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Systems and Network Architecture Division

Institute for Computer Sciences and Technology
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THE NBS COMPUTER NETWORKING PROGRAM

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A B S T R A C T

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This report provides a description of the NBS program in computer networking. The description includes activities in computer network protocol development for large global networks, protocol development and measurement research for local area computer networks, and protocol and format development for computer based office systems. These efforts include the development of standards and the performance of the necessary research to support that standards development. Descriptions of the specific products being developed are also included.

Key words: Computer based office systems; computer networking; interfaces; local area networks; measurement techniques; protocols; and standards.

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THE NBS COMPUTER NETWORKING PROGRAM

1.0 INTRODUCTION

This document, prepared by the Systems and Network Architecture Division of the National Bureau of Standards (NBS), provides an overview of NBS' programs in high level network protocols, computer based office systems and local area networking. Products and their associated dates as identified in this report are subject to change.

1.1 Background

In the United States, and in other countries, networking technology for interconnecting a wide variety of computers, terminals, and special purpose systems is rapidly evolving. National and international public data networks are developing and expanding. Special technologies for local area networks are now available. Special purpose networks, for computer based office systems and for laboratories, for example, are also emerging. Almost all manufacturers of computing systems are developing network architectures for interconnecting their diverse systems and, in some cases, for connecting to the systems of other manufacturers. All of these networking technologies and network architectures have incompatibilities which obstruct interconnection. Such interconnection would permit users to exploit the full potential of networks and distributed systems. These technologies must be able to work together, not only on a local network to local network, or global network to global network basis, but also across different network technologies. It must be possible to transmit, and therefore share information originating in an office network, through a local network, through a global network in any combination.

The need for standard protocols to enable systems to be interconnected and to operate together is well recognized. The high level of activity by the manufacturers to develop network architectures, and to develop communications

standards by the communication service providers attest to this need. Likewise, within the Federal Government there is a strong need to develop communications and higher level protocol standards as well as standards to permit the interchange of documents among computer based office systems. In recognition of these critical needs, NBS has been funded to develop such standards. This program is being conducted in coordination with voluntary standards activities, with the efforts of manufacturers of computing equipment to develop network architectures, with the providers of computer based office systems, and with agencies of the Federal Government.

1.2 Program Structure

This report describes the computer networking programs of the Systems and Network Architecture Division which has responsibility for the principal portion of the NBS computer networking program. These programs fall into three major areas: (1) high level computer network protocols, (2) computer based office systems, and (3) local area computer networks. The goal of these programs, collectively, is to provide for distributed computing within the Federal Government and to enable Government organizations to select components of distributed systems based on cost and performance without the constraints imposed by incompatibilities.

The computer network protocols program develops high-level network protocols to enable the effective exchange of information among computers as well as between terminals and computers. The computer based office systems program develops guidelines and standards to enable the effective transfer of documents among systems through the electronic interchange of information as well as through media interchange. The local area networking program produces standards and guidelines for the selection of local area data networks, for the connection of devices to local area networks, and for the interconnection of local area networks to national and international global networks.

The overall NBS effort has three major components: (1) developing standards and guidelines for the benefit of all agencies within the Federal Government, (2) providing direct assistance on a reimburseable basis to Federal agencies requesting such assistance in technical problems related to computer networking, and (3) conducting computer network research in direct support of specific standards development and agency assistance activities.

1.3 Organization

Programmatically, the computer network program is one of the major components of the computer network and systems interface standards program being conducted by the Center for Computer Systems Engineering of the Institute for Computer Sciences and Technology (ICST). ICST is one of three major operating units (MOU's) of the National Bureau of Standards. The development of standards and guidelines pertaining to the high level computer network protocols, computer based office systems, and local area networks is carried out by the Systems and Network Architecture Division. This work is complemented by the programs conducted in the System Components Division that address the development of base level communication protocols and interface standards to enable the effective interconnection of computer system components as well as the interoperation of computer and data communications systems.

Sections 2 through 4 of this report describe the three program areas in terms of standards development, advisory services and research activities.

2.0 COMPUTER NETWORK PROTOCOLS

Designing, implementing and maintaining a useful collection of computer network protocol standards is a complex problem. This complexity reflects: (1) the difficulty in determining protocol features and then defining these features in an unambiguous manner, (2) the need to assure conformance of new protocol implementations with existing standards, and (3) the requirement for future protocols to support more sophisticated information processing requirements.

This section describes NBS activities directed toward solving this problem.

2.1 High Level Computer Network Protocol Standards

The ICST program to develop high level computer network protocol standards has three major objectives: (1) support distributed computer networking, (2) enable the interconnection of different components selected through competitive procurements based on cost and performance, and (3) provide agencies a means of avoiding unique and therefore expensive solutions to networking problems.

