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Functional Requirements Document for NASA/MSFC Earth Science and Applications Division

Data and Information System (ESAD-DIS) Interoperability, 1992

J. Briscoe Stephens and Gary W. Grider

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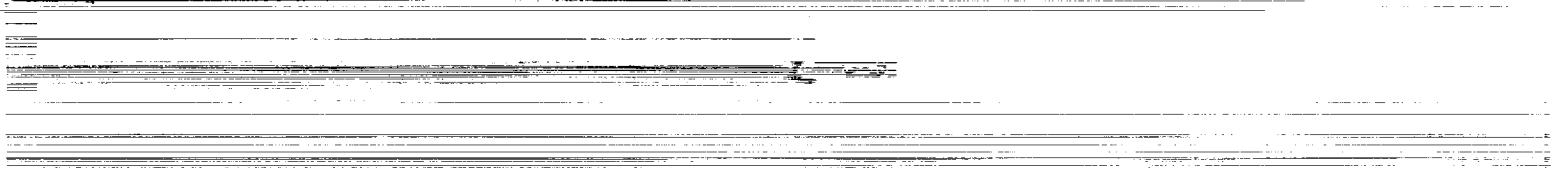

NASA Technical Memorandum 4388

Functional Requirements Document for NASA/MSFC Earth Science and Applications Division

Data and Information System (ESAD-DIS) Interoperability, 1992

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NASA
National Aeronautics and Space Administration
Office of Management
Scientific and Technical Information Program
1992

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Technical Memorandum

Functional Requirements for:

NASA/MSFC Earth Science And Applications Division -- Data and Information System (ESAD-DIS)

Interoperability, 1992

I. Summary of New Requirements

In 1992, the facilities for the NASA/MSFC Earth Science & Applications Division (ESAD) will be augmented by the addition of Building 4492 [Memorandum for Record: Facility Utilization Agreement for the MSFC Mission to Planet Earth Program, JA92 (92-005), Concurrence: T. J. Lee, Director, February 14, 1992]. The building will house the NASA/MSFC Earth Observing System (EOS) Data and Information (DIS) Distributed Active Archival Center (DAAC) along with other NASA/MSFC Earth science and applications activities. This will be the focus of the operational ESAD-DIS Local Area Network (LAN) ethernet interoperability requirements.

Interoperability is the systems engineering approach to computational networks capable of meaningful communications without requiring the users to know the details of the underlying technologies. This means interoperability between operation systems such as Windows, OS/2, and UNIX. The challenge of interoperability is not to simply have one computer "talk" to another, but rather it is how to turn components from different vendors into a coherent, transparent, and powerful computing environment. Effective or high level interoperability requires a systems engineering approach that recognizes the uniqueness of each network within the system and designs the system to accommodate multiple network architectures.

An example of a system that provides an ability to "talk" although at a low level of interoperability is the ESAD to UAH link (see Appendix A). This link between two points less than 10 miles apart traverses approximately 2400 miles through four intermediate points, adds 10 routes with a combined delay of 1440 ms, and has an effective transfer rate of 1 kilo byte (kB)/sec.

New requirements for 1992 - 1993 period

- ☐ The ESAD-DIS Local Area Network (LAN) will require 10 base T ethernet interoperability between Building 4492 and the existing ESAD facility in Buildings 4481 and 4614.
- ☐ The ESAD Local Area Network (LAN) will require ethernet interoperability for the DAAC.
- ☐ The ESAD-DIS Local Area Network (LAN) will require ethernet interoperability with the NASA/MSFC Institutional Area Network (IAN), Metropolitan (Huntsville) Area Network (MAN), NASA Wide Area Network (WAN), and the international Earth science scientific community.
- ☐ The ESAD-DIS Local Area Network (LAN) will require ethernet interoperability with EOSDIS.

- The ESAD has a requirement to add some 125 workstations to the ESAD-DIS LAN in 1992 and 1993.

