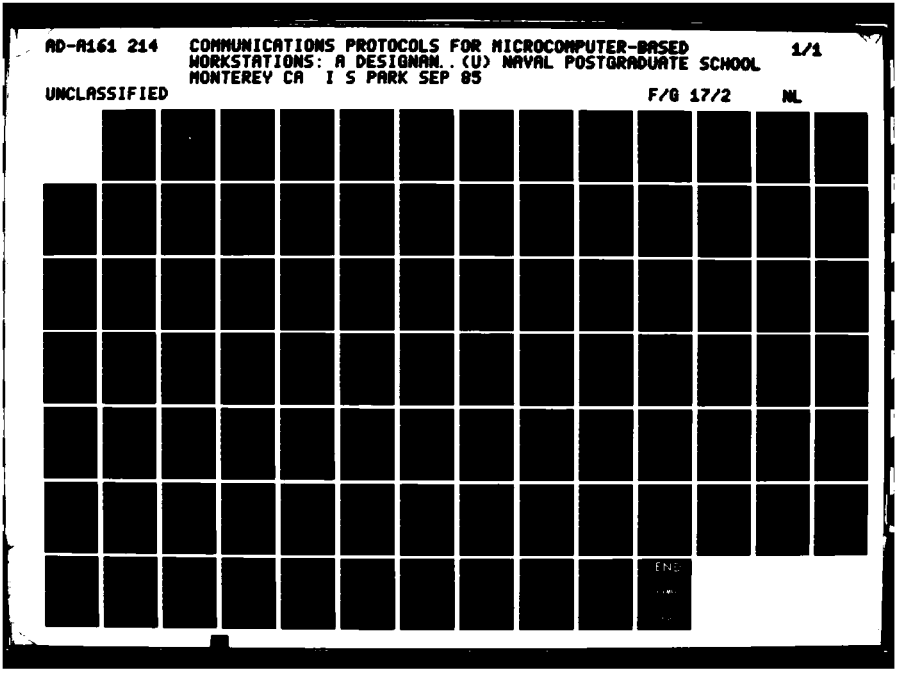
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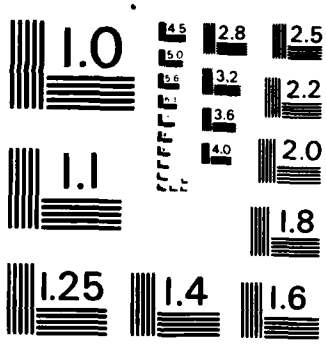

NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

COMMUNICATIONS PROTOCOLS FOR
MICROCOMPUTER-BASED WORKSTATIONS:
A DESIGN AND IMPLEMENTATION OF AN ELECTRONIC
BULLETIN BOARD SYSTEM (NPS-BBS)

by

Park, In Seop

September 1985

Thesis Advisor: Tung X. Bui

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The area of research for this thesis is to develop communications protocols required to support electronic mail and data transfer service through voice graded telephone lines using modems. This thesis concentrated on prototyping an IBM-PC based Electronic Bulletin Board System (NPS-BBS). Major features of NPS-BBS include electronic mail and data transfers as well as electronic notepad, on-line conversation, (Continued)

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ABSTRACT (Continued)

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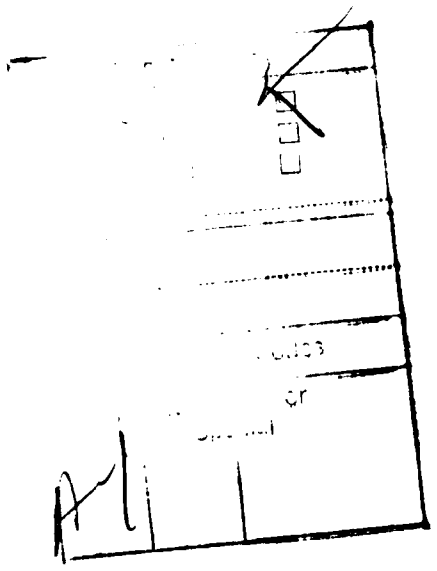

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Communications Protocols for Microcomputer-based Workstations : A Design and Implementation of An Electronic Bulletin Board System (NPS-BBS)

by

Park, In Seop
Captain, Republic of Korea Army
B.S.E.E., Kwang-Woon University, Seoul, 1979

Submitted in partial fulfillment of the requirements for the degree of

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September 1985

Author: Park, In Seop
Park, In Seop

Approved by: Tung Bui
Tung X. Bui, Thesis Advisor

Barry Frew
Barry A. Frew, Second Reader

Willis R. Greer, Chairman,
Department of Administrative sciences

K. T. Marshall
Kneale T. Marshall,
Dean of Information and Policy Sciences

ABSTRACT

The area of research for this thesis is to develop communications protocols required to support electronic mail and data transfer service through voice graded telephone lines using modems. This thesis concentrated on prototyping an IBM-PC based Electronic Bulletin Board System (NPS-BBS). Major features of NPS-BBS include electronic mail and data transfers as well as electronic notepad, on-line conversation, and running BBS under a multitasking operating system with MultiLink between remote and distributed microcomputer based workstations.

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My country, The Republic of Korea, gave me an opportunity to attend graduate studies in Information Systems. I am very grateful to a number of people for their help and encouragement.

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Special thanks to the members of The Capital PC Users Group Inc., a non-profit organization, that made its IBM-PC based Bulletin Board System available for this thesis. RBBS-PC has been selected to avoid the time needed for programming, and debugging. The Bulletin Board System implemented in this thesis is a value added protocol based on RBBS-PC.

I also appreciate my Indonesian classmate Mohammad Subekti, who has been very helpful, and Diane Gifford, who helps me with my English problem, and Chip Cooper, who is the system manager of the Epson-BBS network in Monterey California. They helped me a lot for preparing this thesis. Thanks again to my classmates.

I must thank Major Hong's family for their encouragement during the past three months. Finally, I must give thanks to my parents, my lovely wife, Young Soon, and my pretty two daughters, Jeong Eun and Han Mi, for their understanding and encouragement throughout the work.

I. INTRODUCTION

The purpose of this research is to explore design issues of Bulletin Board Systems (BBS). In particular, it focuses on communications protocols for micro mputer based workstations through the implementation of an electronic Bulletin Board System.

The first computer bulletin board system was created by Ward Christensen and Randy Suess in 1978 to enable local computer club members to call in and leave simple messages for one another. [Ref. 1]

Bulletin Board System (BBS) is a term used to describe the service allowing remote callers using a telephone and a computer terminal to access various functions. These functions range from simple message entering and retrieval to complicated database functions using large storage offered by minicomputers.

A bulletin board can be viewed as a community corkboard where computer users can read and post advertisements, items wanted, and future events. Add the ability to exchange personal messages between users. Electronic Bulletin Boards are springing up all over the country. They are being used for everything from small town-club activities to large scale, nationwide organizations. BBS already serves as a meeting ground for diverse groups of people scattered across the continent - a place where they can exchange comments, ideas, computer programs, tips, announcements, and other information. The phenomenon is just begining. But the potential impact is staggering. As computer and modem prices continue to fall, more computer bulletin board systems will come online. In the future, it is expected that BBSs may be seen as the most significant result of the

personal computer revolution. At the very least, the existence of computer based bulletin board systems means that no one needs ever be alone again. [Ref. 2: pp. 186-187]

Chapter II addresses a systems approach to design the NPS-BBS. Chapter III presents the environment which includes the need for communication, communication techniques, and advantages and disadvantages of BBS. The objectives of NPS-BBS design and implementation will be discussed in chapter IV. Chapter V deals with the roles and functions of the NPS-BBS which show the basic services provided by the system. Chapter VI presents three major system components. Chapter VII addresses the arrangement of NPS-BBS which links three components and describes development tactics. Chapter VIII is devoted to the evaluation of the NPS-BBS component. Finally, chapter IX provides some concluding comments and addresses issues for future research.

II. A SYSTEMS APPROACH TO DESIGNING THE NPS-BBS

This thesis adopts the Decision Support System (DSS) approach to analyze and design the proposed NPS-BBS. Furthermore, it follows the systems approach to understand the raison d'etre and mission of decision support systems. The use of the systems approach is motivated by the fact that it helps the information system design focus more on the problem rather than on the DSS itself.

The fundamental premise of systems theory (or the systems approach) is the systems, regardless of their specific context, share a common set of aspects or elements [Ref. 4]. The systems view, however, is an abstract model, as systems exist only in the mind of the analyst.

Systems thought emphasizes the need to take an holistic view to determine why an object is structured as it is, or how it should be structured. Thus the system study starts from without, identifying the environment in which the object exists and the way it impacts that environment, i.e., its role. Only after these external aspects of the system have been studied does it make sense to consider the internal aspects, i.e., the components and their arrangement. Following the study of these aspects, resources can be knowledgeably selected and allocated.

The following sections discuss briefly each of these system elements. [Ref. 5: pp. 3-7]

1) Environment : The environment includes all entities outside of the system boundary which affect or are affected by the system. The distinction between a system and its environment is somewhat arbitrary, and different observers may choose to draw the boundary in different places, i.e., including more or less in

'the system' itself. The entities in the environment may be affected by the system, but are not controlled by it. That is, the coupling between the system and environment is looser than that among the system components.

Entities in the system environment may include other systems, people (those who have a stake in the system and its performance), and the constraints placed on the system's operation.

2) Role/Function/Objective : The role, function, or objective of a system represents its (intended) impact on its environment. It specifies what services the system is supposed to deliver and what its goals are. It also provides the basis for evaluating the system, and thus should be specified in terms which are amenable to measurement.

3) Components : The components of the system consist of identifiable elements within the system boundary. The definition of component is, to a large extent, arbitrary, similar to the choice of where to draw the system boundary. It should, nevertheless, be guided by the reason for studying the system. A general understanding of a system may well be obtained from consideration of its macro-components, though a understanding of system function will require a complementary study at the micro-component level.

The consideration of components should be deferred until after the environment and role has been specified, because the decision about the internal system structure should be made and justified in the context of these external conditions.

The notion of components completes the conceptual perspective in systems study, namely as an environment, a system (the current focus), and its

components (the first level decomposition of the system). To maintain simplicity and to facilitate comprehension, components are presented without internal operational details(i.e., as 'black boxes'). Each could eventually be a subject for further study, applying the same conceptual hierarchy, albeit shifted "inwards" to reveal the internal structure of the component.

4) Arrangement : The arrangement concerns the links among the system components ; and between them and the environmental elements. The fundamental concern in arranging components is the balance between coordination and autonomy.
Generally, it is preferable to have the minimum of interdependence among components which still allows the system, as a whole, to serve its function.

5) Evaluation : How does the NPS-BBS, once implemented, meet the expectations outlined in the previous steps? What are the evaluation criteria? What can be done to improve the system?

The premise of the systemic view of NPS-BBS is that understanding it requires the simultaneous consideration of the five system aspects, i.e., the notion of the system's environment and objective, roles/functions, as well as the more concrete aspects of system components, the arrangement of those components, and finally evaluation of system implementation. Looking at any of these aspects in isolation from the others cannot result in a thorough understanding of a system. From the systemic vantage point, a meaningful BBS design process must explicitly translate the characteristics of the system's environment and objectives into specifications for, or constraints on, its components and their arrangement. [Ref. 5]

III. ENVIRONMENT

A. THE NEED FOR COMMUNICATION

The need for communication and information exchange between computers has grown rapidly in recent years with the increasing use of microcomputer-based offices and individual workstations.

Personal computers are increasingly popular with powerful capabilities and relatively low cost. A PC user will not want to become a standalone computer owner. Individual managers within organizations are independently procuring personal computers for standalone applications, such as VisiCalc and project management tools. Today's personal computers put processor, file storage, high-level languages, and problem-solving tools in an inexpensive, 'user-friendly' package. The reasons for acquiring such a system are compelling. However, collection of standalone processors will not meet all of an organization or particular group's needs. They need to exchange some information. There exist some files that, although specialized, must be shared by a number of users. Sometimes, members of a project or organizational team need to share work and information. By far the most efficient way to do so is electronically. [Ref. 6]

Each type of user is provided with electronic mail and word processing to improve the efficiency of creating and distributing messages, memos, and reports. These needs created a computer bulletin board system and it has now become very popular among computer people.

B. COMMUNICATIONS TECHNIQUES

1. Centralized Processing Technique

Centralized processing has only one central CPU and may distribute many terminals. Each workstation is connected by a point-to-point link to a common, central CPU. Communication between CPU and terminals is directly connected. For a workstation to transmit data, it must first send a request to the CPU, asking for a connection with itself. Once the circuit is set up, data may be exchanged between them. All communications are controlled by the central CPU, which must control and maintain a number of current data paths. Consequently the management of the CPU is rather complex. On the other hand, the communication processing required on the stations is minimal (see Figure 3.1 Communications techniques). [Ref. 6]

2. Decentralized Processing Technique

Decentralized processing is more flexible than the centralized technique. It consists of geographically distributed two or more CPUs and each CPU is connected to many terminals. The strength of the decentralized system is the reduction of CPU overhead. Geographically distributed or functionally distributed systems can reduce the heavy load of a centralized system in order to reduce the central overhead.

3. Network

Figure 3.1. illustrates three kinds of network topologies ; ring,bus, and tree networks. A brief explanation of these networks are described below.

