch. No restricted or sensitive documents are made available.

Allowing anonymous access to a government computer is also a common concern. However, FTP access allows a user to retrieve only the files that are in the file system explicitly defined to hold anonymous FTP files. It is not possible to access files outside this file system during an FTP session. In addition, it is not possible for users to edit, remove, or place new files on the system.

Making the reports available but requiring a password to access them is an option. However, the administrative effort to validate the users, issue passwords, change the password frequently, and inform users of the correct password is prohibitive. While this option would be effective in restricting access, there is still no way to control what happens with the reports once they leave the server. Requiring a password would also inhibit other Internet applications such as Gopher (ref. 18) and World Wide Web (WWW) (ref. 7) from accessing the reports and thus slow the transfer of technology.

4. LTRS Usage During First Six Months

During the first 6 months of production, over 2400 technical reports were distributed. Table 1 and figures 6 and 7 show the accesses during this period. No official or widespread advertising or support was utilized to increase awareness of this service, and the numbers reported here do not reflect possible secondary distribution nor the distribution from other NASA sites that "mirror" (i.e., maintain duplicate copies of) the reports.

There have been 4730 FTP accesses to LTRS. The largest user group is domestic universities, accounting for 37 percent of total usage (fig. 8). Domestic companies account for 11 percent of usage, which indicates significant progress in a new method of technology transfer. Foreign usage, at 36 percent, has been significant, although most foreign accesses are from foreign universities.

Table 1. LTRS Usage for 1/14/93 to 7/18/93

Separate FTP logins	4730
Retrieval of abstract lists:	
1993 list	1069
1992 list	1709
1991 list	468
Total abstract lists	3246
Retrieval of reports:	
Technical Papers (TP)	1499
Technical Memorandums (TM)	895
Reference Publications (RP)	65
Technical Translations (TT)	26
Total reports	2485

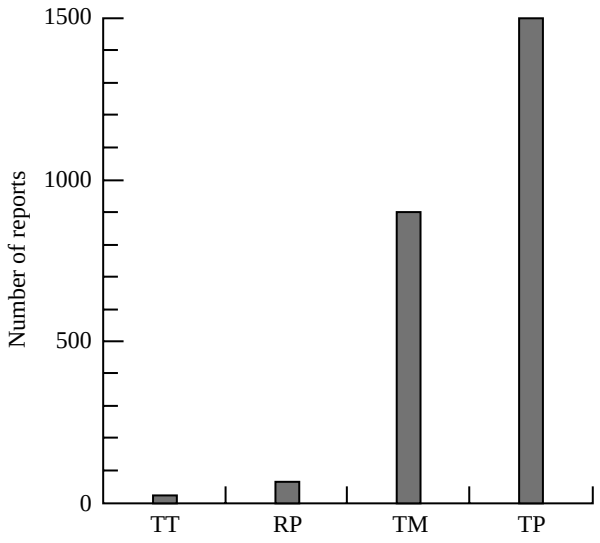

Figure 6. Reports distributed by report type.

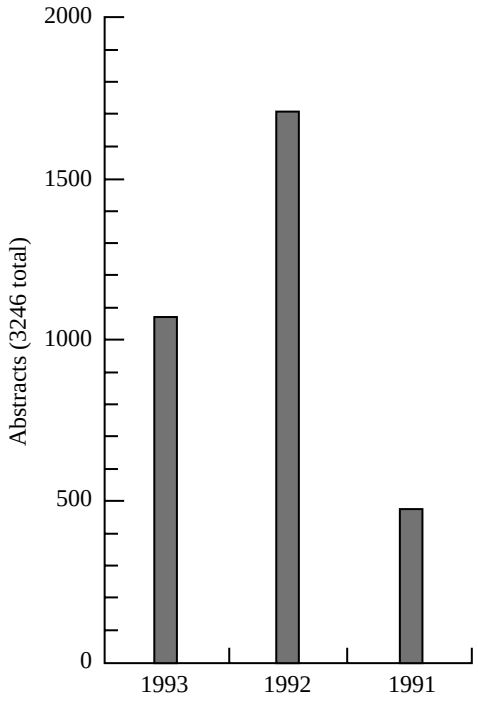

Figure 7. Abstracts distributed by year.