II. Introduction

The NASA/MSFC Earth Science & Applications Division (ESAD) is involved in both NASA-wide operational support activities and international research activities involving the government and the scientific community. ESAD supports Earth system science and global change research including several NASA operational and research missions (Space Shuttle launch support, Mission to Planet Earth, Global Change Research Program, Aerospace Natural Environment Definitions, etc.). To effectively carry out this role, ESAD requires Data and Information System (ESAD-DIS) interoperability, both internally and externally to the ESAD, MSFC, and NASA, with all elements involved in these activities. On the basis of recommendations from the NASA/MSFC Information Systems Office (ISO), these interoperability requirements have been developed within the framework of the universal wiring system with twisted pair ethernet (10 base T) nodes and connected with appropriate bridges and brouters to dedicated

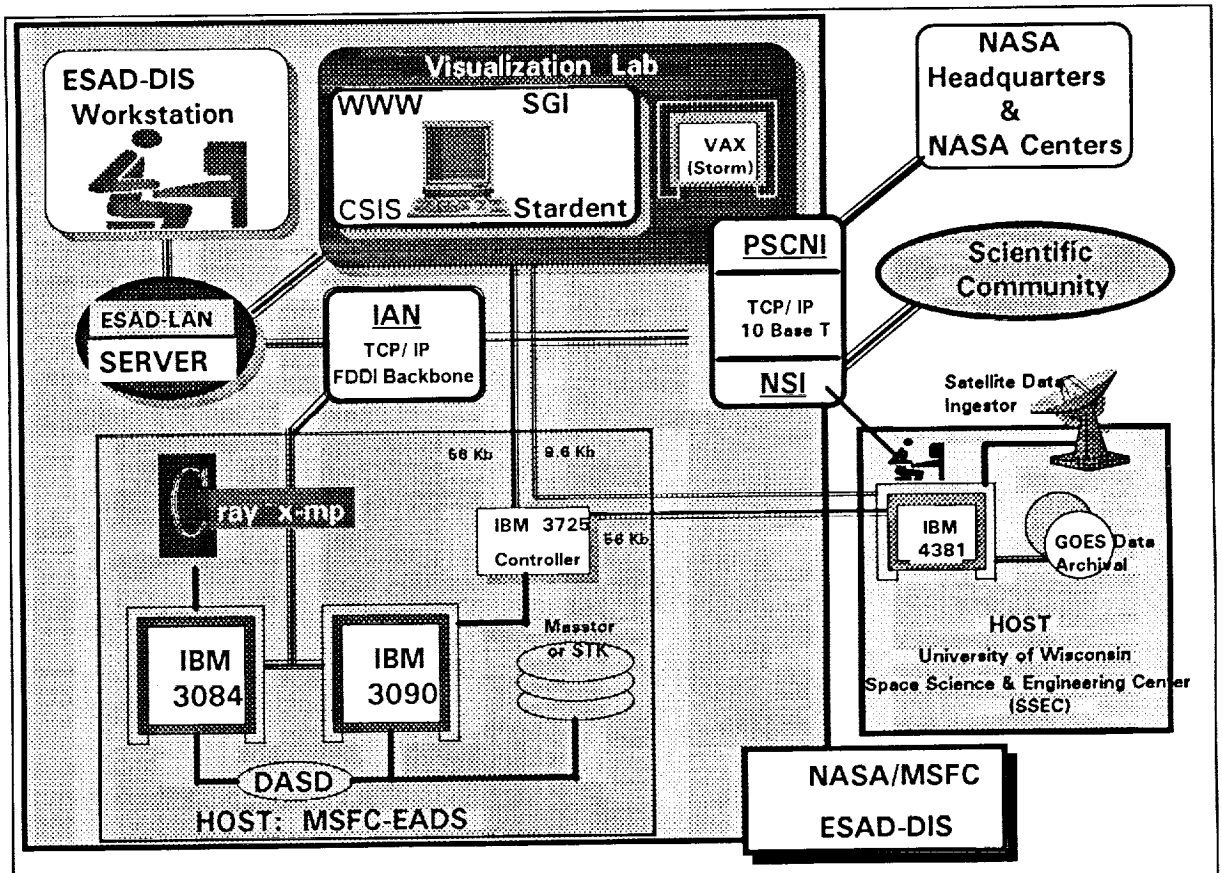

Figure 1. Block Diagram of NASA/MSFC Earth Science & Applications Division -- Data & Information Systems (ESAD--DIS) Wide Area Network (WAN)

communication lines (FDDI [Fiber (optics), Distributed Data Interface], T3, T1, and 56 kB lines) using the TCP/IP, and SNA protocols for the WAN activities; and Netbeui, IPX/SPX, DEC Net/LAT, and AppleTalk protocols for the LAN and IAN activities.