Ring : In the ring network, the local network consists of a set of repeaters joined by point-to-point

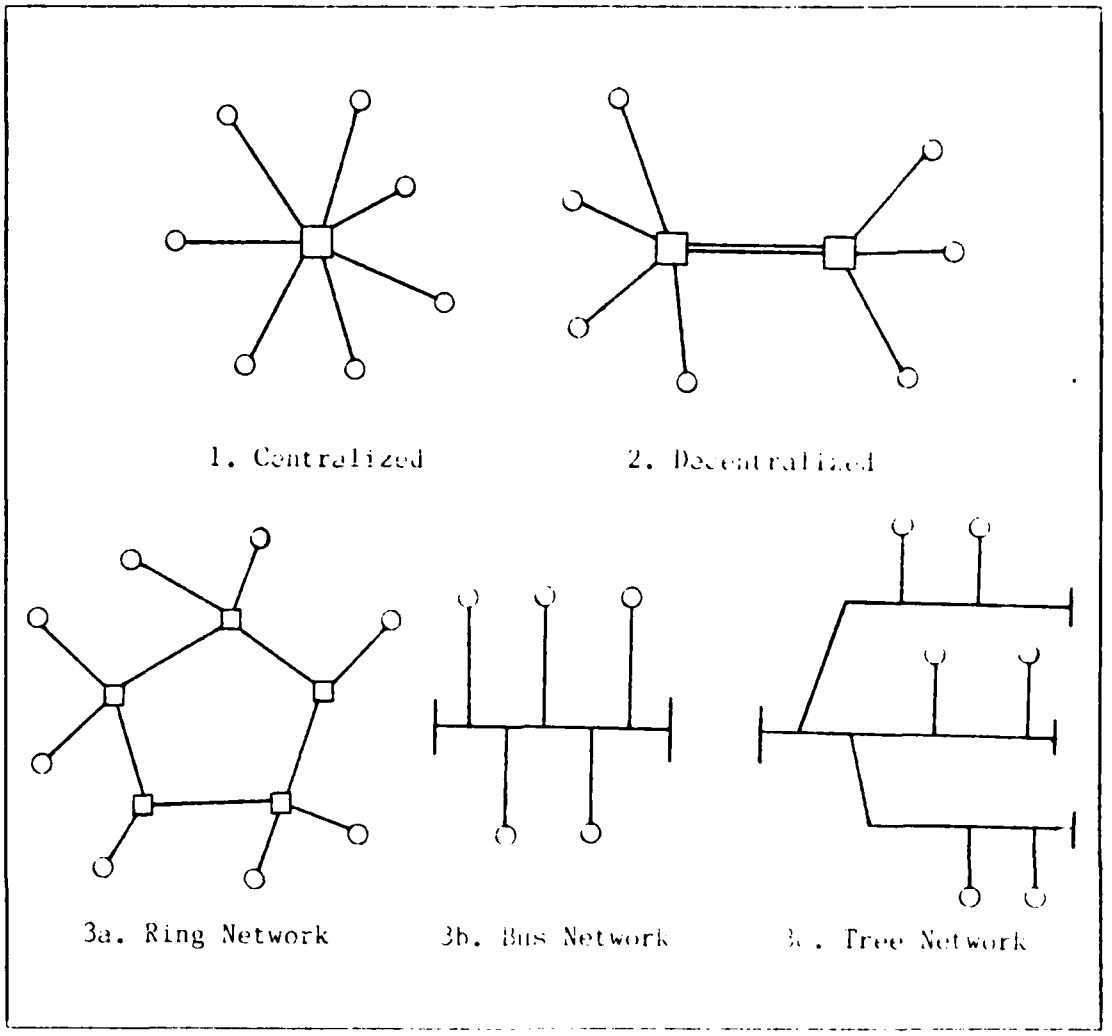

Figure 3.1 Communications Techniques.

links in a closed loop. Hence each repeater participates in two links. The repeater is a comparatively simple device, capable of receiving data on one link and transmitting it, bit by bit, on the other link as fast as it is received, with no buffering at the repeater. The links are unidirectional ; that is, data are transmitted in one direction only, and all oriented in the same way. Thus data circulates around the ring in one direction (clockwise or counterclockwise).

Bus : In a bus topology, the communications network is simply the transmission medium - no switches and no repeaters. All stations attach, through appropriate hardware interfacing, directly to a linear transmission medium, or a bus. A transmission from any station propagates the length of the medium and can be received by all other stations.

Tree : The tree topology is a generalization of the bus topology. The transmission medium is a branching cable with no closed loop. Again, a transmission from any station propagates throughout the medium and can be received by all other stations.

The above processing techniques are generalized communications techniques. On the other hand, BBS which will be described below is a application independant technique.

4. Electronic Bulletin Board System

Electronic bulletin board system is an application independent technique between remote workstations. Its relative ease of implementation has recently made it popular for communication between microcomputers. It has a central CPU server which provides BBS services to the other members of the network and make a star network with its workstations. Information exchanges between central server and remote caller are made via dedicated voice graded telephone line. It does not need a data grade line for operation of the system. Data lines are expensive and are not necessary. Figure 3.2 illustrates how NPS-BBS is connected and works. [Ref. 7]

a. NPS-BBS Program

The system manager is the person who operates the BBS. His/Her computer station is called the server. The

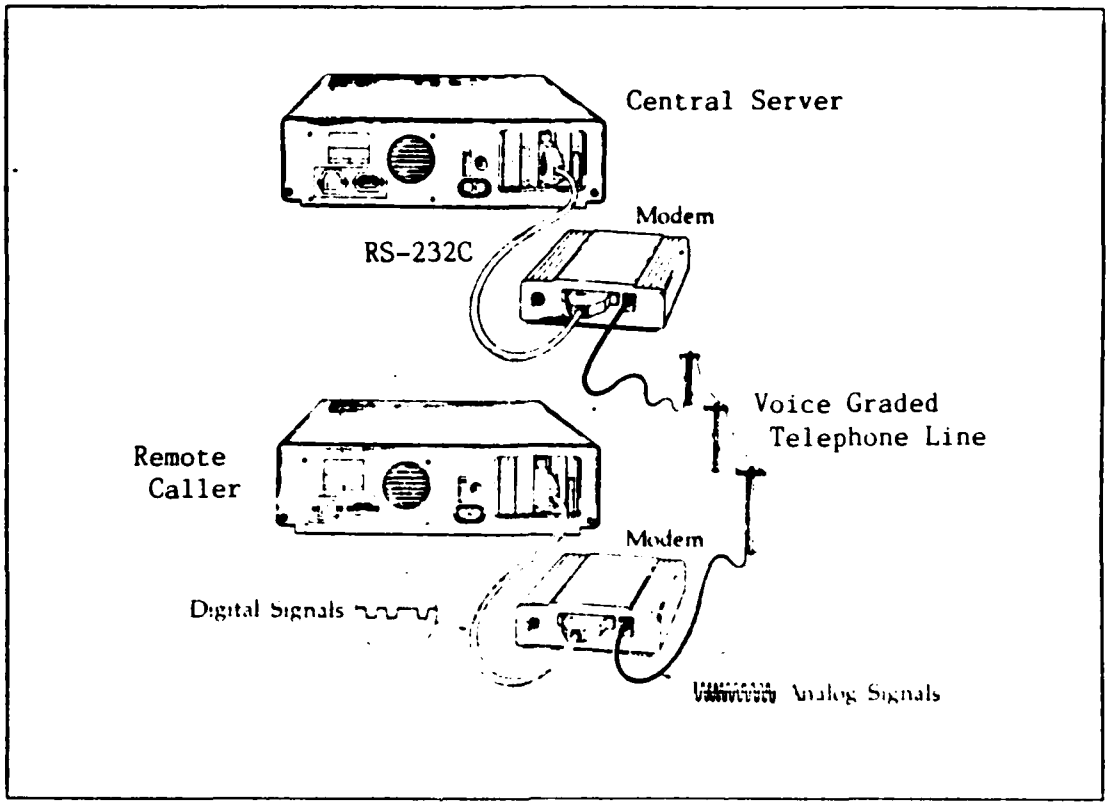

Figure 3.2 Connection Diagram for NPS-BBS.

latter should be equipped with the NPS-BBS software. The system manager's PC, which is the central server of the BBS network, should have a NPS-BBS communications program. Many services, such as electronic mail services, information utilities, offer enhancement like graphics and specially formatted screens that require a Special-Purpose Communications Program running on the PC. Special-purpose programs are written and distributed by a particular service and are designed to operate with only that service. Contrast this to General-purpose programs such as PC-TALK III, Smartcom II, Crosstalk XVI, which allow communication with many different services.

NPS-BBS is a communications program allowing the bulletin board to be used on an IBM-PC or other compatibles. To run NPS-BBS, The system manager will need a modem and RS-232C standard modem cable plus 128K of memory, two double sided floppy disk drives, and DOS 2.0 or a newer version. The program is written in interpretive BASIC and a compilable version is available also for 1200 bps use. More details of NPS-BBS will be described in later chapters. If the system manager wants to run this system under a multitasking operating system, such as MultiLink, he/she can run the BBS concurrently with another computing task.

b. Modem (MOdulator-DEModulator)

PC-to-PC communication requires a digital data link, but telephone circuits were designed for voice. The mouthpiece, or transmitter, in the telephone handset converts sound waves into their electrical equivalent. Instantaneous sound pressure values are translated into voltages and transmitted through the phone system. This analog signal is converted back to sound pressure at the earpiece of the receiver. Voice signals have different components at different frequencies, and the phone system accommodates a frequency bandwidth (range) of 300 - 3100 Hz. A device to convert the digital signal to an analog signal, that is compatible with the phone system, is required.

A MODEM, short for MOdulator-DEModulator, is an electronic device connecting your PC's serial port to a phone line. It is used to convert a digital bit stream into an analog signal suitable for transmission over some analog communication channel (modulation), and can convert incoming analog signals back into digital signals (demodulation). A modem converts +12 volts into a 1270 Hz tone and -12 volts into a 1070 Hz tone, as shown in Figure 3.3. Most modems for PCs are capable of operating at either 300 bits per

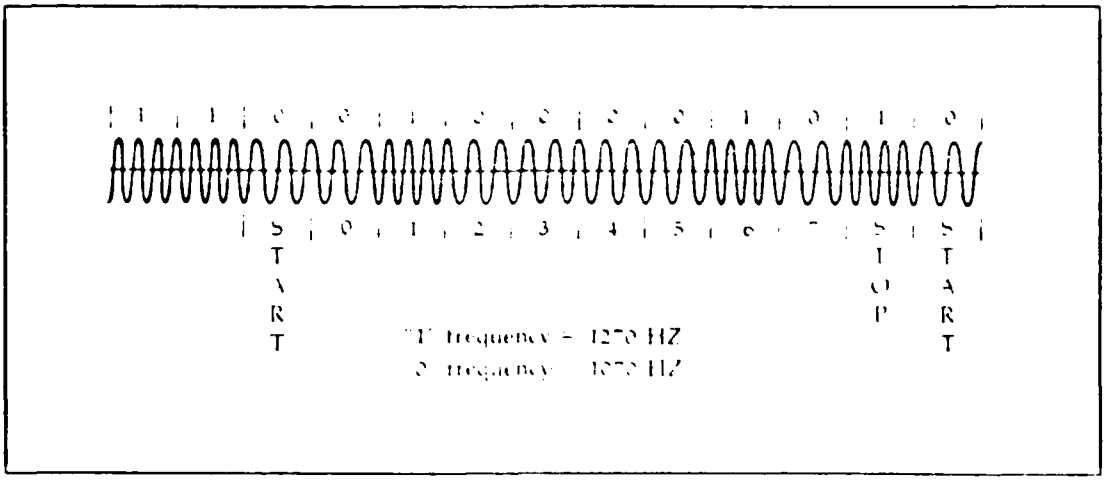

Figure 3.3 Analog Signal for Character 'B' as Transmitted by Phone Line.

second (bps) or 1200/300 bps, and most are automated so that they can automatically dial outgoing calls and answer incoming calls, eliminating the need for a telephone. A 300 bps modem allows communication at speeds of about 30 characters per second (cps). Bulletin board users have successfully pushed the 30 cps limit to 45 cps, but 30 cps is the low-speed standard used by information utilities. A 1200 bps modem allows communication at 120 cps, four times faster then a 300 bps modem. [Ref. 7]

The modem provides a two-way communications path between two computers. Since there is only one telephone circuit for sending messages in two directions, the two directions must be differentiated through the use of different signaling frequencies. In the 300 bps standard modem, the two frequency bands are 1070 - 1270 Hz and 2025 - 2225 Hz. By convention, the 1070 - 1270 Hz band is the originating channel used by a remote terminal (or PC) to send data to an information utility or another host system. The 2025 - 2225 Hz band is the answer channel used by the information utility to send data back to the terminal (or

PC). When a remote computer communicates with an information utility, the modem would transmit only at 1070 - 1270 Hz and receive only at 2025 - 2225 Hz, making it an originate-only modem. Indeed, most early modems were originate-only because of component costs. But two PC owners with originate-only modems cannot communicate with each other. At least one person must have an originate/answer modem, and fortunately, almost all available modems for the PC are originate/answer. [Ref. 7: pp. 159-160]

The NPS-BBS requires the use of a Hayes Smartmodem 300, 1200 or any modems that have the same functions, in order to operate properly. The switch settings on the modem are important and are shown in Figure 3.4 according to Hayes Modem Protocols : [Ref. 3]

Switch	Position	Symbol	Status
1	UP	MR	Modem Ready
2	UP	TR	Terminal Ready
3	DOWN	SD	Send Data
4	DOWN	RD	Receive Data
5	DOWN	OH	Off Hook
6	UP	CD	Carrier Detect
7	UP	AA	Auto-Answer Mode
8	DOWN	HS	High-Speed(1200)

Figure 3.4 Configuration Switches and Their Functions.

c. The RS-232C Serial Interface

RS-232C is an electrical interface standard for connecting system components such as modems, printers, and computers. The standard was established by the Electronic Industries Association (EIA), an industry trade organization. [Ref. 7]

RS-232C defines a 25-wire signal path that establishes 18 circuits with a return through ground. The standard also defines the voltages - the ranges for a logical '0' and a logical '1' - used in all circuits. Note that no physical damage results from a short circuit within the cables or connectors.

The RS-232C standard was defined by a committee, and the resulting interface had to satisfy an entire industry.

The PC and most communications equipment output signals of plus and minus 12 volts. However, an input of plus or minus 3 volts is enough to define the logic state. Figure 3.5a shows a clean signal going into a 100-foot cable. The noisy signal emerging from the other end is shown in Figure 3.5b, and the signal as it appears inside a receiving PC is shown in Figure 3.5c. Remember that the RS-232C signal in the cable is reversed in polarity from the TTL signal in the PC ; a 3 volts TTL logic '1' is equivalent to a minus 12 volts logic '1' or mark.

Wires lead to connectors, but the actual physical connector is not defined in the standard. Connectors have pins, and the pins are numbered 1 through 25. The RS-232C standard refers to pin numbers. The RS-232C pins that are available in the typical PC serial port are defined in Figure 3.6. Since the IBM-PC serial port uses only 9 wires, only the 9 signals used by the PC were described in that figure.

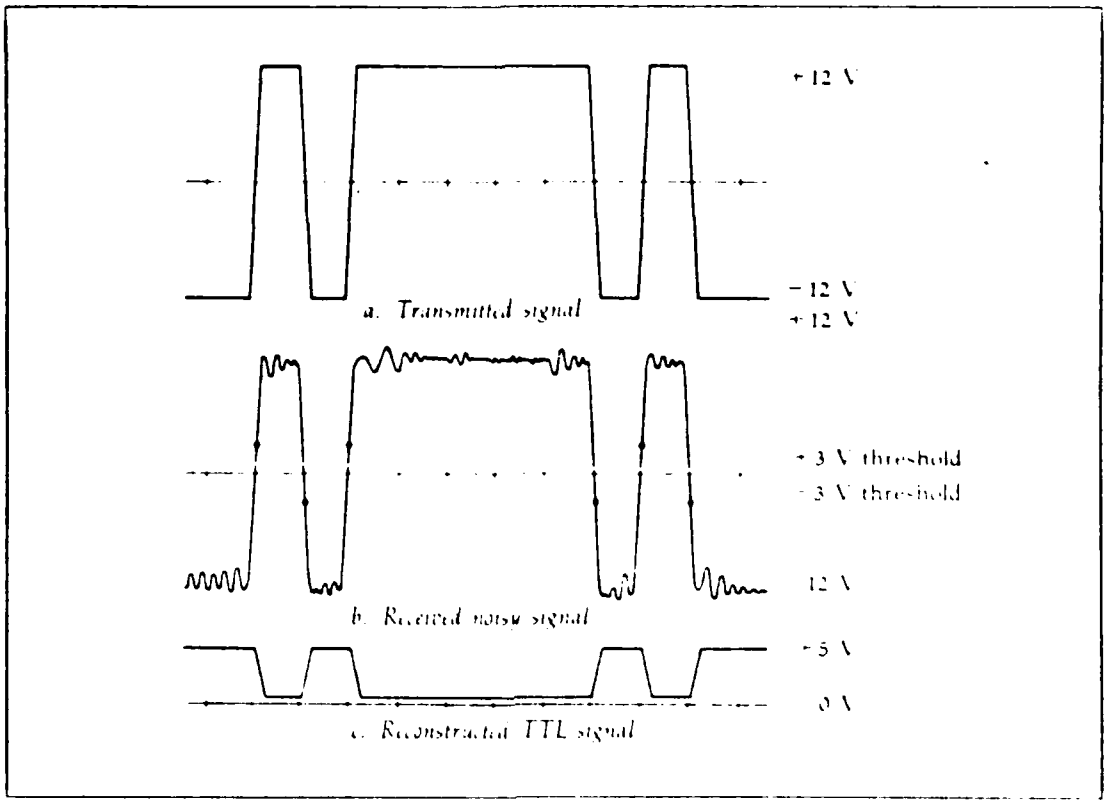

Figure 3.5 The Effects of Noise.