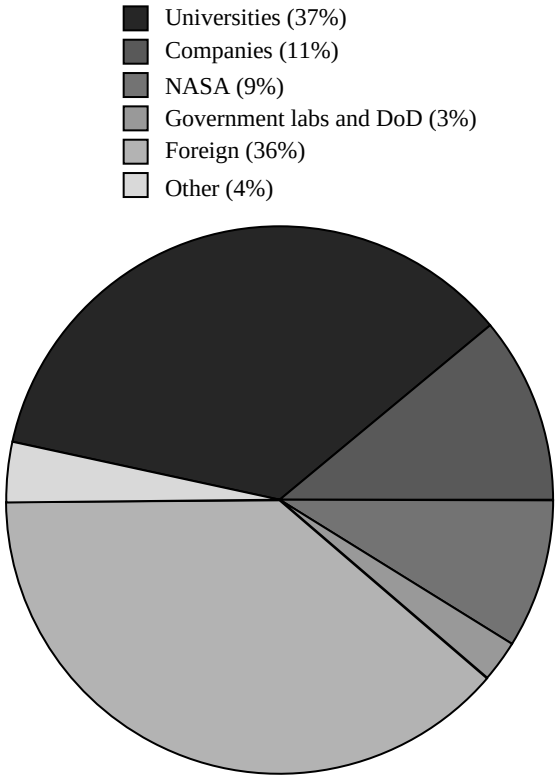

Figure 8. Access percentage by organization.

The 1993 abstracts and reports have not been available for the full 6 months. Given their limited numbers and late inclusion, users have expressed a greater interest in 1993 reports. Thus, the users of this service are interested in obtaining the latest information and are less interested in older reports.

Table 2 shows the titles of the top five most retrieved reports, exclusive of the report featured in the example session of the README file. While most of the reports had an even distribution of about 20 retrievals each, these 5 reports clearly stood out above the rest. For a complete listing of the companies, universities, research laboratories, and countries that have transferred reports and abstracts, see appendix C.

Table 2. Top 5 Retrieved Reports

1.	72 Copies	TITLE: Fault Tolerance of Artificial Neural Networks With Applications in Critical Systems AUTHOR(S): Peter W. Protzel, Daniel L. Palumbo, and Michael K. Arras REPORT NUMBER: NASA TP-3187
2.	61 Copies	TITLE: Grid Generation and Flow Solution Method for Euler Equations on Unstructured Grids AUTHOR(S): W. Kyle Anderson REPORT NUMBER: NASA TM-4295
3.	53 Copies	TITLE: An Optimization-Based Integrated Controls Structures Design Methodology for Flexible Space Structures AUTHOR(S): Peiman G. Maghami, Suresh M. Joshi, and Ernest S. Armstrong REPORT NUMBER: NASA TP-3283
4.	52 Copies	TITLE: Validation of Three-Dimensional Incompressible Spatial Direct Numerical Simulation Code AUTHOR(S): Ronald D. Joslin, Craig L. Streett, and Chau-Lyan Chang REPORT NUMBER: NASA TP-3205
5.	39 Copies	TITLE: Generalized Hypercube Structures and Hyperswitch Communication Network AUTHOR(S): Steven D. Young REPORT NUMBER: NASA TM-4380

5. Integration With Other Internet Systems

As previously mentioned, the FTP and WAIS servers can be accessed from other Internet resource applications. Because LTRS is a proof-of-concept

system, no time was budgeted to develop a sophisticated interface to the system. Following accepted guidelines and protocols and not introducing Langley specific features ensures that the FTP and WAIS servers function independently of the advances made in new accessing mechanisms. Many other Internet access mechanisms are currently in use. Good introductions to WAIS, WWW, Gopher, NCSA Mosaic, Archie, and others are included in references 2, 3, and 19 to 21.