A block diagram of the basic ESAD-DIS WAN configuration to support the NASA ESAD activities is shown in Figure 1. The fundamental requirement is that all of these systems are compatible with the Man computer Interactive Data Access System (McIDAS) which is the primary data visualization and analysis tool for ESAD. The ESAD-DIS workstations at each scientist's desk and the visualization lab workstations must have either an OS/2 or UNIX operating system to be McIDAS compatible. It is also required that interoperability be maintained over 10 base T lines using TCP/IP protocol.

Another facet of the ESAD-DIS is that the ESAD-DIS LAN servers utilize Microsoft LAN Manager, version 2.1, to provide interoperability between management, scientific, and clerical users. The ESAD-DIS workstation uses Windows 3.1 (DOS 5.0) and OS/2 (revisions 1.21, 1.3 and 2.0) operating systems. The ESAD-DIS LAN must communicate with other NASA LANs using AppleTalk, Novel NetWare, etc. Since LAN Manager is a multiprotocol system that supports IPX/SPX, DECnet, TCP/IP, NETBEUI, etc.; this requirement is normally met. It is a requirement that the NASA/MSFC ESAD-DIS electronic mail systems like NASAmail, All-in-One, Microsoft Mail, cc:Mail, CEO, etc. use the X.400 gateway for interoperability.

The specifics of the above requirements will be addressed later in this document.

III. Purpose

This **"Functional Requirements Document for: NASA/MSFC Earth Science And Applications Division -- Data and Information System (ESAD-DIS) Interoperability, 1992"** is designated as the current 1992 overall functional backbone of the NASA/MSFC ESAD-DIS Local Area Network (LAN), Institutional Area Network (IAN), Metropolitan Area Network (MAN), and Wide Area Network (WAN) interoperability requirements. While specific requests for service (RFS) will be staffed through the appropriate channels, this document is intended to supply the overall scope and justification for these RFSs.

IV. Scope

To identify Man computer Interactive Data Access System (McIDAS), Meteorological Interactive Data Display System (MIDDS), WetNet, Earth Observing Systems Data and Information System (EOSDIS), Distributed Active Archival Center (DAAC), and all other ESAD-DIS functional requirements for the TCP/IP, SMA, Netbeui, etc protocols with twisted pair ethernet (10 base T) nodes and connected with appropriate bridges and brouters to dedicated communication lines (FDDI [Fiber (optics), Distributed Data Interface], T3, T1, and 56 kB lines) for these activities.

V. ESAD-DIS Workstation Interoperability

The ESAD-DIS interoperability requirements are for workstations that utilize DOS, Windows, OS/2, and UNIX operating systems. Their is a need to maintain interoperability with Macintosh personal computer, since these personal computers are especially popular in NASA Headquarters and in the university scientific community.

The requirement for DOS interoperability is dictated by the need to have an operating system that supports the traditional PC programs. DOS 5.0 is recommended since it affords high memory to support utility programs which helps to reduce the serve 640 K memory limitation of DOS. Use of X-Windows/Motif with DOS provides interoperability with UNIX systems having X-Windows.

The requirement for Windows interoperability is dictated by the need to have an operating system that supports the information programs that afford interoperability with the Macintosh. Windows 3.1 is the introduction to the new graphic user interface (GUI) and affords Macintosh System 7 compatible true type fonts, it affords a work-around for the 640 K memory limit, and it affords 16-bit quasi-multiprocessing interoperability between Windows programs (word processor, spread sheet, graphics, and electronic mail) and DOS programs. The true type font compatibility between Windows 3.1 and Macintosh System 7 affords direct interoperability, without reformatting, between Windows and Mac Word 2, Excel 4, Project 3, and PowerPoint 3. Use of X-Windows/Motif with Windows provides interoperability with UNIX systems having X-Windows. Windows will operate in the limited standard mode on a 80286 PC, but requires an 80386 or 80486 PC to operate in the multiprocessing enhanced Windows mode.