Most data communication tasks do not use all the circuits shown in Figure 3.6. The most important circuits are Transmit Data and Receive Data, pin-2 and pin-3. These are the two wires over which, serial data is simultaneously sent and received. The remaining circuits, with the exception of ground (pin-7), are control circuits. For the NPS-BBS to be activated, pin-22 must be connected on the RS-232C cable (that runs between modem and computer). Without pin-22 connected, even though the modem answers the phone, the program will never respond, due to the fact that it is not aware that the phone has rung and that the modem has answered. Pin-22 is the ring indicator coming from the modem going to the computer.

Pin	Signal	Description
2	Transmit Data	Data out from PC
3	Receive Data	Data into PC
4	RTS	Request to send, set by PC when it wants to send data
5	CTS	Clear to send, received by PC when device is ready for data
6	DSR	Data set ready, received by PC when modem is powered on and connected
7	Ground	Signal ground
8	CD	Carrier detect or received line signal detect received by PC when modem detects career
20	DTR	Data terminal ready, set by PC whenever data communication is active
22	RI	Ring indicator, received by PC when modem is receiving a ring signal (answer mode only)

Figure 3.6 PC serial port RS-232C Pin Definitions.

d. Communication program

The Special-purpose communications programs described above are designed to be used with specific information utilities. In contrast, General-purpose communications programs are designed to work with a variety of information utilities. Most general-purpose communications programs can allow access to services like The Source, CompuServe, or NPS-BBS from a menu and allow

automatic log in to each service at the touch of a key. These programs let remote users dial into a host PC, enabling them to run any of the host computer software, as if they were typing on the host computer keyboard. General-purpose programs also work with remote mainframes, minicomputers, and other PCs. A general-purpose program is essential for using bulletin board, doing PC-to-PC file transfers, and using most electronic mail systems. [Ref. 7: p. 133] Any microcomputer with an appropriate modem and appropriate general-purpose communications program such as PC-TALK III, Smartcom II, or Crosstalk XVI for the IBM-PC DOS can call NPS-BBS, which is the central server of the BBS network. PC-TALK III was selected for this thesis, since it is public domain software and is compatible with RBBS-PC.

C. WHY BBS IS NEEDED?

1. Trends toward Organization Decision Making

After nearly two decades of advancement in information technology, the real nature of information system requirements is still not well understood. The issue is further complicated by the realization that managers' needs and the needs of other 'knowledge workers', with whom they interact, are heavily interdependent. The DSS philosophy and approach has already shed some light on this issue by emphasizing 'capabilities' - the ability for a decision maker to do things with an information system - rather than just 'information needs', which too often implies, data items and totals on a report.

Nevertheless, it is tempting to call for a slowdown in the development of DSS until decision making and related managerial activities are fully understood. Although logically appealing, such a strategy is not practical. Neither managers, who face increasingly complex tasks, nor

the information systems industry, which has increasingly strong technology to offer, will be denied. They point out that a truely comprehensive theory of decision making has been pursued for years with minimal success.

A potential resolution of this problem is to develop and use DSS in a way that reveals what decision makers can, and should, receive from an information system. For example, the system should be designed to capture and track the steps taken by users in the process of making key decisions. Such a strategy would serve both as an aid to the analysis of the process and as a potential education device for new users. [Ref. 9: p. 36] Personal computers, computer networks, large databases, color graphics and computer based models such as LOTUS 1-2-3 or electronic BBS are among the technological developments which are stimulating interest in the use of computers to support decision making. Now, big changes of organizational structure are expected. Everybody who is employed in groups will have their own workstation and exchange information with the intelligent DSS software packages. Even they can work in their home through the data communication networks. Rapid development of software and hardware technologies, which lead to this result will be continued. This trend results from a development of electronic BBS and this technology is spreading all over the country from small town club activities to every office in an organization.

2. Advantages

The use of BBS provides a number of advantages : It offers better, faster, geographically remote communications between members of networks. Since BBS makes use of existing telephone lines, installation of special data communication lines is not necessary. This results in significant financial savings. Additionally, the members' PCs can be

used more efficiently and provide a reliable data transmission system.

3. Disadvantages

Busy signals are a fundamental problem with NPS-BBS. The system can handle only one-call-at-a-time. Therefore, the line must be free, in order to let a new user log into the system. More phone lines could be installed to get around the one-caller-at-a-time limit with a multi-user message system, such as Qbulletin. The latter is available from Quantum Software Systems, and it runs with the QNX operating system. The use of Qbulletin requires the user to learn a new operating system, and to have extra phone lines and necessary hardware [Ref. 7: p. 126]. NPS-BBS does not support multi-user message system.

IV. OBJECTIVES OF NPS-BBS DESIGN AND IMPLEMENTATION

The objectives of NPS-BBS design and implementation are to provide better, faster, and less expensive, geographically remote communications between members of the network.

To meet these objectives, NPS-BBS must be simple enough to be implementable to the user of NPS-BBS. It also must be flexible to be implemented with, and communicate with, a variety of existing BBS systems. Additionally, NPS-BBS must be capable of supporting both currently required services and be sufficiently extensible, so that new features can be added to it. [Ref. 8]

V. ROLES AND FUNCTIONS OF NPS-BBS

From the system manager viewpoint, the BBS should perform the following functions :

* It should have a function that can control the files, messages, and other data.
* It should get control of the system after the current user is off.
* It should allow local use of the central node without interrupting the BBS operation.

From the caller viewpoint, since the role of BBS is to provide an exchange of files and messages between workstations, it should have a function that performs electronic mail services, Data transfer and also have a notepad function and chat function, which can assure the conversation between system manager and caller.

A. ELECTRONIC MAIL (PERSON TO PERSON)

This function provides a mailer function between workstations. The user can send a message to the MESSAGES file, which is in system manager's PC (Which is CPU server). The user sends a message to the central node with a destination (his friends name) attached, when his friend logs on to the PC and calls the central node, he can find the message title by entering his password, and he can receive the message.

B. DATA TRANSFER

The user can also send some data files to another member. The user can upload the data file to the central node with a destination on it. These uploaded files are stored in DIR or DIR99 files which are system files with the name of the user who wants to send them. This information will automatically appear in the receiver's screen when he calls the system. At that time, he can download the file using PC-TALK.

C. NOTEPAD (COLLECTIVE BULLETIN BOARD)

Collective bulletins provide a means of displaying general information. Topics can include anything, computer related or not, which might provide useful information to users. Thus, a user can ask, or send, any information to members of the network using a collective bulletin board. NPS-BBS provides a maximum of 6 bulletin boards. Anytime the user wants to send something, he can notify all members or individuals and can receive from any the member who has a response.

D. CHAT (SYSTEM MANAGER VS CALLER)

A chat function allows the caller to talk directly with the system manager while on-line with the bulletin board system. Why have a chat function? A new caller often has difficulty performing some function or cannot understand the protocol used by the system. By having an option to talk to the system manager, these problems can be dealt with as they arise.

E. BBS UNDER MULTILINK

MultiLink is a software product of The Software Link Incorporated. It interfaces to the PC-DOS and enables it to act as a multi-tasking, multi-user operating system. MultiLink has the ability to run electronic communications in a 'background' mode without affecting usage of the machine for standard operations. With Multilink, system manager can use the central node for his own working PC without interrupting the BBS service.

VI. COMPONENTS OF NPS-BBS

This chapter deals with the three major technology components required to build NPS-BBS. The approach used for structuring the technology is the user interface dialog component, data component, and the communication component. This paradigm has proven valuable in organizing the functions and capabilities that must be provided in order to develop and build an effective bulletin board system. This is currently the most widely used approach. [Ref. 9: p. 195]. Figure 6.1 shows the interrelation of each component.

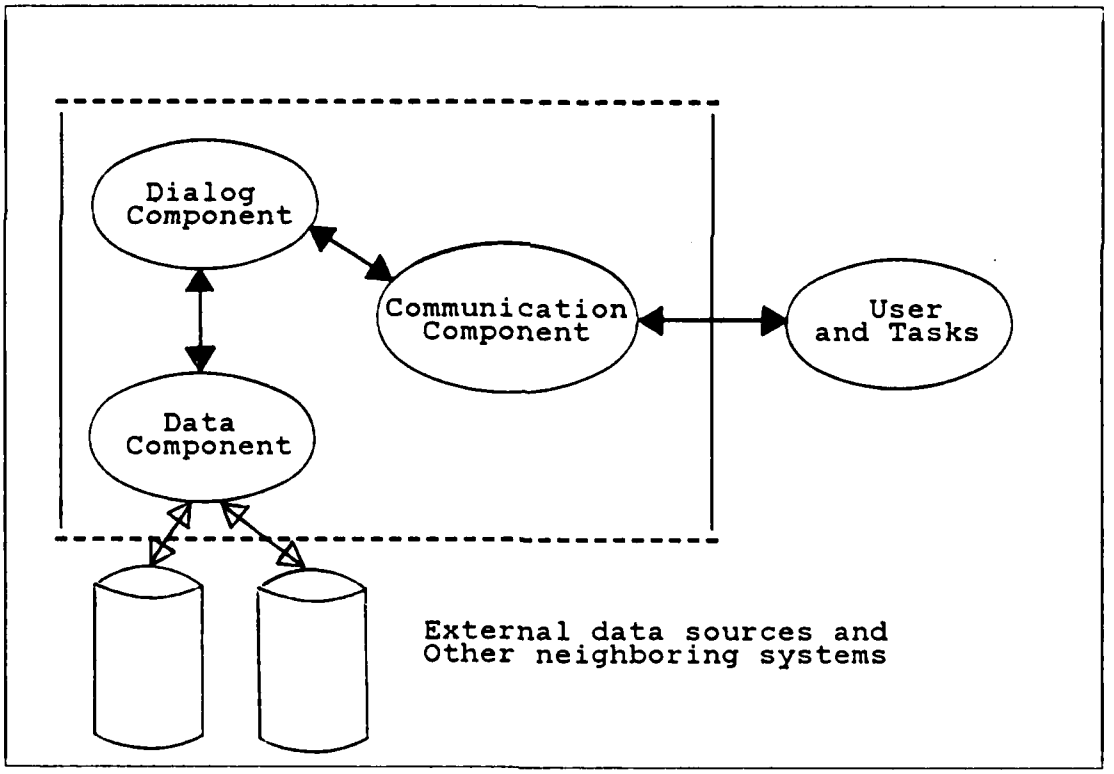

Figure 6.1 NPS-BBS Design -- Major Components.

The justification for each of these components can readily be seen if we consider the NPS-BBS environment, objectives, roles and functions. The most pervasive and fundamental aspects of the NPS-BBS environment are the people. From a DSS point of view, the dialog manage is the specialized component which handles the man-machine interaction. The communication component reflects another fundamental aspect of the NPS-BBS. It uses public voice telephone lines and does not require special data lines for networking. All data are controlled by system manager.

The following section discusses in detail the theory and the composition of each component.

A. USER INTERFACE DIALOG COMPONENT

Much of the power, flexibility, and usability characteristics of a decision support system depend on the capabilities in the interaction between the system and the user. For years there have been systems with strong computational algorithms or excellent data access routines, but whose effectiveness was limited because they were difficult to use. In fact, from the NPS-BBS user's point of view, the Dialog is the System. All the capabilities of the system must be articulated and implemented through the dialog.

1. Examples of Dialog Styles

Examples of dialog styles are described below. The examples given in this section certainly do not cover all possible dialogs, nor do they necessarily represent the best dialog styles. The examples are classified according to the "style" of the dialog that takes place between the user and the DSS. [Ref. 9: pp. 199-204]

a. Question-Answer Dialogs

A dialog style that is very common in DSS, employing line-at-a-time terminals, is the question-answer (Q/A) design. Figure 6.2 shows a Q/A dialog from the MYCIN system. [Ref. 10]

```
--------PATIENT-248--------
1)  Patient's name: (first-last)
**  C.R.
2)  Sex:
**  MALE
3)  Age:
**  52
4)  Have you been able to obtain positive microbiological information about
    a possible infection of C.R.?
**  YES

        --------INFECTION 1--------
        5)  What is the infection?
        **  ENDARTERITIS (6)
        6)  Please give the date and approximate time when signs or symptoms of
            the endarteritis (INFECTION 1) first appeared. (mo da yr time)
        **  21 JULY 1975
        The most recent culture yielding positive microbiological information
        about the endarteritis (INFECTION 1) will be referred to as:

                -------CULTURE 1--------
                7)  From what site was the specimen for CULTURE-1 taken?
                **  BLOOD


Questions from MYCIN preceeded by: 1), 2),...
User answers are typed in following: **
```

Figure 6.2 Q/A Dialog from MYCIN.

With Q/A dialogs, the DSS asks the user a question (possibly multiple choice), the user answers the question, and so on, until DSS produces the answers needed to support the decision. As shown in the MYCIN example, a Q/A dialog may use 'natural' language, and may determine the next question based on the answer(s) to the previous question(s). If the DSS can not 'understand' an answer, or

needs additional information, clarification questions may be asked. In some DSS the user can redirect the questioning by giving answers such as 'SKIP QUESTION' or 'BEGIN WITH QUESTION 25.'

Q/A dialogs tend to be most successful for inexperienced or infrequent users who are unfamiliar with the problem to be solved. Q/A dialogs tend to be least successful for sophisticated or frequent users, who get tired of proceeding through the questions. To accommodate both frequent and infrequent users, a Q/A dialog may provide more than one mode of use (e.g., full sentence mode and abbreviation mode) or may have default answers. The Q/A dialog leads to awkward usage patterns if, during a dialog, users need to modify answers to previous questions.

b. Command Language Dialogs

A second dialog style is to develop a common language for invoking DSS functions. The usual format of command dialog involves verb-noun pairs (e.g., PLOT SALES) with short spellings (e.g., six to eight characters) for the nouns and verbs. Figure 6.3 gives an example of a command language dialog. [Ref. 11]

The implied verb is "PRINT" and the output commands are a set of nouns. Several existing DSS use this style of dialog. For simple applications, a command language is easily learned, but it will probably need to be relearned by infrequent users. For complicated applications, a common language can easily become a programming language, thereby requiring more skill to use. It is, however, possible to develop a "layered" command language. In a layered language there are simple commands for simple or frequently used functions, and these commands can be combined with other, more complicated commands for complex or infrequently used functions.