The initial standards are those required to provide general support to network users. They are intended to satisfy Government requirements while deviating as little as possible from existing protocols. The development of these protocols will be carried out within an overall framework established by the Reference Model of Open Systems Interconnection*. These protocols are high level computer network protocols that correspond to the transport control, session control, presentation control and application control layers of the ISO Reference Model. A major portion of the work to develop the protocols and associated technical products is being accomplished through contracting. The initial standards and the projected completion dates, in parentheses, are shown below.

*The International Organization for Standardization (ISO), Reference Model for Open System Interconnection, working document no. ISO/TC97/SC16 N227.

1. Transport and Session Control Protocols -- these protocols encompass functions commonly referenced in the transport control layer and session control layer of the ISO Reference Model, (1981).
2. File Transfer and Data Presentation Protocols -- these protocols, implemented at the application layer and the presentation layer, provide a common representation and access method to files, (1981).
3. Common Command Language Protocol -- these commands provide a common user interface applicable to data transfer, remote job entry, and other network operations, (1982).
4. Virtual Terminal Protocol -- this protocol results in a presentation layer protocol that will permit terminals with different characteristics to connect to any network computer system, (1982).
5. Remote Job Entry Protocol -- this protocol(s) permits batch jobs to be initiated and executed remotely in a network, (1983).
6. Network Interconnection Protocol -- this protocol permits the interconnecting of computer networks through a gateway facility, (1983).
7. Unified Presentation Layer Protocol -- this protocol integrates other specific presentation layer protocols to provide a uniform data transformation capability, (1983).
8. Network Interprocess Communication Protocol -- this protocol facilitates initiation and control of asynchronous processes on distributed computers, (1984).
9. Distributed Data Protocols -- this set of protocols facilitates user access to distributed data in a networking environment, (1985).

As part of the development of these standards, NBS staff is providing briefings to managers and technical experts in Government and industry and has received information from them on their networking activities and developments.

2.2 Protocol Research And Development

In order to develop computer network protocol standards for this dynamic technology it is necessary to perform a certain amount of directed research and development. This section describes NBS research and development efforts which support the protocol standards program.

2.2.1 Protocol Design And Specification Research -

The ability to communicate using networks of heterogenous computers requires computer network protocol standards. A family of protocols, organized in a hierarchical relationship, that together satisfy the requirements of a broad spectrum of applications, makes implementations easier and provides greater compatibility. With the growing number of different networks and diversity of uses, it is becoming increasingly more difficult to define efficient protocols that match applications needs effectively.

Among the problems of modern protocol design are the following:

1. There are no agreed upon syntax and semantics for expressing the service and functional capabilities of a protocol. Hence, it is difficult for users and designers to devise complex protocols, and readily reach a common understanding of them.
2. There is no taxonomy of applications as they relate to the requirements imposed on protocols. Nor is there a viable methodology in constructing such a taxonomy.
3. There is no procedure for expressing the quantitative and qualitative association of application needs and protocol features.
4. Finally, there is no demonstratable technique for selecting the optimal protocol set based upon sufficiency of need and cost/performance.

Resolving these problems would simplify the design of computer network protocol standards. In order to begin answering these questions, NBS has a small research project to construct a methodology for precisely defining the service features provided by a protocol. Initial results from this project have already been obtained. As this methodology develops, it will become important in defining

the precise collection of protocol standards being developed by NBS.

2.2.2 ICST Protocol Laboratory For Research And Development -

To gain wide acceptance by Government organizations and to promote compliance by manufacturers, it is necessary to insure that the protocol implementations operate in accordance with their design specifications and that individual features perform at an acceptable level. Furthermore, it is desirable to demonstrate and certify implementations on vendors' systems.

NBS is developing a Protocol Laboratory for the purpose of testing the correctness and performance of draft standard protocols. The major benefits derived from the Protocol Laboratory are to:

1. Ascertain that the protocols perform correctly and according to their design specifications,
2. Determine the performance of the protocols to improve algorithms implementing individual features,
3. Permit alternate implementations of individual protocol features to study relative performance,
4. Make possible accuracy and performance testing of commercial implementations, and
5. Enable offloading studies that can decide the most advantageous placement of protocol functions within a network.

Initially the Laboratory will provide the capability to simulate computer networks. Later a network emulator may be added in order to accurately assess high-level protocol behavior under realistic network throughput and congestion conditions. The Laboratory will be coupled to one or more public data networks connecting the Laboratory to NBS contractors and other interested parties.

2.3 Additional Activities Supporting the Development of Network Protocols

In addition to those activities already cited in this section, NBS has initiated other efforts to support the development of network protocols. These efforts will all

result in either draft or final reports in calendar year 1981.