The requirement for OS/2 interoperability is dictated by the need to have an operating system that supports the McIDAS. OS/2 revision 2.x is recommended for maximum ESAD interoperability since it currently supports true 32-bit multiprocessing interoperability with DOS, Windows. and OS/2 programs. OS/2 2.x will have X-Windows/Motif to provide interoperability with UNIX systems having X-Windows. It also has sockets that could be utilized for AIX (IBM UNIX). Since OS/2 2.0 can use up to 4 gigabit (Gb) of memory, it is idea for ESAD-DIS data analysis. OS/2 2.x requires an 80386 or 80486 PC (it will not operate on the 80286 PC).

The requirement for UNIX interoperability is dictated by the need to have an operating system that supports the ground rules of EOSDIS. UNIX supports 32-bit operations on reduced instruction set (RIS) workstations and mainframe computers and runs McIDAS-X. X-Windows/Motif is required with the DOS, Windows, and OS/2 operating systems to provide UNIX interoperability with the visualization workstations and the mainframe computers.

By the end of 1992, it is anticipated that there will be a requirement for the 32-bit Windows NT. The requirement for Windows NT interoperability is dictated by the need to have an operating system that supports interoperability between DOS, Windows, and SCO UNIX programs. Windows NT will run on both the 80386/486 complex instruction set (CIS) and R4000 RIS workstations. Windows NT will support parallel symmetric processors.

Current advanced CIS workstation requirement are for upgradeable 486/50 single and multiprocessor workstations with at least 32 MB of memory and a 1 GB harddisk. Current advanced RIS workstation requirement are for upgradeable R4000 single and multiprocessors workstations with at least 32 MB of memory and a 1 GB harddisk.

VI. Baseline NASA/MSFC Earth Science & Applications Division -- Data & Information Systems (ESAD-DIS) Interoperability Connectivity Requirements

The ESAD-DIS interoperability will be divided into two types of requirements -- the ESAD-DIS data interoperability requirements and the ESAD-DIS information interoperability requirements to isolate the unique features of each set of requirements. Effectively, all ESAD personnel have both the data and information interoperability requirements to meet in a concurrent timeframe on a single workstation -- hence, the term ESAD-DIS requirements.

A. Baseline ESAD-DIS Data Interoperability Requirements

The ESAD-DIS data interoperability requirements are driven by Earth observing satellite data retrieval; currently primarily by Geostationary Operational Environmental Satellite (GOES) data downlinked to the Space Science and Engineering Center (SSEC) at the University of Wisconsin. However, in the near-term they will be driven by Earth Observing System Data Information System (EOSDIS). GOES can generate 3 to 13 images with 1 km or 4 km resolution every half hour -- depending on the mode of operation.

One regional image is typically 300,000 8-bit pixels. Using 10 base T, this requires about 1 second to transmit. However, one image of the United States is about 3,000,000 8-bit pixels of information or requires between 10 to 15 seconds to transmit. For a day of GOES data, using the above baseline, it requires about 6 minutes of 10 base T transmission time or about 50% of ESAD could dominate a 10 base T ethernet line analyzing a day of GOES data. In practice, GOES often uses the Rapid Interval Scan Operation Plan (RISOP) mode. In the RISOP mode, the imagery is reduced in dimension; 4 km data may only be 2,000 x 1,500 pixels or even smaller. GOES NEXT will generate an entirely different scenario of image data and field of views. Hence, the above is a worse case analysis.

One global image with 1 km resolution is 510,000,000 pixels or 4.8 Gb (bits) of information. Currently, satellites only provide 1 km data for about 2/3 of the hemisphere; hence, images are only about 6,400 x 9,600 pixels or 61,380,000 pixels. However, by the later part of the 1990s, there are planned observational mission orbits of 80 to 85 degrees, which should afford nearly 500,000,000 pixels of data. This implies a 10 base T ethernet line would require about a half hour to transmit.