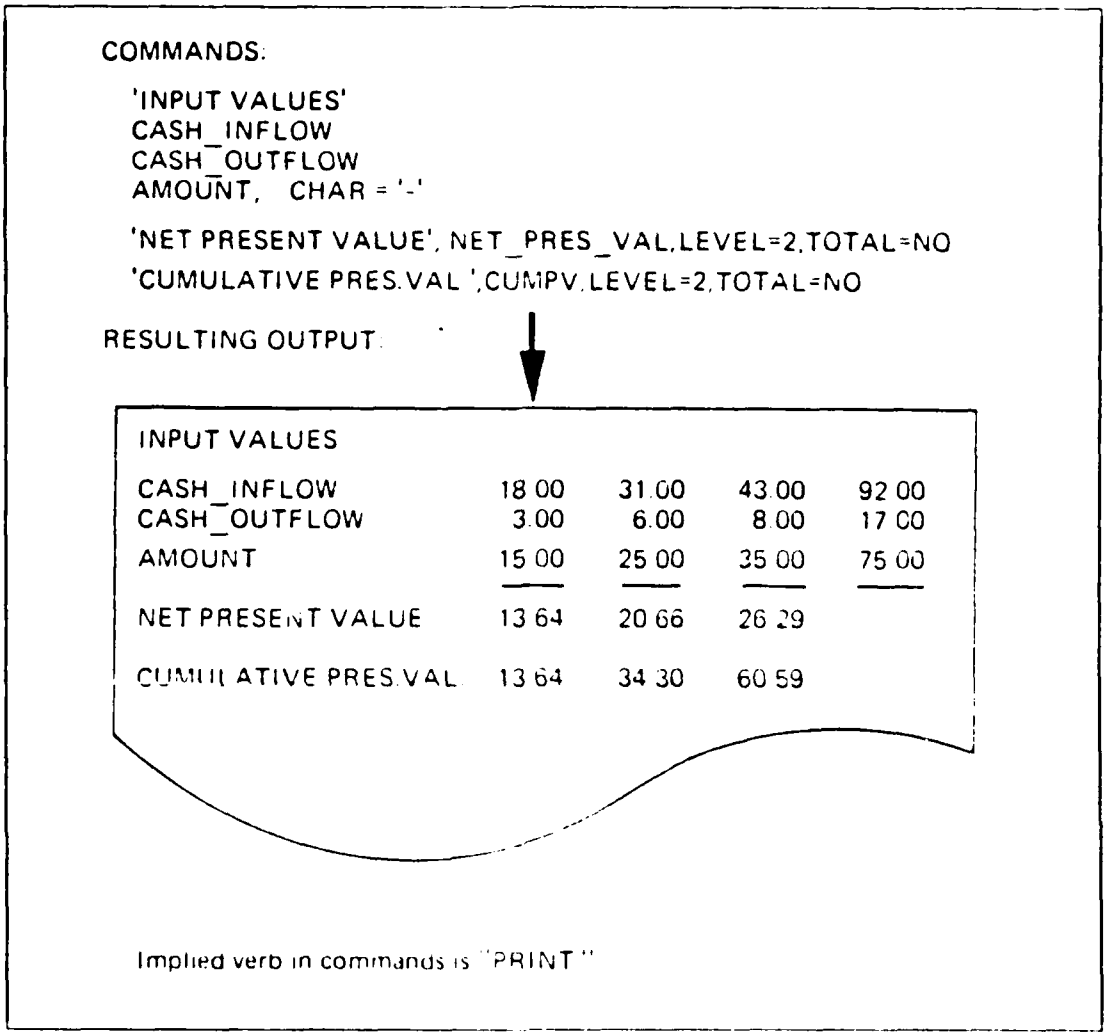

Figure 6.3 Command Language Dialog from PLANCODE.

c. Menu Dialogs

A popular dialog style for DSS is the menu dialog. Instead of having to type commands, a menu dialog lets the user select from a menu of alternatives, such as report names or computation commands. Selection is accomplished with a keyboard or a "picking" device such as a light pen. Figure 6.4 illustrates a menu interface from NPS-BBS.

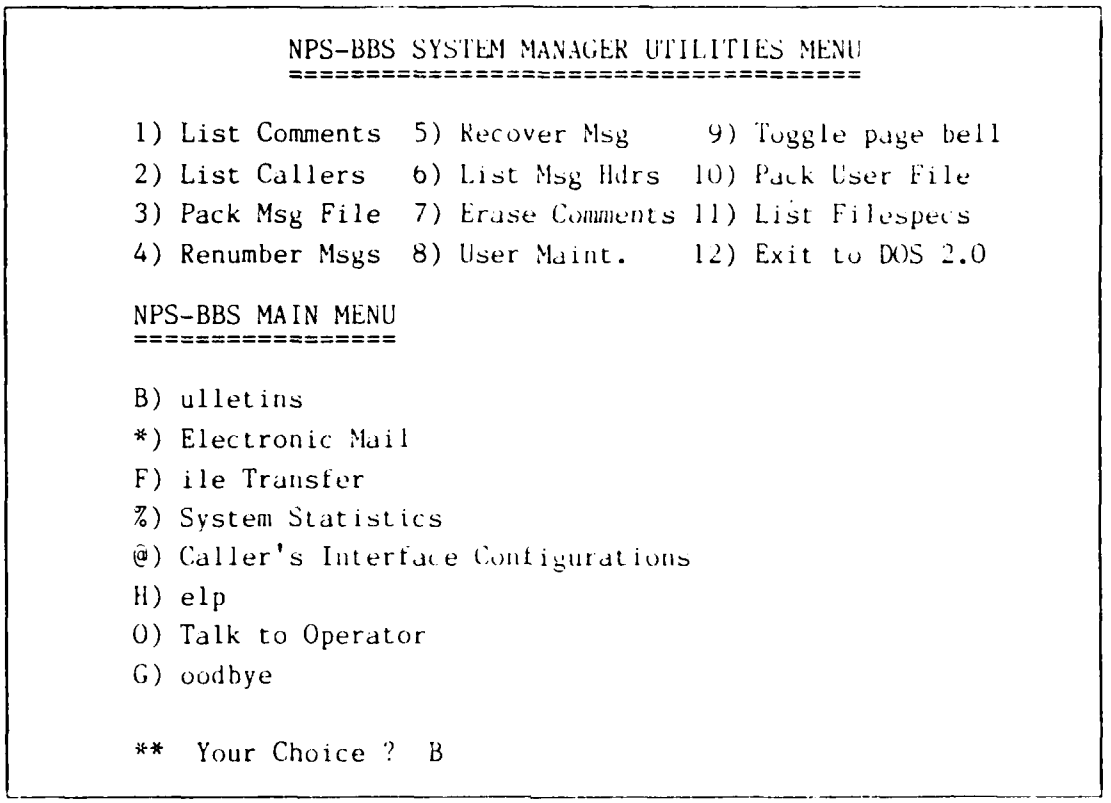

Figure 6.4 Menu Dialog from NPS-BBS.

The menu lets the user select the type of reports to be displayed by the DSS.

The menu dialog seems to be quite effective for inexperienced or infrequent users who are familiar with the problem to be solved. For DSS that provide a large number of functions, menu dialogs often require many menu items, and in such cases the menus should be structured. Restaurant menus are examples of structuring by grouping (entrees, desserts, wines, etc). Another structuring technique is to use hierarchies of menus. NPS-BBS use this style and Q/A dialog style.

d. Input Form/Output Form Dialogs

Input form/output form dialogs provide input forms in which the user enters commands and data, and output forms on which the DSS produces responses. After viewing an output form, the user can fill in another input form to continue the dialog. If the system determines which input form is next, this dialog style parallels the Q/A style, with input forms corresponding to a set of answers. Figure 6.5 shows an input form and an output form from Query-by-Example. [Ref. 13]

Input form/output form design can be very successful if there is a correspondence between the input/output forms in the DSS and paper forms or thought patterns which are familiar to the users. For example, an input form can correspond to an existing checklist, or it can be arranged to group items that a decision maker is likely to think about together.

e. Input-in-Context-of-Output Dialogs

An extension of the input form/output form dialog is to combine input and output forms so that user inputs are always given in the context of the previous output from the DSS. In this dialog style, the DSS presents an output (e.g., a table or a graph or a list), within which, the user may fill in or select inputs that will either modify the current output or result in a different output. For example, a skeletal report giving sample or standard data can be used as an input form if the user can write new data names or selection criteria on the report for subsequent use as inputs to the DSS. More sophisticated versions of this type of design combine menus of commands that can be used to create and modify an output form. Figure 6.6 gives an example from GADS where many inputs are given in the context of previous DSS output. [Ref. 14]

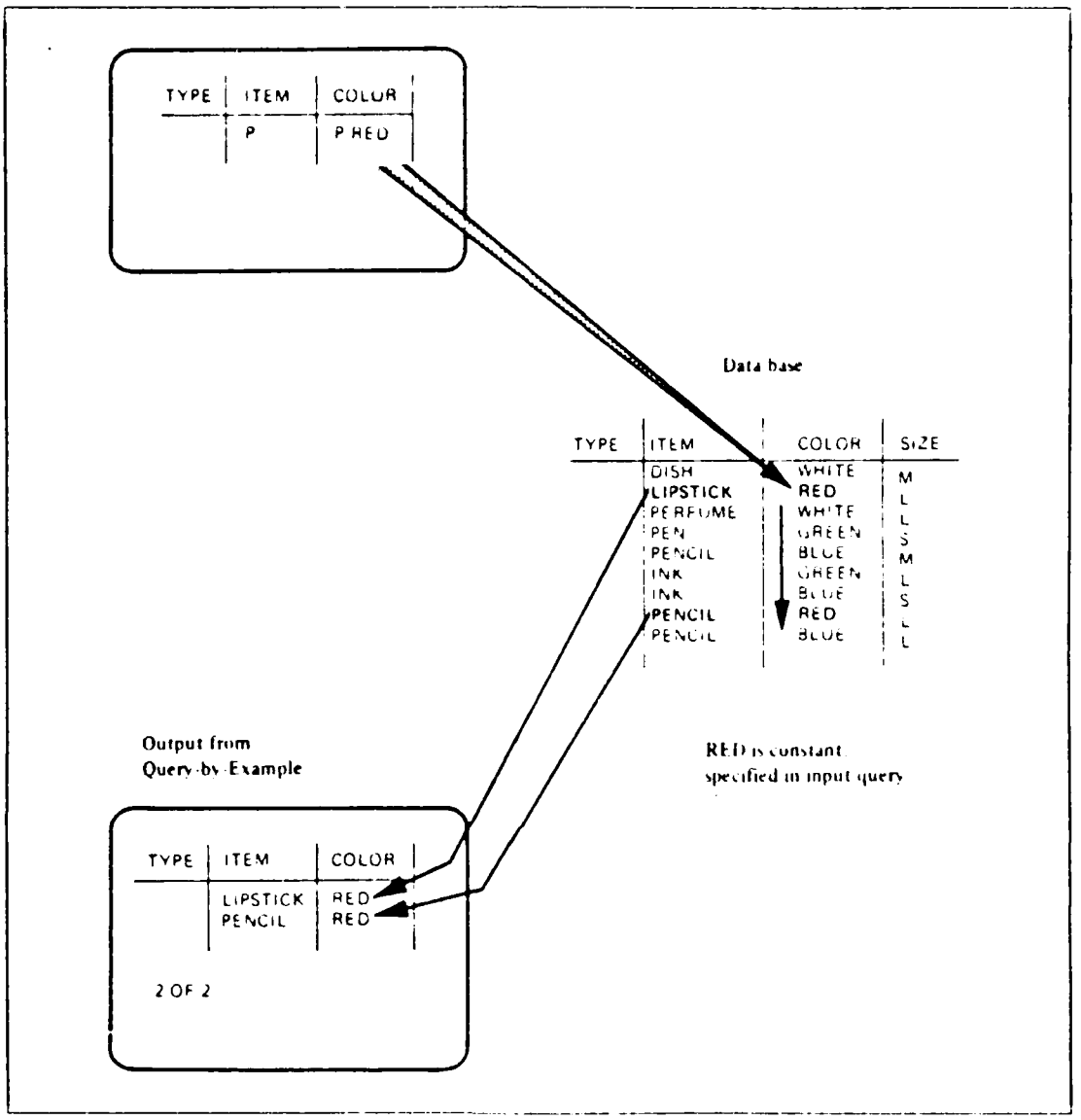

Figure 6.5 Input Form/Output Form Dialog from Qyery-by-Example.

The output is a scatterplot and the inputs for any scatterplot are given beneath the output. The inputs are the variable names (TBASE, CEIDENT) and the xy axis scale (0-200, 100-610). An output/input context dialog can provide a "high-function" user interface which supports

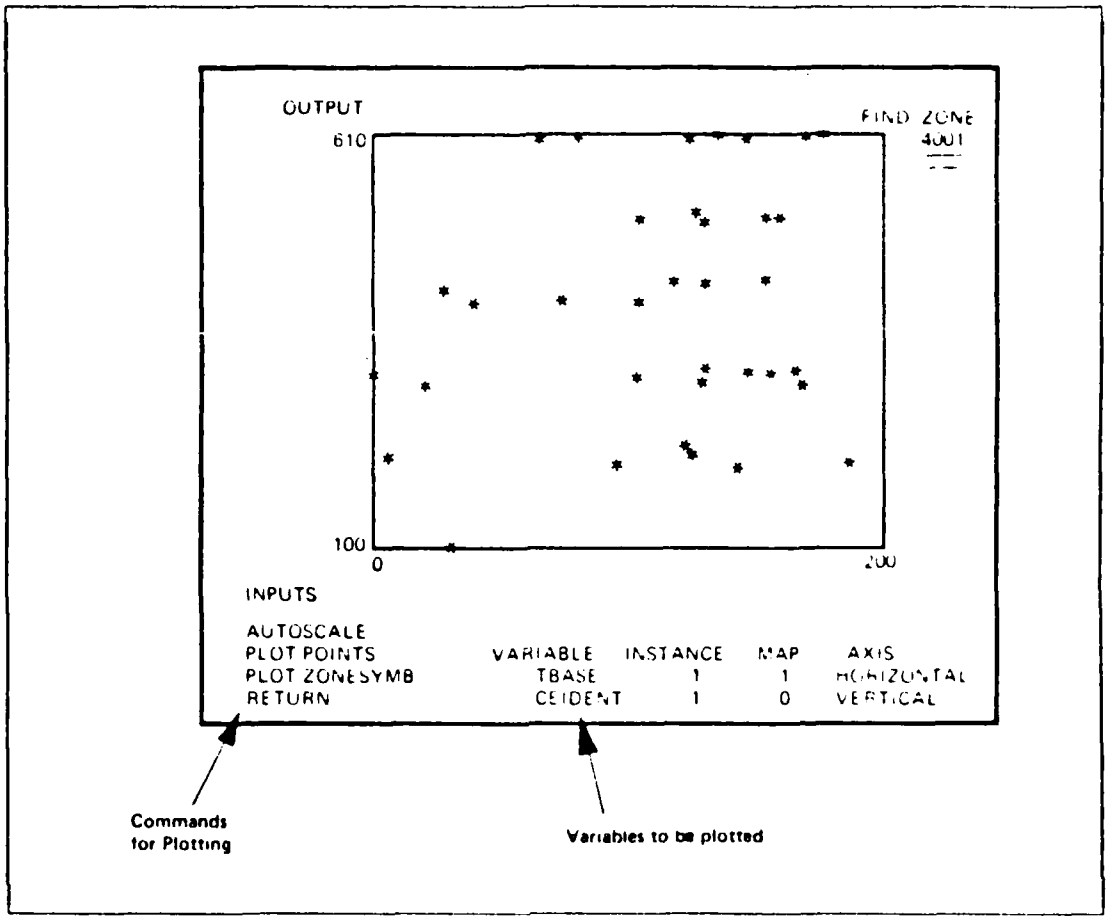

Figure 6.6 Input-in-Context Dialog from GADS.

complex decisions. Using a system based on this design, however, is likely to require a few hours of training. [Ref. 15]

f. Combinations

It is likely that the dialog component for a Specific DSS will combine one or more dialog styles. For example, a Q/A dialog could be used in a "help" or "tutorial" feature of a DSS, with command or menu dialogs being used for routine interactions. In such a DSS, the HELP command would invoke a Q/A dialog to assist the user in

accomplishing a task. The multiple-choice answers could be the possible commands that the user could have selected from the menus to accomplish the same task. Thus the Q/A dialog can help train users. Another possible combination is to use menus for command selection in a command language dialog or to use menus for input to an input-in-context dialog.