2.3.1 Impact of Satellite Communications

A study has been initiated which will result in an analysis of the impact of satellite communications on network protocol design. This analysis will factor in the impact of high speed, long propagation delay communications on all high levels protocols (levels 4, 5, 6 and 7 in the ISO Reference Model). Recommendations will be made on how protocol design should reflect these considerations.

2.3.2 Impact of Security Considerations

The computer network protocol program is not attempting to solve the network security problem, however, it is essential that the protocols be specified in such a way so as not to preclude computer security. A study will soon be initiated to analyze the impact of security on the design of high level protocols. This analysis will result in protocol specifications that can support computer security as security is needed in a particular environment.

2.3.3 The Impact of Tariff Structures

It is possible that changing tariff structures in the United States and in other countries will have a significant impact on the design of computer network protocols. It is necessary that the protocols be specified in such a way to maximize the benefits to the users under different tariff structures. A study has been initiated to evaluate the impact of current tariff structures on high level network protocols and to analyze protocol features that should be made dynamic in order to accommodate changing tariffs.

2.3.4 Management Protocols

ICST intends to initiate a program to identify and, as appropriate, specify network management protocols. This activity will closely parallel associated activities within ISO and ANSI to develop such a set of management protocols.

2.3.5 Guidance on the Use of Standard Protocols

ICST intends to develop a set of guidance documents, the first in 1981, to provide assistance in utilizing standard protocols in different application and communication environments. These guidance documents will assist users in specifying protocols and in selecting the appropriate features of individual protocols for different application environments. In addition, examples will be given of software specifications to interface the transport protocol to different kinds of lower level technologies.

2.3.6 Distributed Data Protocols

All of the protocol described so far (with the exception of network interprocess communication) require the user to deal with a "network of computers", that is, the user must be aware that many systems are connected to a network in order to use those systems. Research has been initiated in defining a set of distributed data protocols to locate, structure and present data on behalf of the user without the user having to deal with individual systems. These protocols will use the services of the lower level protocols described herein including the extension of the session control protocol which is called the "network interprocess communication protocol".

3.0 COMPUTER BASED OFFICE SYSTEMS

The term "computer based office system" refers to computer-based techniques applied to the information processing requirements of office workers to help them do their jobs more efficiently and effectively. These techniques include automated data entry, text processing, document formatting, document storage and retrieval, and document distribution, both through media interchange and data communications networks.

3.1 Standards Program

A number of standards are planned in the Computer Based Office Systems Program. NBS is working with such voluntary organizations such as ANSI and the International Federation of Information Processing Societies (IFIPS). NBS is also meeting with vendors and Federal agencies to ensure that the standards reflect the interests of the Government and are compatible with industry trends. This program is intended to foster cooperation and interaction so that the standards may be developed efficiently and effectively.

A Message Interchange Format Standard is being developed for issuance in 1981. It will apply to "electronic mail" or messages exchanged among computer-based message systems. This standard will permit interconnection, so that users on one system will be able to send and receive messages to and from users on other systems.

A Flexible Disk File Format Standard is scheduled for issuance in 1982. It will establish common file formatting and labeling conventions for flexible or "floppy" disks, permitting them to be widely used as a medium of data interchange between dissimilar systems.

A Text Editing Directives Standard is also scheduled for issuance in 1982. It will establish a minimum common set of user directives or commands for text editing systems or services. This will ensure a minimum level of functionality on the part of all text editors considered for Federal use, as well as reduce the amount of retraining required when operators switch from one editor to another.

A Text Formatting Directives Standard is scheduled for issuance in 1984. It will provide a minimum common set of user directives or commands for text formatting systems or services. This will ensure a minimum common functionality on the part of all text formatters considered for Federal use, as well as reduce the amount of retraining required

when operators switch from one formatter to another.

A Message Processing Directives Standard is also scheduled for issuance in 1984. It will establish a common set of user directives or commands for computer based message systems. This will ensure a minimum common functionality on the part of all computer based message systems considered for Federal use, as well as reduce the amount of retraining required when operators switch from one message system to another.

3.2 Guidelines Development

A document entitled Guidance on Requirements Analysis for Office Systems has been issued in 1980. It addresses the justification and evaluation criteria for the installation of computer-based office equipment.

A FIPS Office Automation Glossary will be issued in 1981. It will ensure the use of a common vocabulary among the individuals involved with office automation, and will provide a uniform basis for the standards development program.

3.3 Laboratory Facilities

NBS operates an Office Systems Laboratory to support its program in Computer-Based Office Systems. Included in the laboratory are a number of modern text processing systems.