Many other Internet-based systems are under development that will provide library specific functions. These systems include the NASA Electronic Library Systems (NELS) being developed at Johnson Space Center (ref. 8), the NASA Access Mechanism (NAM) being developed at NASA Headquarters (ref. 9), and the Wide Area Technical Report Server (WATERS), a joint effort by the computer science departments of Old Dominion University, Virginia Polytechnic Institute and State University, University of Virginia, and the State University of New York, Buffalo (ref. 22).

6. Areas for Future Work

While LTRS has been well received, many areas for improvement remain. The most obvious and immediate are the issues of document completion and the inclusion of older reports. In addition, the search, retrieval, printing, and viewing capabilities of LTRS need to be more fully integrated and improved.

Making the files available in formats other than PostScript would increase the potential audience for the reports. Standard Generalized Markup Language (SGML) (ref. 23) and HyperText Markup Language (HTML) via Mosaic (ref. 6) are formats for consideration. LTRS should provide a foundation for developing multimedia technical reports.

The long-range area of improvement is increasing the number of documents available; for example, LTRS could include reports from outside the current controlled, homogeneous publication environment. LTRS could also include reports from other NASA centers, NASA contractors, and NASA research institutes such as Langley's Institute for Computer Applications in Science and Engineering (ICASE).

7. Concluding Remarks

The Langley Technical Report Server (LTRS) confirms that researchers outside Langley, and even outside the aerospace discipline can easily search and retrieve NASA formal technical reports. The file transfer protocol (FTP) and Wide Area Information Server (WAIS) servers are not intended to supplant existing library systems but are designed to provide the library users with another valuable tool. Users can now quickly perform their own searches and retrieve Langley formal technical reports from their offices and thus free reference librarians to attend to more difficult reference questions.

LTRS established a core service that was immediately useful. The generalized design of LTRS allows it to integrate with new technologies and systems such as World Wide Web (WWW), Gopher, and WAIS. Of the limitations that remain, document completion is perhaps the most pressing. Future reports can be expected to be more electronically accessible, but the addition of older reports (pre-1992) remains unresolved.

In the first 6 months, over 4700 users accessed LTRS, and over 2400 technical reports were distributed. This project has successfully shown that electronic report distribution is both feasible and desired by the research community. Researchers have embraced the ability to have technical documents delivered to their desktop, even while advanced searching and retrieval interfaces for the server are under development. The benefit to the researcher is that document delivery is now measured in minutes, not days, weeks, or even months.

NASA Langley Research Center
Hampton, VA 23681-0001
January 21, 1994

Appendix A

Minimum System Configuration Needed To Access LTRS

- IBM PC or clone, Apple Macintosh, UNIX workstation, or DEC VMS with Internet access
- TCP/IP networking software for the above
- FTP capability (provided with most TCP/IP implementations)
- WAIS client software (available via anonymous ftp from think.com)
- PostScript printer or PostScript previewing software

Appendix B

Anonymous FTP Location of Non-UNIX Compress/Uncompress Utilities

- VMS
  unix.hensa.ac.uk:/pub/uunet/systems/vms/compress_vms.tar
- MS-DOS
  nic.cerf.net:/pub/infomagic_cd/dos/compress/comp430d.zip
- Macintosh
  wuarchive.wustl.edu:/mirrors/archive.umich.edu/mac/util/compression/maccompress3. 2.hqx