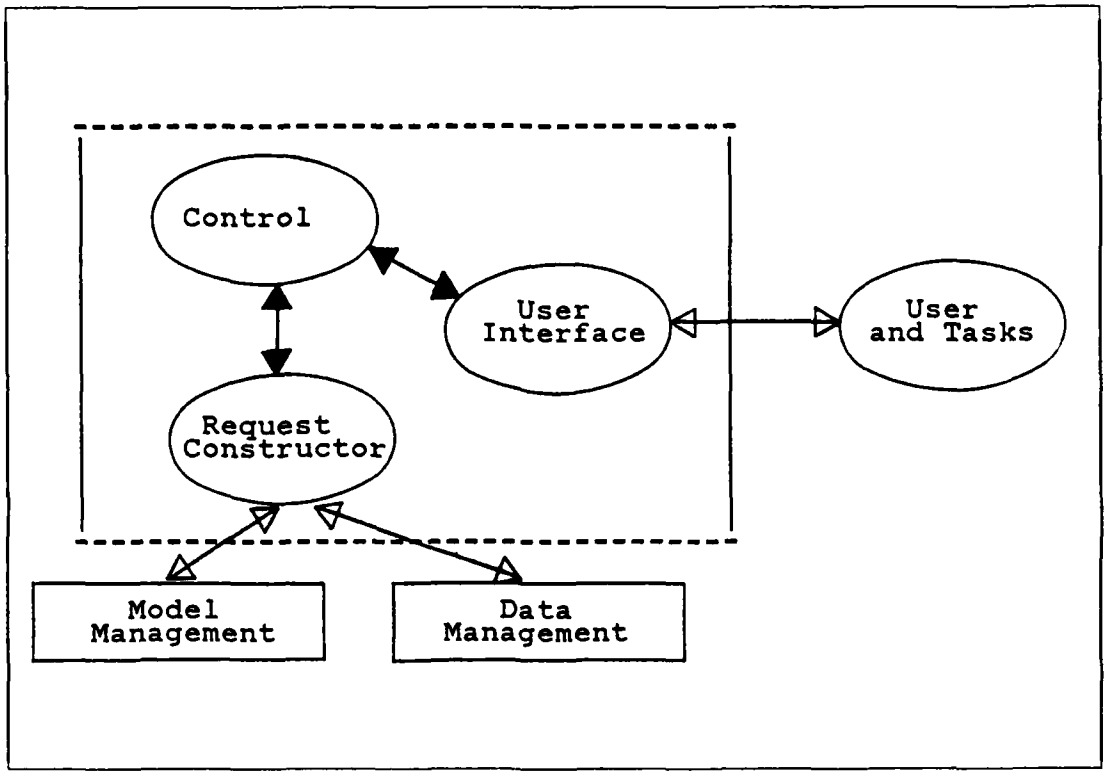

Figure 6.7 The Dialog Management of NPS-BBS.

The management of the dialog between the user and the system implies providing and managing the framework, in which, outputs are presented and, in which, inputs are specified. The traditional focus on the input side should not mislead. The dialog is a two way process, in which output presentation defines the context for the subsequent user action. The three functions identified as part of an ideal dialog management sub-system are shown in Figure 6.7.

The user interface unit provides the link between the user and the system. Conventional man-machine interaction often has a menu-driven style and a hard copy output. Recent technology continues to enhance man-machine interaction by using colorful graphics, sounds, joysticks, etc. The NPS-BBS provides links between remote terminal and the central node using conventional menu-driven style with colorful graphics and beep sound and question-answer one-line-at-a-time style. [Ref. 16: p. 14]

2. Menu Tree of NPS-BBS

There exists a fundamental limitation in our ability to manage a number of different objects or concepts at one time. In 1954, the psychologist George Miller concluded that the limit to the number of entities humans can process at one time is roughly 7, plus or minus 2 (See Figure 6.8). [Ref. 17: p. 31]

According to this theory, NPS-BBS was designed to avoid the menu which has more than 7 subselections. Figure 6.9 shows the menu structure of the NPS-BBS.

a. Main Menu

When a caller calls the bulletin board, he can see the NPS-BBS main menu. According to the appropriate order, he can just follow the instructions. The menu structure was designed to be user friendly. The items in the menu are explained below :

B) ulletins : You can see the system bulletins.

*) E - Mail : When user wants to send a mail, this key allow to extend a E-mail menu.

F) ile transfer : When user want to send a file, this key allows to go into Data Transfer Menu.

%) System statistics : When user want to see system

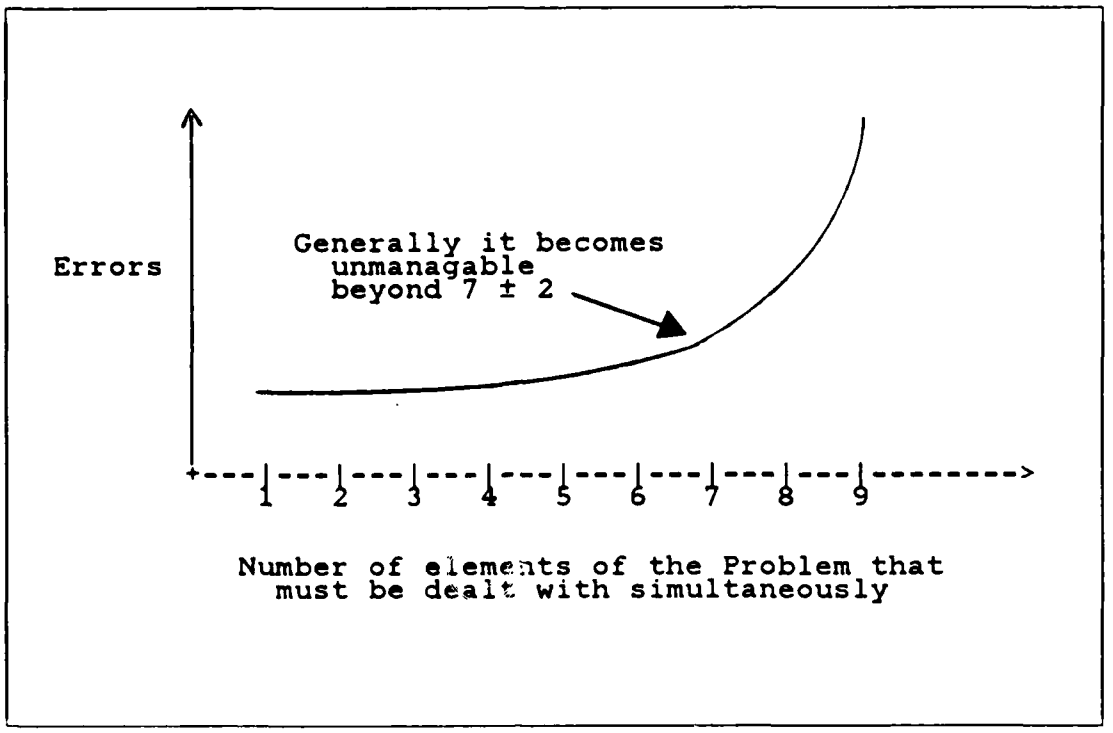

Figure 6.8 Error Curve for Normal Problem Solving.

statistics data, this key extends to a SYSTAT menu.

@) Caller's interface configurations : When user want to change the interface configurations. This key extends to a Caller's Interface configuration Menu.

O) Talk to system manager : This key forces beep sound on central node to enter the chat mode.

G) ood-bye : This key disconnect the system.

b. Electronic Mail Menu

If the user wants to send or receive a message to other members, by typing '*' from the main menu, he can enter the E-mail menu. He can control the messages that he

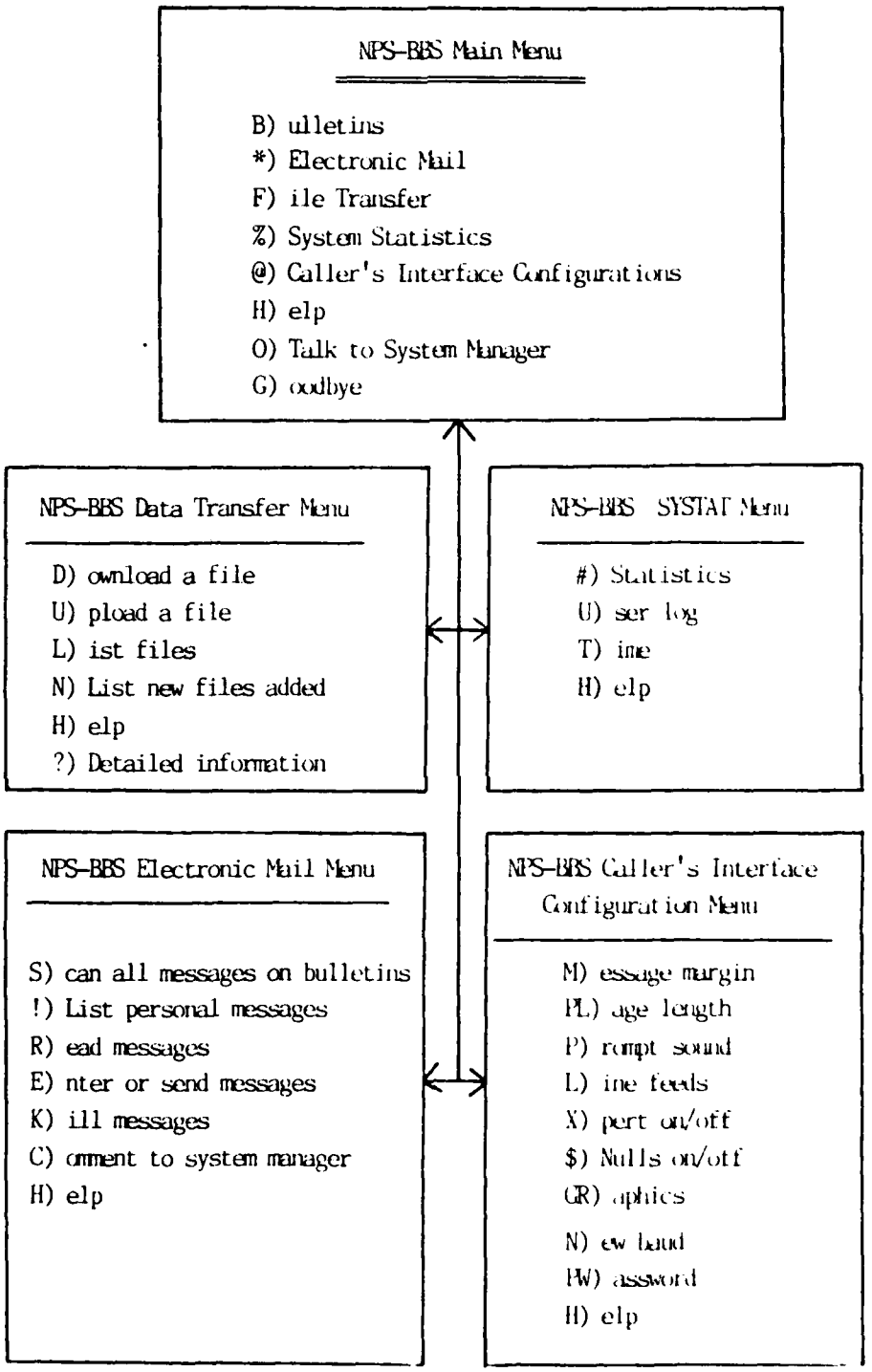

Figure 6.9 The Menu Structure for NPS-BBS User.

wants to work with. The E-Mail menu includes following elements :

S) can all messages : He can see messages that were sorted as a public message.

!) Scan personal message : He can see the messages that were directed to him, specifically.

R) ead messages : Using this key, he can select message numbers that he want to read.

E) nter or send message : He can write and send a public or personal password protected message.

K) ill messages : He can kill the messages that he left before.

C) omment to system manager : he can send a private message to system manager.

H) elp : Help file in E-Mail menu.

c. Data Transfer Menu

By choosing 'F' from the main menu, the user can enter the Data-transfer menu that allows the exchange of files with other members. The following functions are included :

D) ownload a file : He can receive a file which was stored in the system manager's data file.

U) pload a file : He can send his file to system manager's data file. Later, another user can receive that file.

L) ist files : He can see titles of files that are ready for downloading.

N) List new files added since last log on : He can see new files in directory from last log on.

H) elp : Help for data transfer information.

?) Detailed information : He can see the detailed instruction for uploading and downloading.

d. SYSTAT Menu

This system statistics menu shows the statistical data that the system has. The BBS user can see present time, user log etc. SYSTAT includes :

#) Number of callers and message

U) ser log list

T) ime of day and elapsed time of call

H) elp for the SYSTAT menu

e. Caller's Interface Configuration Menu

The '@' prompt allows the user to alter the caller's interface configuration menu. The following parameters can be modified :

M) essage margin : Set the right text margin

PL) age length : Change scroll page length
(0 is continuous)

P) rompt sound : On/off toggle

L) ine feed : On/off toggle

X) pert on/off : Toggle between novice and expert menu

$) Nulls : On/off toggle switch

GR) aphics : Toggle graphics menus on/off

N) ew baud : Baud rate switch from 300 to 450

PW) assword : Change message protection password

H) elp for the caller's interface configuration menu

3. Caller Activities

Two most frequent BBS activities are message and file transfer. There are two basic ways to transfer data to and from NPS-BBS. One way is the straight ASCII text file transfer. This simply means that the data to be sent is sent over the phone line as if it is on the disk file. No error checking of any kind is done and data can be modified by a bad phone connection. BASIC program files can be sent or received written in ASCII. The other method used on this system for file transfer is the CP/M method, commonly referred as the XMODEM Error Checking Protocol, which will be described in the appendix D [Ref. 7]. This transfer method does error checking to ensure that the data being sent or received is intact. The file checking method uses a checksum of the data bytes sent to verify data correctness. This is the preferred method when exchange programs are written in binary files.

a. Transfering Messages

The caller can enter the E-Mail menu by typing '*' from the main menu. From the E-mail menu, hitting the 'E' key allows the BBS user to enter or send the messages to system bulletins. The system will display a message number and 'To (C/R for ALL) :'. If a personal message must be sent, the friend name must be declared. A <C/R> will make the message public. Then system will give you a subsequent question such as subject, message status etc.

b. Transfering Files

Typing 'F' from the main menu allows the caller to enter the transfering files menu. In the file transfer menu, hitting the 'U' or 'D' key permits uploading or downloading the file to/from the system manager's data file.