WetNet is a prototype satellite image processing and distribution system for Version Zero (V0) Distributed Active Archive Center for EOSDIS. WetNet downloads geostationary satellite images (GOES and Meteosat) from the Space Science and Engineering Center at the University of Wisconsin over the NASA Science Internet (NSI). Each 2-week satellite data set is composed of 28, 1 MB images. Therefore, for two geostationary satellites approximately 56 MB are downloaded to MSFC. In the 3rd to 4th quarter of 1991, in addition to the above geostationary data, WetNet started receiving EOSDIS V0 data from the Special Sensor Microwave Imager (SSM/I) on two Defense Meteorological Satellite Program (DMSP) satellites, DMSP F-8 and DMSP-F10. These SSM/I data will be downloaded from the National Environmental Satellite Data and Information Service (NESDIS) over NSI communication lines. The daily SSM/I data volume is about 160 MB. These data will be archived and processed on either the IBM 3090 or ESAD UNIX workstation. These data will also be relayed to the Jet Propulsion Laboratory in California each day.

Currently the ESAD-DIS workstation uses VGA (640 x 480) with OS/2 McIDAS to view these data. That is, using the 9.6 kBps line on the Hyperbus requires about 4.5 minutes to download one image. In the ESAD-DIS Visualization Laboratory, there are Stardent, SiliconGraphics (SGI), and Wide Word workstation with monitors that have 1,280 x 1,024 pixel resolution and have pan and zoom features for large area analysis. It can take about 45 minutes to download the data for one channel of GOES data for the United States to one of these workstations using the Hyperbus. If we used the ethernet with 10 base

T with an effective throughput of 0.5 Mb, it would require about 20 minutes to download the peak US GOES data for 1 hour for one McIDAS user. The ESAD has a current potential peak user load of 30 to 60 users and growing. WetNet currently downloads over 600 Mb of data per week for archival to the WetNet scientific community of users. As stated, this goes to twice this per day in the second half of 1991. This means between 7 to 9 hours per day using 56 kB lines or 45 to 90 minutes using ethernet, to just upload the data on the IBM 3090. Then these data must be downloaded to JPL.

The three-dimensional (3D) atmospheric models being used by the Fluid Dynamics Branch in ESAD are run on our Cray X-MP and require graphical interoperability with the researcher. A researcher utilizing just a 10 variable model with a 10 x 100 x 100 km grid generates 100 Mb of data per run. If he can get these results to his workstation in less than 10 minutes (at a rate of better than 200 kB/sec), the research will make some 10 runs per day. That is, the modelers in ESAD need to move 1 Gb of data per day. This is independent of other ESAD research activities.

From these examples of the ESAD-DIS data flow interoperability requirements, it can be seen that using a 10 base T ethernet LAN for ESAD will probably require some segmentation.

B. Baseline ESAD-DIS Information Interoperability Requirements

The ESAD-DIS information interoperability requirements are based on all members of ESAD (currently 128 and in the near term 180 to 200 people) having ethernet access to the NASA/ MSFC ESAD-DIS LAN, and most members having ethernet access to other MSFC LANs (PD LAN, JA LAN, CEO, NASAmail, NPSS, etc) and the NASA ESAD-DIS WAN. There are currently two NASA/MSFC ESAD-DIS LAN Manager servers for the ESAD that probably will be expanded to between four to six servers in the near future.

The ESAD-DIS standard basic information software (DOS 5.0, Windows 3.1, Word 2.0 for Windows & PM, Excel 4.0 for Windows & OS/2, PowerPoint 3.0 for Windows & OS/2, and Project 3.0) and other specialized applications will be stored on the ESAD servers where it can be uploaded each day as needed. This means that at the start of each day, ESAD personnel could be uploading using the ethernet LAN from their server about 6 to 18 MB of files (that is, less than 15% of the available applications software) when they initialize their workstation. That is, potentially over 1 GB of information will be moved over the ESAD-DIS ethernet LAN by some 120 people at the beginning of the day when the LAN becomes operational. This would require from 1 to 2 hours to upload on a single segment ESAD-DIS LAN or about 15 minutes in 2 hours with four segments. This requirement for a host-based distribution system stems from the need for a site license for the ESAD-DIS applications software to reduce costs and to insure the all ESAD personnel have legal up-to-date copies of this software. By not storing all this applications software on the individual ESAD-DIS workstation, the costs of these workstations will be significantly reduced.