Appendix C

Organizations That Have Accessed LTRS

Companies

3M Company
ASK/Ingres Products Division
AT&T Bell Laboratories
Adobe Systems Inc.
Allen-Bradley Company, Inc.
Analog Devices, Inc.
Anasazi, Inc.
Apertus Technologies Inc
Apple Computer Corporation
BP
BT North America, Inc.
Beckman Instruments, Inc.
Biotechnet
The Boeing Company
Bolt Beranek and Newman Inc.
Bristol-Myers Squibb
Bull HN Information Systems Inc.
Byte Information Exchange
CADAM
CLAM Associates
CST Entertainment Imaging Inc.
CTA Incorporated
Cellular Technical Services
Charles Stark Draper Laboratories
Chevron Information Technology Co.
Concurrent Computer Corporation
Convex Computer Corporation
Cray Research, Inc.
Dallas Semiconductor Corp.
Datapoint Corporation
Dell Computer Corporation
Delmarva Power and Light Company
Digital Equipment Corporation
Digital Express Group, Inc.
Dupont Experimental Station
EUTeC
Eastman Kodak
Epilogue Technology Corporation
Exxon Research
GTE Government Systems Corporation
GTE Laboratories
General Electric Company
General Motors Research Laboratory
Gordian
Gulfstream Aerospace Corporation
Halcyon
Halliburton Company
Harris Corporation
Hewlett-Packard
Hibbett, Karlson, and Sorensen Inc.
Honeywell, Inc.
Horizon Research Inc.
Hughes Aircraft Company
Hughes Information Technology Company
Info Connections, Inc.
Insignia Solutions Inc
Integrated Systems, Inc.
Intel Corporation
InterCon Systems Corporation
Intergraph Corporation
Intermetrics, Inc.
International Business Machines
James Spottiswoode & Assoc.
Kendall Square Research Corporation
LSI Logic Corporation
Lockheed Software Technology Center
Loral Corporation
Lucid, Inc.
MEGATEK Corporation
Martin Marietta Corporation
McDonnell Douglas Corporation
Mentor Graphics Corporation
Merck and Co., Inc.
Mobil Corporation
Monsanto Company
Morgan Stanley and Company, Incorporated
Motorola Inc.
NEC Research Institute Corporation
Netcom—Online Communication Services
NorthWest Research Associates, Inc.
Oracle Corporation
PARAMAX SYSTEMS CORPORATION
PDH Inc.
Pacific Gas and Electric Company
Panix Public Access Unix of New York
Phillips Petroleum Company
PictureTel Corporation
The Pivot Group
Portal Communications Company
Process Software Corporation
Promis Systems Corporation
QMS, Inc., Imagen Division
Qualcomm Inc.
Rockwell International Corporation
Rockwell Power Services Company
SAIC
SRI International
Schlumberger Limited
Sequent Computer Systems, Inc.
Silicon Graphics, Inc.
Software Tool and Die
Solbourne Computer Inc.
Southwestern Bell Corporation
Sterling Software
Stratus Computer, Inc.

Sun Microsystems, Inc.
Sun Tech Journal
Sunquest Information Systems
TRW Inc.
Telebit Corporation
Texaco
Texas Instruments
Thinking Machines Corporation
Transarc Corporation
The Turing Institute Limited
UNIX System Laboratories
United Technologies Corporation
Visual Understanding Systems
Vitro Corporation
The Wollongong Group
Xerox Palo Alto Research Center

Universities

Adelphi University
American University
Appalachian State University
Arizona State University
Auburn University
Baylor College of Medicine
Board of Governors Universities
Boston University
Brandeis University
Brigham Young University
Brown University
Bucknell University
Cal Poly State University
California Institute of Technology
California State University
Carleton College
Carnegie-Mellon University
Case Western Reserve University
Chico State University
Chowan College
Clarkson University
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Naval Ocean Systems Center
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Other Organizations

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The Austin Unix Users Group
California Education and Research Federation
Colorado SuperNet, Inc.
Communications for North Carolina Education, Research, and Technology
European Southern Observatory
IDA/Supercomputing Research Center
Institute for Defense Analyses
Institute of Electrical and Electronic Engineers, Inc.
InteleCom Data Systems
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North Carolina Supercomputing Center
Open Software Foundation
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