(1) To Transfer ASCII File. ASCII files (e.g., text files) can be easily transfered since the communication parameter of PC-TALK is already set to E,7,1 which is Even parity, 7 data bit (default option).

* Type Alt-R to receive a file from the central node.
* Then type path:filename to download (e.g. a:MYFILE.TXT).
* The system will begin to download file block by block. When the transfer is finished,
* Hit Alt-R again to terminate reception.
* At this time PC-TALK will save the contents of the downloaded file from the virtual drive (RAM) to the default diskette drive. The use of the virtual drive stored in the computer random access memory helps shorten I/O time.

(2) To Transfer Binary File. When binary files (e.g., .COM, .OBJ, .EXE, etc) are uploaded or downloaded, NPS-BBS automatically checks the communication parameters (they should be N,8,1). If it was not correctly set, it will automatically switch that parameter into N,8,1 with PC-TALK. The caller must specify to the computer that the downloading file is binary by adding the command : filename = x at the end of the downloading file specification. PC-TALK then checks the communication parameters at the remote computer and, if necessary, requests a corresponding binary protocol. Once adjusted, Alt-R should be requested again to activate the transfer.

After the transfer is terminated, the communication parameter should be replaced to the text protocol (i.e., E,7,1).

c. Other Communications Activities

(1) CHAT with System Manager. Another service offered by NPS-BBS is the capability to talk with the system operator when the latter is nearby the host system. By typing 'O' from the main menu, a caller can call the system operator. If the latter is available, he will hear a beep sound that notifies him the caller wants to talk with him. By hitting function key 10 from the central node, on-line talk can be routed through their screens.

(2) Bulletin Board. A caller can use the system bulletins as his public notepads. Like a newspaper classified advertisement, he can advertize or request anything that he wants to know or make announcements to other members of the network. Also, he can send private messages to his friends using system bulletins. Currently, most personal computer manufacturers provide a software package that supports data communication between PCs such as PC-TALK III, Smartcom II, or Crosstalk XVI [Ref. 7]. However, it is impossible to leave a message if the other PC logged off. Bulletin boards can solve this problem. The user can send/receive a message to/from the system bulletins at any time.

4. System Manager Activities

For successful operation of BBS, the role of the system manager is very important. The system manager or operator must have control of the entire system. A BBS should be running for 24 hours. It should be possible to use the central node for his private computer work without interrupting the BBS operation. In order to ensure a

working system, NPS-BBS provides utility routines for the system manager's use. These special functions will be described below. [Ref. 18]

a. NPS-BBS Utilities Menu

The system manager utilities menu is available at the main system function prompt. These functions are not available to the caller. To enter the system manager mode press the ESC key locally or enter the special 'Pass' and 'Word' first and last name from a remote terminal. The following operations can then be performed by entering a number only at the command prompt (see also Figure 6.10 Utilities Menu) :

1. List COMMENTS file	2. List CALLERS file
3. Pack MESSAGE file	4. Renumber messages
5. Recover messages	6. List message headers
7. Erase COMMENTS file	8. Users maintenance
9. Toggle page bell	10. Pack Users file
11. List filespecs	12. Exit to DOS 2.0

Figure 6.10 NPS-BBS System Manager Utilities Menu.

1) Type comments file. Comments sent from the callers can be displayed. This file can also be inspected using a TYPE command from DOS. It is a ASCII sequential text file.

2) Type callers file. A log is maintained of all persons who have called the system. This function will list the file showing the user's name, the date and the time signed on as well as the files he upload/downloads.

3) Pack message file. This function should be used periodically to recover the space occupied by the killed messages. A summary of the space recovered will be printed when the pack is completed.

4) Renumber the messages. This function permits messages to be renumbered sequentially starting from a specified message using whatever starting number you wish. When completed, the next messages created will be the next higher number from the resequenced messages.

5) Resurrect a message. This function will return a message that has been killed to an inactive state. If function 3 has been used, the killed messages are no longer recoverable. The function will ask for the message number to be recovered.

6) Print message headers. This function will display the message headers of all messages, active and killed, that are present in the message file. This is useful to obtain the message number for use with function 5.

7) Erase the comments file. This function will erase the comments file by creating an empty file.

8) Users file maintenance. The users file contains entries for each user registered with the system. This function permits the system manager to list the file on the display, print the file on the printer or to perform limited editing of the user file records.

9) Toggles the system manager page bell on/off.

10) Pack users file. This removes deleted users and users who have not been on the system for over one month.

11) The system manager can view all file specifications under the BASICA interpreter of DOS 2.0.

12) Exit to DOS 2.0.

b. Special Function Keys

The following function keys (ten keys on left side of the IBM-PC keyboard) are designed to give the system manager special local controls that can be activated without entering the system manager mode (using the ESC entry key).

F1) Return to DOS. This will terminate session if a caller is on-line.

F2) Return to BASIC. This will also terminate a session. This returns to DOS under the compiled version.

F3) Printer toggles on/off. This changes printer on-line status. This function should match the condition of the printer. If the printer is going to be left off, the printer toggle should be left off.

F4) Operator page toggle. This changes the status of operator office hours and records the change to the top of the MESSAGES file.

F5) Forces a ring back system to answer the phone.

F6) System manager available toggle. This changes the status of system manager available and records the changes to the top of the MESSAGES file. Off returns 'System Manager not available' to the caller.

F7) System manager gets control of the system after current user is off.

F8) Allows the system manager to grant an on-line user temporary system manager privileges. This is a toggle on/off switch.

F9) SNOOP toggle. This changes the SNOOP from the default value that the first time it is pressed and toggles it on/off thereafter. SNOOP off clears the screen and turns the curser off. It also keeps the download beeps from sounding. The SNOOP should be left off for normal use to keep the system startup screen from 'burning into' the monitor. If SNOOP is left on, the monitor should be physically turned off except when you are observing the BBS in action. Leaving the monitor off will not affect the performance of the BBS.

F10) This is the forced CHAT switch. It announces forced CHAT to the caller and system operator. Along with the ESC key (which ends the CHAT mode), this is the same key the the system operator uses to answer a page.

?) The '?' key is the special system manager key. It allows the system manager to take over the system for maintenance when no one is on-line. It also allows the system manager to answer a page.

B. DATA COMPONENT

The management of data i.e., the ability to store, retrieve, and manipulate data is fundamental to any service that NPS-BBS provides. This component maintains system manager's diskettes which store various files to provide BBS services. Fig 6.11 shows the schematic view of data management.

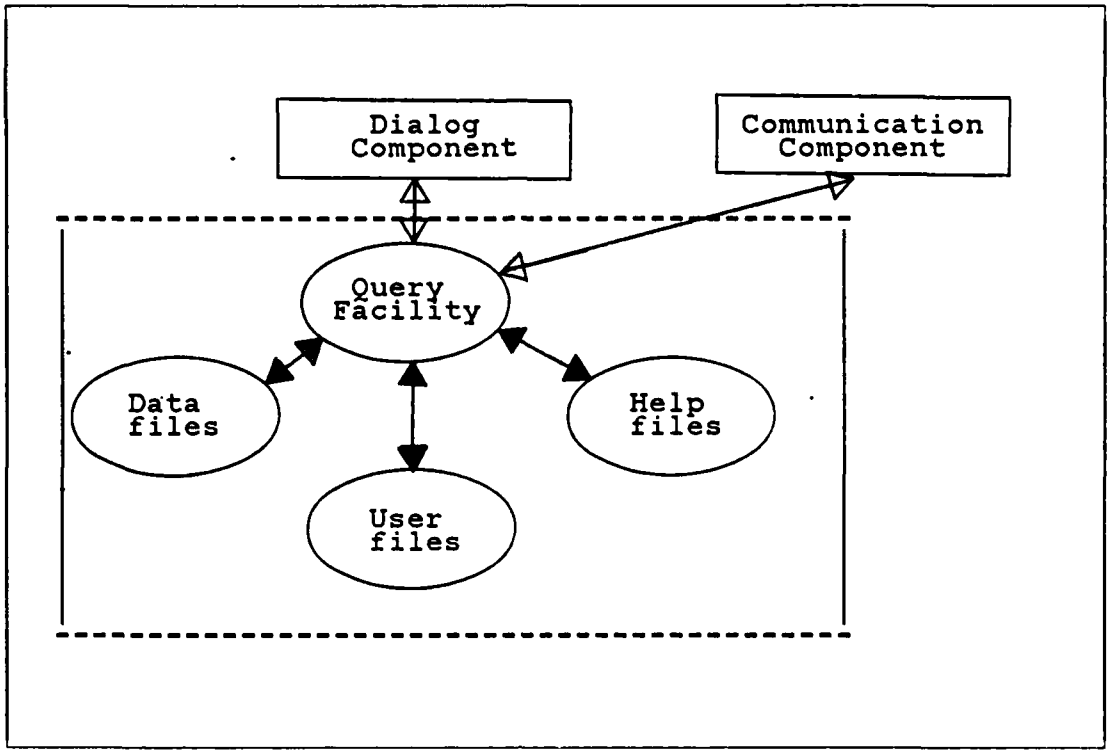

Figure 6.11 The Management of Data in NPS-BBS.

Data components contain a query facility to permit dialog with user through the dialog component. In this system, there are 3 major files : help files, user files, and data files. [Ref. 18]

1. Help Files

There are 7 help files in the system to provide a help facility when users have questions about how the function operates. All of these files are written as a text file and appear on the screen whenever the user request. Detailed content of help files are available in Appendix C.

Help 01 : Command information help. A Text file that is printed when <H>elp is requested on the main function prompt. It contains command information.

Help 02 : Functions supported help. A Text file that is printed when <?> is entered on the main function prompt. It is also printed following the newuser file for new users and tells users what functions the system supports.

Help 03 : Message protection help. A Text file that describes the message protection options when <?> is entered after the message <E>nter command is executed at the E-Mail menu.

Help 04 : Editing message help. A Text file that describes the message entry subfunctions when <?> is entered at the subfunction prompt.

Help 05 : Files menu help. A Text file that is printed when <H>elp is requested in the file transfer menu subsystem function prompt.

Help 06 : File subsystem extra help. A Text file that is printed when <?> is entered in the file transfer menu subsystem function prompt.

Help 07 : Message read help. A text file that is printed when <H>elp is requested at the message reads prompt in E-Mail menu.

2. User Files

Initially, user files are empty files. When NPS-BBS is activated, the system generates these user files automatically. These files store the messages, files, and comments that are needed to exchange information between users. Each user file will be described below.

a. USERS

This file is a random access file that has a record for each user that used the system. The record contains a profile for the user that includes the users name, password, city, state, type of machine, the last time and date signed on, the last message read, the number of times signed on, the level of expertize, line feed, prompt, system manager and lockout flags, and page length. The records are 128 bytes in length and are automatically maintained by NPS-BBS.

b. MESSAGES

This file is a random file that contains the message text for the NPS-BBS system. It consists of two parts : head and text. Head contains message number, from, to, subject, password, data, and status. Text contains main contents of user message. If NPS-BBS does not find the MESSAGES file it will create it and initialize it with no messages.

c. CALLERS

This file is a random file that contains a log of all callers as they signed on to the system along with callers city and state, the date and the time. The names are added to the end of the file as well as are the names of the files uploaded/downloaded by the caller. If the file is not found, NPS-BBS will create a new one. The file should be erased to clear the log.

d. COMMENTS

This file is a sequential file that contains comments that have been left by users, for the system manager. The file can be scanned by a system manager

function or it can be typed or edited outside of the NPS-BBS.

e. LONGCALR

This file contains a log of any caller whose session was longer than the maximum time allowed on the system (current default option is 72 minutes). This file is appended to and will be created if not found on the system.

3. Data Files

The system has data files that prepare a dialog facility to the user.

a. WELCOME

This is a text file that is printed when a user first enters the system. It must be present and gives a brief system description in a friendly manner for user.

b. MENU files

These files are text files which contains various command and subsystems.

MENU1 : System manager utilities menu

MENU2 : NPS-BBS Main menu

MENU21 : Electronic Mail menu

MENU22 : Data transfer menu

MENU23 : SYSTAT menu

MENU24 : Callers interface dialog menu

c. BULLETIN

This is a text menu file that is printed following the WELCOME file when a user first enters the system. It can also be called from the main menu with the <B>ulletins command. The following 6 bulletins are specified here.

BULLET1 : The first bulletin file

BULLET2 : The second bulletin file

BULLET3 : The 3rd bulletin file

BULLET4 : The 4th bulletin file

BULLET5 : The 5th bulletin file

BULLET6 : The 6th bulletin file

d. Directory

DIR is the name of the text file describing the names of the directory files that contain the description of the files available for downloading. Sub directories should be numbered and should be reflected in the DIR file. At least one DIR file has to be present on one of the diskettes available for downloading.