The Office Systems Laboratory shares facilities and space with the Local Networking Laboratory. Nodes on NBSNET (a local area network developed at NBS) connect laboratory terminals to other on-campus computing resources, including the variety of text processing software available in the ICST Experimental Computing Facility. Special purpose I/O equipment is also available for use in the Office Systems Laboratory such as voice recognition (input) equipment and a voice synthesizer (output).

3.4 Future Direction

Based on the responses to the draft message format standard and interaction between NBS and others working in the area of computer based message systems (CBMS), a number of standards and developmental activities are being initiated. A logical extension to the message format standard is a message presentation standard. This standard will address the user interface to a CBMS with respect to a how a message received by a CBMS is displayed to the user (e.g., the order of presentation of the message fields).

There are a number of developmental activities with respect to CBMS which NBS will be addressing in the timeframe of 1981 through 1985. Among these future activities are: an architecture for CBMS, specification of message recipient and originator identities (i.e., addressing), a message protocol, and incorporation of multi-media messages into the message format standard.

4.0 LOCAL AREA NETWORKING

NBS has initiated a local area networking program with three major components. The first component provides FIPS standards and guidelines applicable to local network installations in the Federal Government. The second component provides agencies with technical assistance from NBS in the selection and use of local area networking hardware, protocols, and applications. The third component is a research initiative in the design, development, and implementation of local network performance measurement techniques. These three program components provide the framework to address three important local area data networking issues: standards, selection, and measurement.

4.1 Standards

Local area network technology is relatively new. To identify the need for standards in the Federal Government, a needs assessment is being performed. Preliminary results indicate that over the next five years, the Federal Government will procure upwards of 2000 local area networks. NBS plans to complete this assessment of local area network standards in 1980 and to develop a local area network interface standard for the Federal Government by 1982. NBS is participating in local area networking standards activities in ANSI and the IEEE.

Recent activities within the IEEE local networking standards group may make it possible to accelerate the local area network interface standard effort. NBS is assisting this effort through direct participation and through technical development. In particular, NBS is generating a formal description of the proposed link level protocol using the formal description technique which has been applied to the NBS transport protocol. In addition, NBS is analyzing a network interface sublayer required to map the requirements of the NBS transport protocol to the local area network protocol.

4.2 Selection Guidelines

The first product from the local area networking program is a guideline on the selection of these networks. This guideline will discuss the criteria by which Federal agencies specify, evaluate, and select local area computer networks based on applications. These guidelines will enable Federal agencies to perform a step-by-step analysis of their local computer networking requirements and to state these in functional terms. This selection criteria guideline will be available in 1981.

4.3 Measurement

The design and implementation of data communication facilities includes instrumentation, measurement, and control capabilities. To better understand how these capabilities apply to new local networking technologies, NBS has established a research program in the measurement and control of local area networks. This program includes the engineering of interfaces to local area networks, the development of low level software routines to gather data from these networks, and the development of analysis routines to aggregate data and to produce reports for the managers and engineers responsible for the performance and maintenance of the local area network.

The research goal is to develop expertise in the measurement and control of these networks and to apply this expertise to existing and planned Government local networks.

4.3.1 Measurement and Control Objectives

There are five objectives of the NBS measurement and control study. The first objective is to develop a local data network measurement and control system capable of recording and time tagging packets of data on the local area network. In addition, this system must be capable of generating controlled traffic loads. The second objective is to perform experiments under controlled loading conditions. From these experiments performance characteristics such as utilization, throughput, delay, and stability can be determined. The third objective is to study usage patterns of local area data networks; of primary interest is the data traffic to and from terminal nodes to major computing resources in the local community, and the intra and inter building traffic patterns. The fourth objective is to validate and verify proposed local data network models. The fifth objective is to evaluate the impact of host interfaces and gateways on the performance of local data networks. In this way the methods for interconnecting local networks to other local networks and interconnecting local networks to global networks will be analyzed.

4.3.2 Approach

The measurement and control center utilizes existing local area data networks at NBS. These networks include NBSNET, a local area broadcast packet switched network designed and implemented to support the scientists and engineers on the NBS campus. This network employs a carrier sense multiple access, collision detection protocol for sharing a common coaxial cable among all active users. In addition a small experimental CATV local area network, called the Mitrebus, will be utilized to study the technical control of radio frequency cable systems. The measurement and control center complete with its traffic generator will enable ICST to

perform controlled experiments in the local area networking laboratory.

5.0 REQUESTS FOR ADDITIONAL INFORMATION

The products described in this document take the form of Federal Information Processing Standards and Guidelines. In addition many intermediate results have been reported in NBS Special Publications, NBS Interim Reports, contractor reports to NBS, and papers published in trade and professional journals. Organizations needing more information or copies of any of the products or reports should write to the NBS at the following address:

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