Again, from these examples of the ESAD-DIS projected information flow rates interoperability requirements, it can be seen that using 10 base T ethernet LAN for ESAD will probably require some segmentation.

VII. Support Functions

A. Interoperability, Accessibility for ESAD-DIS (Images & Text)

Ability to access Engineering Analysis Data System (EADS), via emulation of a DEC VT100, or IBM 3270 terminals on a link with 10 Mb/s bandwidth or greater. Graphics emulation for Tektronix graphics terminal emulation.

☒ Interoperability between mainframe McIDAS and OS/2 McIDAS utilizing TCP/IP sockets in the ESAD-DIS LAN Manager.

☒ Host to Host McIDAS interoperability. This focuses first on the 4381/3090 McIDAS connection. May be extended to include TCP/IP McIDAS connection, to other sites (e.g., JPL, JSC, SSEC, CCFF).

☒ ESAD-DIS interoperability between Buildings 4481, 4492, 4614, and 4663 and other ESAD facilities, in a seamless manner, with an interbuilding bus that has 10 Mb/s or greater bandwidth.

☒ ESAD-DIS LAN Manager interoperability for four to six servers.

☒ EOS DIS WAN interoperability.

☒ Space Station interoperability (Reston, VA).

☒ Interoperability to CEO, All-in-One, and NASAmail.

☒ Interoperability to the Internet and NASA Science Network (NSN).

☒ International interoperability (e.g., Australia, Spain, England, etc.).

☒ Internet addresses are needed for users of the Institutional Area Network (IAN).

Support for a generic distributed computing environment using the UNIX 'rsh' and 'rexec' utilities, or the NASA-developed Network Queuing System (NQS). The Cray supports all of these under UNICOS. In the DECnet World, this is achieved semi-transparently through VMS and applications such as CrayStation.

B. Compatibility

ESAD-DIS requires compatibility with McIDAS per Space Science and Engineering Center (SSEC), University of Wisconsin recommendations for computer mainframe, UNIX workstations, and personal computer OS/2 based systems. The following are required by ESAD:

☒ OS/2 version 2.x [Minimum, Extended Edition version 1.3 (OS/2 EE)] or UNIX

☒ TCP/IP for personal computers

☒ Industry Standard Architecture (ISA), Extended Industry Standard Architecture (EISA), or IBM

MicroChannel (MC) ethernet card (3COM or Standard Microsystems Corporation-SMC)

☒ TCP/IP for MVS (for IBM Mainframe)

☒ ESAD-DIS compatibility with Microsoft's LAN Manager and associated ESAD-DIS applications software here at MSFC, NASA Headquarters, other NASA Centers, and NASA ESAD contractor sites. The following are NASA ESAD-DIS standards:

☒ DOS Windows 3.x or OS/2 1.3 EE or 2.x

C. Hardware

Hardware for personal computer systems: Ethernet cards for ISA, EISA, and MicroChannel architectures. These devices must comply with the Network Driver Interface Specifications (NDIS) for personal computers.

D. Operating Systems

Operating systems which need to be supported are:

☒ PC -- OS/2 (rev 1.x -2.x), UNIX (SCO Open Desktop Release 1.0 and higher), Windows 3.x/ DOS (rev 5.x)

☒ Workstations -- UNIX

☒ VAX -- VMS (5.x)

☒ IBM mainframe -- MVS

E. TCP/IP Software

IBM TCP/IP (rev 2.x) software packages for the IBM 3090 computer mainframe and PC (FTP software Inc, IBM TCP/IP for MVS and OS/2, UNIX TCP/IP)

F. Data Base Management Software

Interactive Data Integration Management System (IDIMS) (Archive Manager) access to a server and archival system using NFS services.

G. File Transfer Capability

File transfer capability (binary, ASCII) using TCP/IP File Transfer Protocol and Trivial File Transfer Protocols, or DECnet Data Access Protocol.

H. Network File System (NFS) Services

Must allow for ability to support NFS protocol on PCs, workstations, and mainframe computers. PCs will generally function only as NFS clients. Hosts will require both client and server functionality.