C. COMMUNICATION COMPONENT

1. Characteristics

The communication component, represents the potential impact. It causes on data and file transferring between microcomputer based workstations, and its functions specify the services it offers to its users. This component has two functions. First, it monitors a broad spectrum of

data transports during a transferring process. This transport function ranges from information exchange to information hiding, from selective and personalized routing to collective diffusion of data, from public to private information. Second, it coordinates various communication activities (i.e. initialization, operation during transfer etc.) by making it as transparent as possible to the users of the BBS. [Ref. 19: pp. 9, 12]

2. An Architecture of the Communications Component

The architecture described below is based on the Open System Architecture OSA-RM (ISO, 1982). This model defines a framework for providing data communication links between systems. Specifically, five communication functions are specified : link establishment (generally in a switched network), transmission opening, data exchange, transmission terminating, and link releasing. The reference model proposes decomposition of the communication architecture into seven layers. [Ref. 19]

The advantage of the layered approach is that, changes in one layer do not affect the other layers. Thus, definition, implementation, and testing of the various layers can proceed in parallel. The first level, or physical control layer, provides the physical, functional, and mechanical characteristics of the interface. The second, or link control layer, provides for the reliable exchange of messages. In particular, it specifies the rules for overcoming transmission errors. The third level, or network control layer, provides the functions required for intra-network operation, such as addressing and routing. The forth level, or transport end-to-end control layer, ensures the reliable transfer of data between end points across a communications network. The fifth level is concerned with the control of a session, which is the period

1. Physical Layer	Arbitration of access to the transmission media (network topology)
2. Data Link Layer	Management of information transfers via an established data link (e.g., throughput, transit delay, error detection algorithm)
3. Network Layer	Network routing and switching (Priority, delay, security, costs, grade of service)
4. Transport Layer	End-to-end transport of messages traversing any topological configuration (access control, throughput, transit, delay, residual errors, service availability, sequencing, flow control, accounting)
5. Session Layer	Maintenance of the state of the dialog between nodes e.g., synchronization, deliminating of data (configuration of transport connections, dialog types, type, and quality of transport service used)
6. Presentation Layer	Management of formats including the format control phase, the data transfer phase, and the presentation termination phase (security, flexibility, correctness)
7. Application Layer	Support of service-oriented functions (reliability, flexibility, security, adaptability)

Figure 6.12 The Layers of the ISO Reference Model, Their Functions and Performance Factors. [Ref. 19].

of time, during which, a user is connected to a computer system. In particular, this session control layer provides for identification and authentication of the user and for control of data flow during the session. The sixth level, or presentation control layer, formats the information as required by the interacting entities. The application layer, which is concerned with applications software, provides the support of service-oriented functions. The services offered by each layer are described in Figure 6.12. Also, the factors indicating the performance of the layers are included in the parentheses. [Ref. 23]

The reference to such a standard is justified by the fact that the use of an ISO network Model would (i) minimize operating system dependencies, (ii) simplify protocol interfaces, (iii) assure reliability, ease of maintenance and portability, and perhaps the most important, (iv) facilitate the integration of communication protocols in NPS-BBS. [Ref. 19: pp. 12-13]

When applied to the NPS-BBS architecture in a distributed environment, the first five ISO layers are covered by modem and RS-232C serial interface modem cable. The presentation layer is supported by PC-TALK III with XMODEM Error Checking Protocol, which is a general purpose communications program. The application layer is supported by NPS-BBS software, which is a special purpose communications program. Figure 6.13 proposes an integration framework for the NPS-BBS communications component into the ISO layering concept.

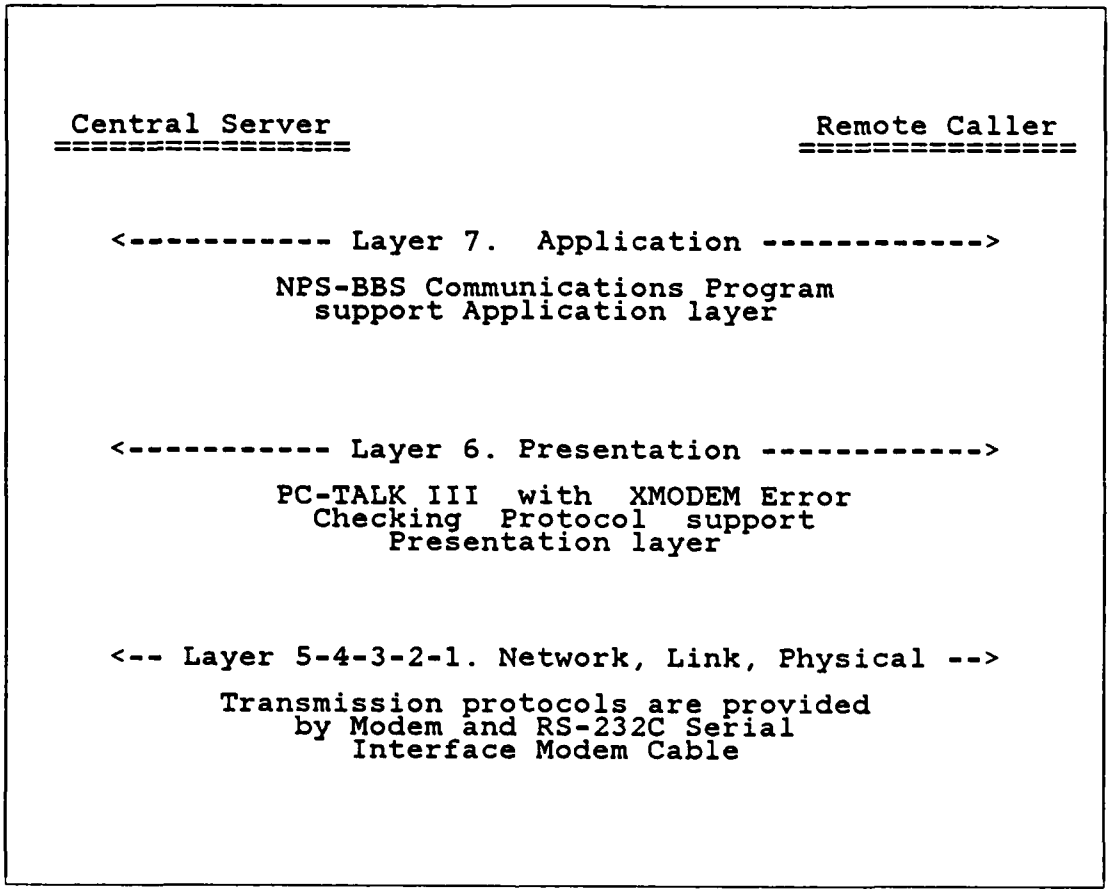

Figure 6.13 The NPS-BBS Communications Component and the ISO Model.

VII. ARRANGEMENT OF NPS-BBS

A. NPS-BBS ARCHITECTURE

The arrangement consists of intermixing the system components by installing interfaces among components. This integration will determine the success or failure of the system. For simplicity of development, maintenance, and reuse of software, it has generally been more effective to separate the functions of the three components in building NPS-BBS than to intermix them. If the software structure separates the functions, it must also provide a mechanism for integrating them. Effective integration of the components is important for more then just technical elegance of the NPS-BBS software structure. In Alter's study of DSS, many of the causes of problems with a DSS were technical in nature, which can be related to ineffective integration. Among the integration problems discovered by Alter were [Ref. 9: p. 280] :

1) Poor integration of the DSS data base with other (internal and external) data bases

2) Poor response times

3) Inability to run large models

4) Inability to interface the dialog component with the modeling and database components

5) Inability of maintenance programmers to understand the software structure

6) High development, operating, or maintenance costs

In effect, a poor integration of the components would result in poor response times, in difficulty of integration, in inabilities of maintenance and in high cost.

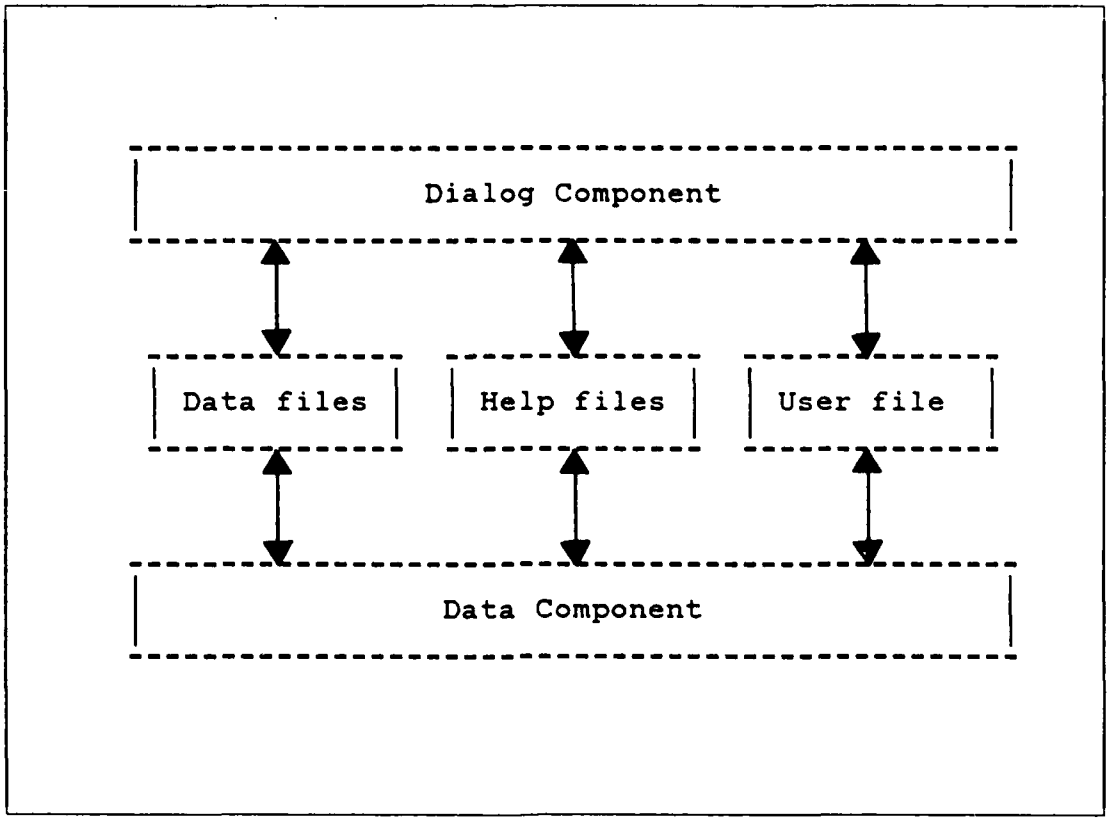

Figure 7.1 Sandwich Architecture.

Sprague [Ref. 9: p. 286] introduces four generic architectures for DSS networks. In this system, we use sandwich architecture. Sandwich architecture attempts to integrate the components by using single dialog and data components. Figure 7.1 illustrates how the shared dialog and data component 'sandwich' the data files which provide various BBS services. Data communication among data files is via the shared data component. Communication of control information among data files is via the shared dialog

component. In a sandwich architecture, the standard interfaces are provided by the single dialog and data component rather than by a separate interface. Figure 7.2 shows the composite diagram of the NPS-BBS structure.

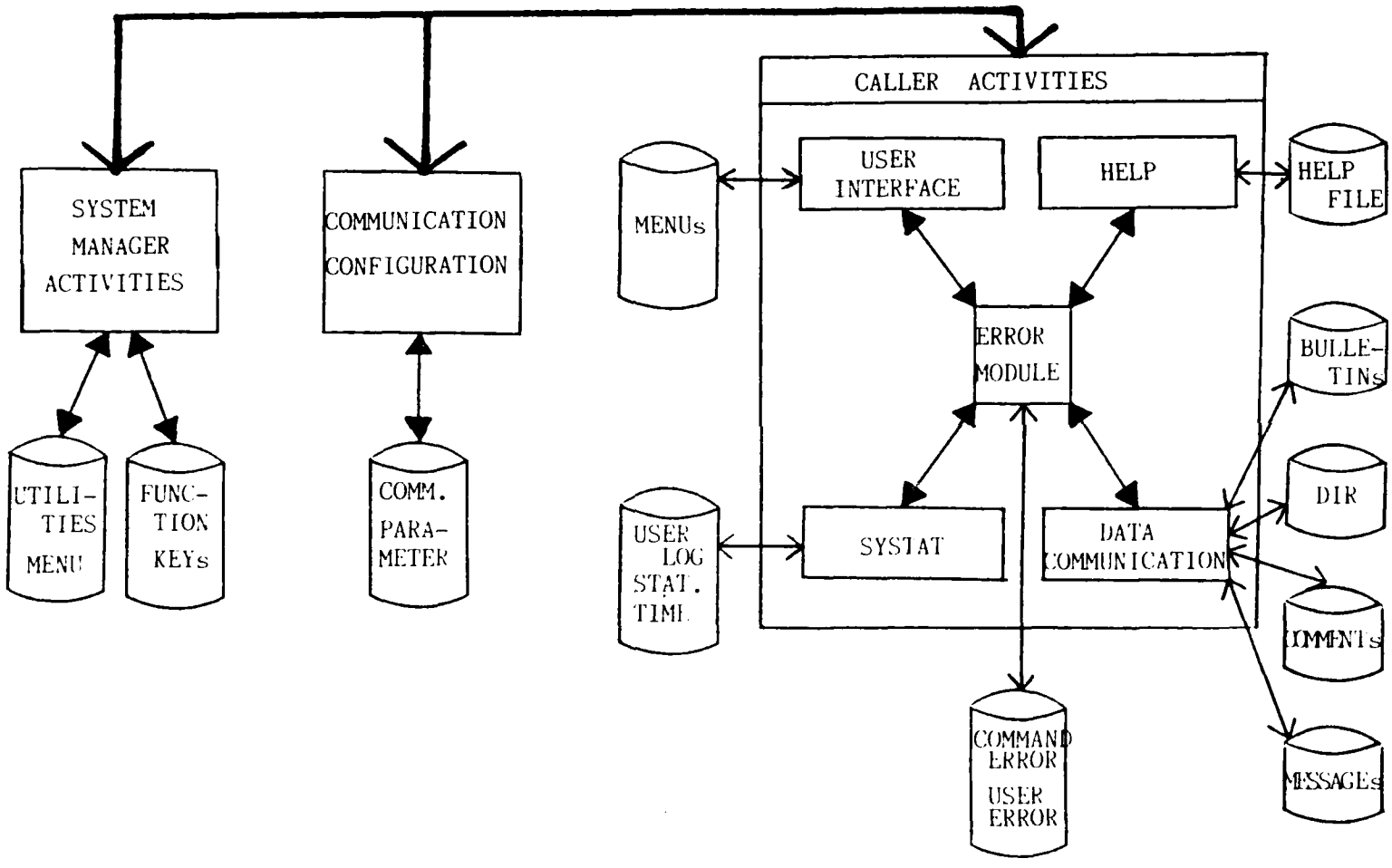

Figure 7.2 Composite Structure of NPS-BBS.

B. DEVELOPMENT TACTICS

The development tactics for NPS-BBS were to deliver a quick but expendable, low cost, but working system. This 'staged development' or 'stepwise refinement' tactic is realized as follows. [Ref. 16: p. 46]

First, an off-the-shelf set of the RBBS-PC has been selected to avoid the time needed for re-programming.

Then the user interface dialog component is carefully designed and implemented to translate the input/output requirements of the NPS-BBS into a 'typical' user's mind.

The data component is implemented next to support the user interface dialog component. It communicates with help files, user file, data files by means of OPEN/CLOSE file management in BASIC language.

The very first working version is then tested by a few selected users. After a few weeks, the system is evaluated, modified and incrementally expanded. This cycle is repeated until a relatively stable system is evolved which supports the operation of the NPS-BBS.

VIII. EVALUATION OF NPS-BBS

Since evaluation is the primary guidance and control mechanism in interactive design, it is important that it, too, be supported with techniques and mechanisms built into the DSS. The evaluation step serves as a systematic checkpoint to capture feedback on the specific DSS and its use.

One of the pioneering Electronic Message Systems (EMS), the EIES at the New Jersey Institute of Technology, uses a variety of data gathering approaches for evaluation. [Ref. 9: p. 144]

* User surveys in which users periodically respond, through the system, to questions from user consultants (builders).
* Participant observation, including the use of a user consultant file in which the user enters observations and notations during use of the system.
* Automatic monitoring which can be used to detect frequently used facilities and operations (especially in pairs or in combination) or infrequent activities.