I. Internal Mail Systems

All of the following electronic mail systems should be compatible with the X.400 gateway at NASA/MSFC:

☒ NASAmail: Currently, primary E-mail for ESAD-DIS activities

☒ Microsoft Mail: Current prime candidate to replace NASAmail for ESAD-DIS LAN

☒ cc:Mail

☒ CEO

☒ All-in-One

☒ VAX Mail

☒ SMTP (Simple Mail Transfer Protocol) -generic UNIX- TCP/IP Mailer

VIII. McIDAS Support

In order to support the OS/2 McIDAS using TCP/IP, the following are recommended by SSEC:

☒ OS/2 Extended Edition (OS/2 EE)

☒ TCP/IP for personal computers

☒ Ethernet card (3COM or Western Digital)

☒ IBM TCP/IP, version 2.0 or later, for MVS (for IBM mainframe)

ESAD requires implementation of these systems in the manner which SSEC suggested, in order to maintain support for these systems.

The McIDAS TCP/IP server was developed based on an applications program interface called VMCF, which is part of the IBM TCP/IP product. Industry standard TCP/IP and application interfaces are written in 'C'. The VMCF applications program interface is a value-added proprietary feature of IBM's TCP/IP and is written in Assembler.

Other versions of TCP/IP are acceptable to ESAD only if they are 100% compatible with IBM's proprietary assembly VMCF applications program interface.

IX. Network Servers

To provide the necessary interoperability for NASA ESAD-DIS Wide Area Networks (WAN) activities, it is necessary to have interoperability with the following LANs:

☒ LAN Manager at NASA Headquarters

☒ Novel NetWare at NASA/MSFC

☒ AppleTalk at NASA/MSFC

☒ DECnet (All-in-One) at NASA/MSFC

X. Contributors

On December 11, 1990, a working panel was formed by Earth Science and Application Division (ESAD) management to assess the ESAD requirements for implementation of Transmission Control Protocol/Internet Protocol (TCP/IP). They prepared a report: ***Functional Requirements Document for Transmission Control Protocol/Internet Protocol (TCP/IP) Connectivity Over Ethernet and Dedicated Communication Lines of the NASA/MSFC Earth Science and Applications Data and Information System, 1991.*** The members of this panel were as follows:

Paul J. Meyer ..... Chairperson
Karen S. Parker ..... Secretary
J. Briscoe Stephens ..... Coordinator
Catherine A. Lapenta
John V. Parker
Bill Saylor
Matt Smith

This working panel's report has provided the initial backbone of information for this document.

Michael Goodman contributed the inputs for WETNET and EOSDIS. Wilton C. Lide provided systems engineering review and consultation.

APPENDIX A: Route to UAH

The MSFC to UAH connection is shown below.

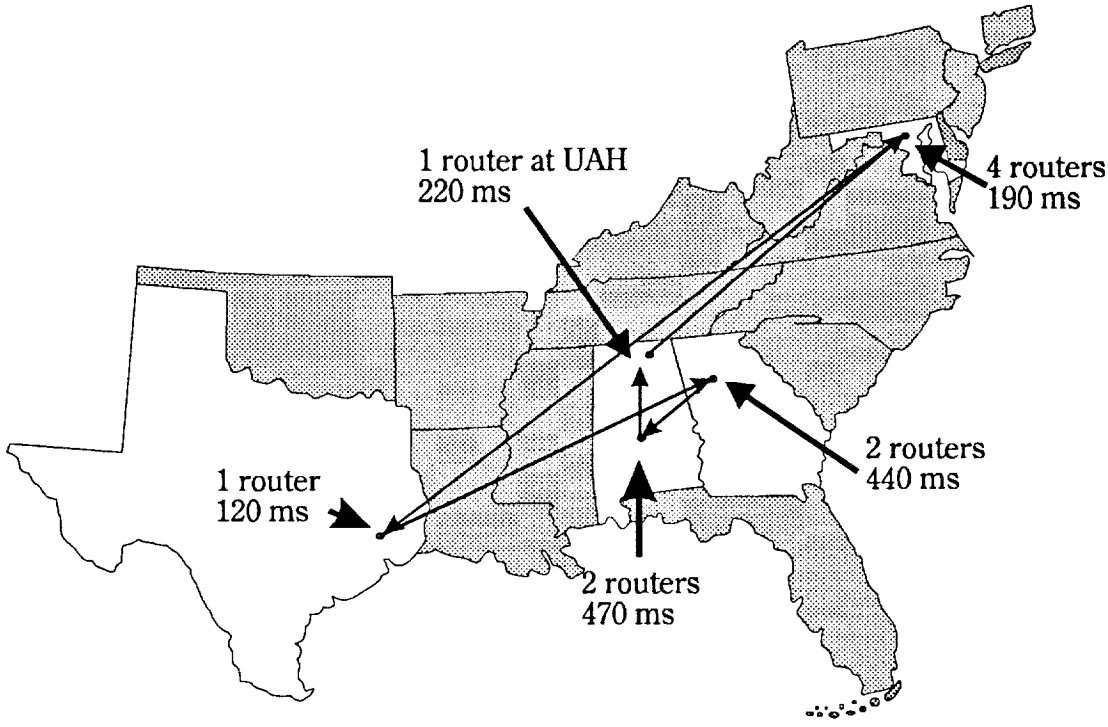

Figure 1A. MSFC to UAH Internet connection

Transmission analysis summary

Destination	Response Time	Approximate Throughput	Line type
UAH	1440 ms	1 kB	NSF net
Nichols Research	120 ms	6 kB	56 kB direct

Communications to UAH goes to the Internet router at MSFC, then to GSFC through four additional routers, from there to Houston, TX to the National Science Foundation (NSF) Internet connection of one

router. The NSF net transfers the message to Atlanta, GA through two routers to UAB and the Alabama High Performance Computer Network (HPCN), and from UAB to UAH. Note the internal processing time at UAH is 220 ms. This makes the total transmission time 1440 ms. A message sent to Nichols Research Corporation using our directly connected 56 kB line is 120 ms (and approximately 6 kB/sec) This means that the UAH connection is 1200% slower than a direct connection. Extrapolating the transfer rate to UAH is typically 1 kB/sec using the Internet connection.

APPENDIX B. Standard ESAD-DIS Workstation Configurations

1. Software:

Applications		Version	Size
Operating System	DOS	5.0	2.4Mb
	Windows	3.1	9.1Mb
	OS/2	2.0	30Mb
Word Processing	Word for Windows	2.0a	14Mb
Spread Sheet	Excel for Windows	4.0	11Mb
Communications	Cross Talk for Windows	1.2	1.8Mb
Presentation Graphics	PowerPoint	3.0	7.2Mb
	Publisher's Paintbush	2.0	5.8Mb
	Corel Draw	2.0	7.9Mb
Project Management	Project for Windows	3.0	8.0Mb

2. Hardware:

Workstation	Interim	Sub-Standard	Standard	Advanced	Prototype
Processor:	286-class	386-class	486/25-class	486/33	486/50
Harddisk	70Mb	100 + Mb	320 + Mb	660 + Mb	660 + Mb
Monitor	EGA	VGA	VGA	SVGA	XGA
Memory	1-4Mb	6Mb-8Mb	8Mb	8-16Mb +	16Mb +
Ethernet Card	8 bit	16 bit	16 bit	16 bit	32 bit

Above systems all include 3 1/2" and 5 1/4" floppy disk drives.

Functional Requirements Document

for:

NASA/MSFC Earth Science And Applications Division -- Data And Information System (ESAD-DIS)

Interoperability, 1992

Approval: Ronald Koczor Date: 4-15-92

Ronald Koczor

Deputy, Earth Science & Applications Division
NASA/Marshall Space Flight Center

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13. ABSTRACT *(Maximum 200 words)*

These ESAD-DIS interoperability requirements are designed to quantify the Earth Science & Applications Division's hardware and software requirements in terms of communications between personal and visualization workstation, and mainframe computers. The electronic mail requirements and LAN requirements are addressed. These interoperability requirements are top-level requirements framed around defining the existing ESAD-DIS interoperability and projecting known near-term requirements for both operational support and for management planning. Detailed requirements will be submitted on a case-by-case basis. This document is also intended as an overview of ESAD-DIS interoperability for new-comers and management not familiar with these activities. It is intended as background documentation to support requests for resources and support requirements.

14. SUBJECT TERMS

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