Brief evaluation of each component will be discussed in the next section.

A. THE USER INTERFACE DIALOG COMPONENT

Two dialog styles have been used to interact with the user : menu-driven style and the question-answer one-line-at-a-time style. In menu-driven style, we tried to avoid the selection criteria of more than 7 subselection

since there exists fundamental limitations in the human ability to manage a number of different objects or concepts at one time. [Ref. 17]

This method is somewhat rigid. But, some users who tested NPS-BBS were satisfied and felt comfortable with these man-machine interaction styles. The series of input/output control subroutine implemented has also proven useful. NPS-BBS has never been accidently interrupted.

B. THE DATA COMPONENT

The data component was composed of three major categories as help files, user files, and data files in order to support the user interface dialog. It communicates with those files by means of an OPEN/CLOSE file management in BASIC language. Since NPS-BBS does not need to provide complex database interfaces, a traditional file management approach to store, retrieve, and manipulate data has been used. Thanks again to the RBBS-PC adopted, we adopted a data component from RBBS-PC in order to reduce the time necessary to build such a complex file management scheme.

C. THE COMMUNICATION COMPONENT

The communication component reflects fundamental aspects of the NPS-BBS. It allows data and file transfering between microcomputer based workstations, and its functions specify the services it offers to its users. They use public voice telephone line, so do not need special data line for networking. The architecture of the communication component is based on the Open System Architecture OSA-RM.

IX. CONCLUSION

The objectives of this thesis were to provide a better, faster, and less expensive, geographically remote communications between members of the NPS-BBS network. Communications between workstations using BBS are separated by two major parts : message and file transfers by use of modems and existing telephone lines. In order to accomplish these objectives, an off-the -shelf RBBS-PC was adopted, instead of starting from scratch, to reduce development and implementation time. Since the roles of NPS-BBS design and implementation is to provide exchange services of messages and files between workstations, it should have a more powerful functions and more user friendly man-machine interface functions. To meet this, Decision Support System technology was used to design and implement the system.

APPENDIX A

WELCOME FILE

```
>>>>> On-line with Naval Postgraduate School BBS <<<<<

**********************************************************

   Naval Postgraduate School Bulletin Board System

            Welcome to The NPS-BBS

**********************************************************

              Your System Manager is
                  In Seop Park

              Naval Postgraduate School
                Monterey, CA  93943
                Phone (408) 646-2630
```

APPENDIX B

NPS-BBS SAMPLE BULLETIN BOARD

NPS-BBS Sample Bulletin Board

==========

Welcome to The NPS-BBS Bulletin. The purpose of this bulletin board is to assist in the free exchange of information. It is dedicated to this purpose. Topics can include not only technical information or help with the IBM, or any other, personal computer, but also poetry, fiction, or just plain feelings. The users of this bulletin board have already gone through an auto-selection process. They are capable of utilizing computers or computer terminals. Presumably they are capable of reading. The quality of their writing remains to be seen. Finally, by finding the telephone number they are interested in exploring new sources of information. No editing will be done -- EVER -- on any messages or information that is uploaded. When disk drive capacities require messages and information to be purged, messages will be purged on a first-in-first-out basis. Files available for downloading will be purged based on the frequency of access with the least frequently accessed files being purged first.

Welcome to the NPS-BBS Bulletin Board.

APPENDIX C

NPS-BBS HELP FILES

```
================ <HELP01> HELP FILE ========================

  B)ulletin listing -- repeat initial log on bulletin
  C)omment for System Manager -- private message to
                                 NPS-BBS System Manager
  E)nter message -- public or password protected
  F)iles menu -- files are downloaded/uploaded here
  G)oodbye -- log off this system
  GR)aphics -- toggles graphics menus on/off
  H)elp -- this help file repeated
  K)ill a message -- erase a message you left before
  L)ine feeds -- on/off toggle
  N)ew baud -- baud rate switch from 300 to 450
  O)perator page -- pages System Manager for 30 seconds
  P)rompt bell -- on/off toggle
  PL)age length -- change scroll page length
  PW)assword -- change message protection password
  Q)uick scan of messages
  R)ead message(s) -- select message number(s) to read
  S)can messages -- read message titles only
  T)ime of day and elapsed time of call
  W)elcome message -- repeat of log on welcome message
  X)pert menu -- toggle between novice and expert menu
  #) of callers and messages -- data on system use
  ?) functions supported on this system
  !) List personal mail -- messages directed to you
                           specifically

============================================================
```

========== <HELP02> FUNCTIONS SUPPORTED ==========

- o Allow the use of menus with graphics characters in them
- o Send and receive messages with password protection
- o Download and upload 7-bit ASCII files
- o Download and upload 8-bit binary files using XMODEM protocol
- o List files available for download with directory number select
- o List new files available since last directory review
- o Save caller's expert/novice, prompt & page length preference
- o Save caller's last message read mark and line feed preference
- o List personal mail message numbers or says no personal mail
- o Quick scan and scan of messages with stacked number option
- o Read messages with stacked number or from last message read
- o Read system manager bulletins from bulletin menu

========== <HELP03> MESSAGE PROTECTION HELP ==========

The message protection options are:

K - Public message that can be read by anyone but can only be killed if the proper password is given. Remember the password and kill the message when it is nolonger needed

R - The message can only be read by the sender, the addressee and system manager. Any of these three parties can kill the message.

N - None. A public message that anyone can read and/or kill.

? - Prints this summary

========== <HELP04> EDITING MESSAGES HELP ==========

The following functions are available:

A - Abort without saving the message.
C - Continue. Enter more lines of message.
D - Delete a line of the message.
E - Edit a line of the message.
I - Insert a line into the message.
L - List the entire message.
M - Set the right text margin.
S - Save the message. This option must be used in order to leave the message.
? - Print this information

```
============== <HELP05> Files Menu HELP File ================
|                                                            |
|   D)ownload a file (XMODEM or ASCII text)                  |
|   G)oodbye -- exit this system                             |
|   H)elp -- this file                                       |
|   L)ist files available for download                       |
|   M)ain menu -- message and comment menu                   |
|   N)ew files available since last directory review         |
|   U)pload file to this system (XMODEM or ASCII text)       |
|   ?)download/upload help (detailed instructions)           |
|                                                            |
============================================================
```

========== <HELP06> File Subsystem Extra HELP ==========

The filing subsystem permits you to move files between your system and this NPS-BBS. Downloading refers to moving files from this NPS-BBS to your computer, and uploading is moving files from your computer to this NPS-BBS.

The transfer of data can either be done in ASCII or using a protocol referred to as XMODEM. The XMODEM protocol is common to CP/M based systems as was originally developed by Ward Christensen. The protocol is also contained in PC-TALK.III. More on this later.

To list the names of the files that are available on the disks for downloading to your system, the <L>ist command should be entered at the Files Menu. The full names of the files will be listed along with a short description of each file. Usually there is a document file that accompanies most of the program items on the system. These document files usually have an extension of DOC or TXT.

For those systems that have a master directory the <L>ist command will present a list of directories available and their contents. To list the names of the files that are available in a specific directory use L;XX, where XX is the directory suffix. These directory <>Lists can be stacked to reduce your responses. i.e. L;10;9;3 will list all files available in directory 10, 9 and 3.

To list the names of the files that have been added since your last directory review simply enter N;XX, where XX is the desired directory to be searched. i.e. N;8;1 will display all new files added to directories 8 and 1 since your last directory review. (NOTE: You can also use "ALL" to check "ALL" directory files for new filenames.

ASCII DATA CAPTURE

The transfer of files in ASCII mode can be done if your system is capable of data capture. To download a file using the ASCII method, follow the sequence of steps listed below.

1. List the files available for download using the L)ist command and either capture the list to your printer or write down the exact names of the files you want to receive.

2. After returning to the Files Menu, select D)ownload.

3. When NPS-BBS asks for the filename you wish to select, input the exact filename including a period between the filename and extension.

4. When NPS-BBS asks for the type of download you want, input A for A)scii method.

5. When the NPS-BBS tells you to open your capture file and enter a carriage return to start the download, you should do so. (Opening your capture file is done by using the Alt-R command in PC-TALK.) After setting up to receive the file on your end, you have to send NPS-BBS one carriage return so that it knows you are ready to start.

6. The file will be sent a line at a time until the entire file is sent. You will see the lines of ASCII code (readable text and numbers) on your screen as they flow to your system. If you wish to suspend the transmission temporarily, your system should send NPS-BBS a Ctrl-S (XOFF). A Ctrl-Q (XON) will restart the temporarily halted transfer. A Ctrl-X (ASCII CAN) can be sent anytime to abort the transmission of the data; because of the output buffering performed automatically by NPS-BBS, there may be up to 120

characters transmitted before the output stops.

7. When the file transfer is finished, NPS-BBS will send you an End Of File Marker (Ctrl-Z) followed by 5 bells. You should close your capture file (PC-TALK Alt-R) as soon as you hear the bells or you will get garbage at the bottom of the file. If you go away for a cup of coffee and end up getting the 'end of file' sign attached to the bottom of the capture file, you can delete it from the file later using a text editor.

8. After the file transfer is complete you will be returned to the File Menu. You should look at the capture file at this point to be sure you got it ok. (Use the PC-TALK Alt-V command to do this.) Do not list the entire file unless it is short; NPS-BBS will give you 3 minutes to remain off-line before it assumes you have left for the day and recycles, dropping you off line.

XMODEM FILE TRANSFER

If you have implemented XMODEM on your system, files with EXE, OBJ and COM extensions and tokenized BASIC files can be moved to your system. Files containing the IBM PC special ASCII characters (ones with ASCII values above 128) can also be transferred with XMODEM -- this includes Wordstar files. These files cannot be transferred in ASCII mode since ASCII transfer is only 7 bit and these types of files require the full 8 bit transfer of the data with no translation of the contents of the file.

para XMODEM also offers the advantage of a block check to assure that the data sent contains no errors. It does this by adding a checksum byte to the end of each block of data;

the receiver calculates its own checksum and compares it to the one received. If an error is detected in the transmission, XMODEM will request that NPS-BBS retransmit the block of data.

To perform an XMODEM file download, follow the instructions shown above for ASCII DATA CAPTURE, but select X)modem instead of A)scii when NPS-BBS asks what file download type you want (step 4 above). The XMODEM file transfer steps are as follows:

5. If you called in using EVEN parity the RBBS-PC will tell you to switch to NO parity and 8 data bits. If you called in using 8 data bits the system will not give you this message. You should then open your capture file (PC-TALK.III Alt-R command) and start the XMODEM receive process. PC-TALK.III starts XMODEM for you when you put '=X' at the end of the download filename.

6. The file will be transferred automatically by XMODEM until the entire file has been transferred. You may abnormally abort the transfer by sending RBBS-PC an ASCII CAN code (Ctrl-X). PC-TALK.III will do this for you if you enter an Alt-R during the file transfer.

7. When the file transfer is finished, XMODEM automatically closes your capture file for you. XMODEM also ensures that no garbage gets into your file; binary files and text files are just as they were sent to you with 99.6% error free transmission. Wordstar files should transfer without extra hard carriage returns being added.

8. XMODEM transferred files cannot be listed on your monitor unless they are actually ASCII files. Binary files will appear as symbols rather than human readable text. You will have to test these files after you exit your communications program.

FILE UPLOADING

File uploading to the NPS-BBS is very similar to downloading. After you have downloaded a few files, you might want to send me one of your favorite programs or files just to test your ability to upload.

Uploading of ASCII files can be done without interruption between lines. This system can handle data uploading at 300 baud without any problem. If the transfer is done at 1200 baud, however, there may be a data overrun if the file is over 20K. If the system falls behind during a file upload operation, it will send an XOFF (Ctrl-S) to your system. If your system supports XON/OFF file transfer speed-matching, data transmission will be suspended until an XON (Ctrl-Q) is sent to you, indicating NPS-BBS is ready to accept data again.

When uploading files, please convert BASIC programs to ASCII before transferring them so callers without XMODEM can download them. To do this, use the file save command format listed below.

SAVE"filename.ext",A

Before sending me a file be sure I have enough disk space to take the file. When you ask for U)pload at the File menu, the system will tell you how much disk space is free on the upload drive. If this system runs out of disk space during an upload function, it will issue a cancel request. This will be in the form of a data stream of one or more ASCII CAN (Ctrl-X) characters. Your system will abort transmission if it supports XON/OFF file transfer speed-matching protocol. If your system does not support XON/OFF, the data overflow will be lost and the NPS-BBS will recycle, dropping you off line.

UPLOAD GROUND RULES

You are encouraged to donate programs to the library on this system. Any type of program or document is welcome, however, a few ground rules are in order. The files donated must contain only information that is in the public domain. No private or commercial information should be placed on this system. The System Manager is not responsible for any of the data that is shared on this system.

* The messages can be read with a stacked read command now. For example r;10;14;32+ will cause messages 10,14 and 32 plus all all messages beyond 32 to be displayed one at a time. This command format must be used from the main menu.

* After an r or R has been input at the main menu, the stacked read can still be used just by separating message numbers with a semicolon. For example, input 10;14;32+ to do the same as described above.

* The stacked read command can have an "m" imbedded in it to read only messages sents to or from yourself. For example, from the main menu you could enter r:10;14;M;32+ to cause messages 10, 14, and only messages to or from you beginning with message 32 to be displayed one at a time.

* While reading messages the "More" prompt indicates the replies N (for no more), Y(to continuing with the next message requested. This is the default when scanning messages forward or backward), RE (to enter a response to the current message without having to go to the main menu), K (to kill a message before continuing. This occurs only for messages to or from you), and NS (for nonstop scanning of messages).

* To read messages backwards, use a minus sign after the last message you wish to read. For example,input r;32- to start reading messages in reverse chronological order beginning at message 32.

* An asterisk (*) can be used in place of a message number on the R, S, and Q functions to start from the next message after the highest one you have read during this or previous sessions.

* Using these brief instructions, try experimenting. Please leave me a message if you feel I should expand this help file.

APPENDIX D

THE XMODEM ERROR CHECKING PROTOCOL

The XMODEM protocol, developed by Ward Christensen, is illustrated in figure D.1. As you can see from that figure, XMODEM does not begin the transfer of data until the receiving computer signals the transmitting computer that it is ready to receive data. The Negative Acknowledge (NAK) character is used for this signal and is sent to the transmitting computer every 10 seconds until the file transfer begins. If the file transfer does not begin after nine NAKs are sent, the process has to be manually restarted.

After a NAK is received, the transmitting computer uses a Start of Header (SOH) character and two block numbers(a true block number followed by a 1's complement of the number) to signal the start of a 128-byte block of data to be transferred. It then sends the block followed by an error-checking checksum. The checksum is calculated by adding the ASCII values of each character in the 128-character block : the sum is then ANDed with 255, and the result is retained as the checksum. After each block of data is transferred, the receiving computer computes its own checksum and compares the result to the checksum received from the transmitting computer. If the two values are the same, the receiving computer sends an Acknowledge (ACK) character to tell the receiver to send the next sequential block. If the two values are not the same, the receiving computer sends the transmitter a NAK to request a retransmission of the last block. This retransmission process is repeated until the block of data is properly received or until nine attempts have been made to transmit

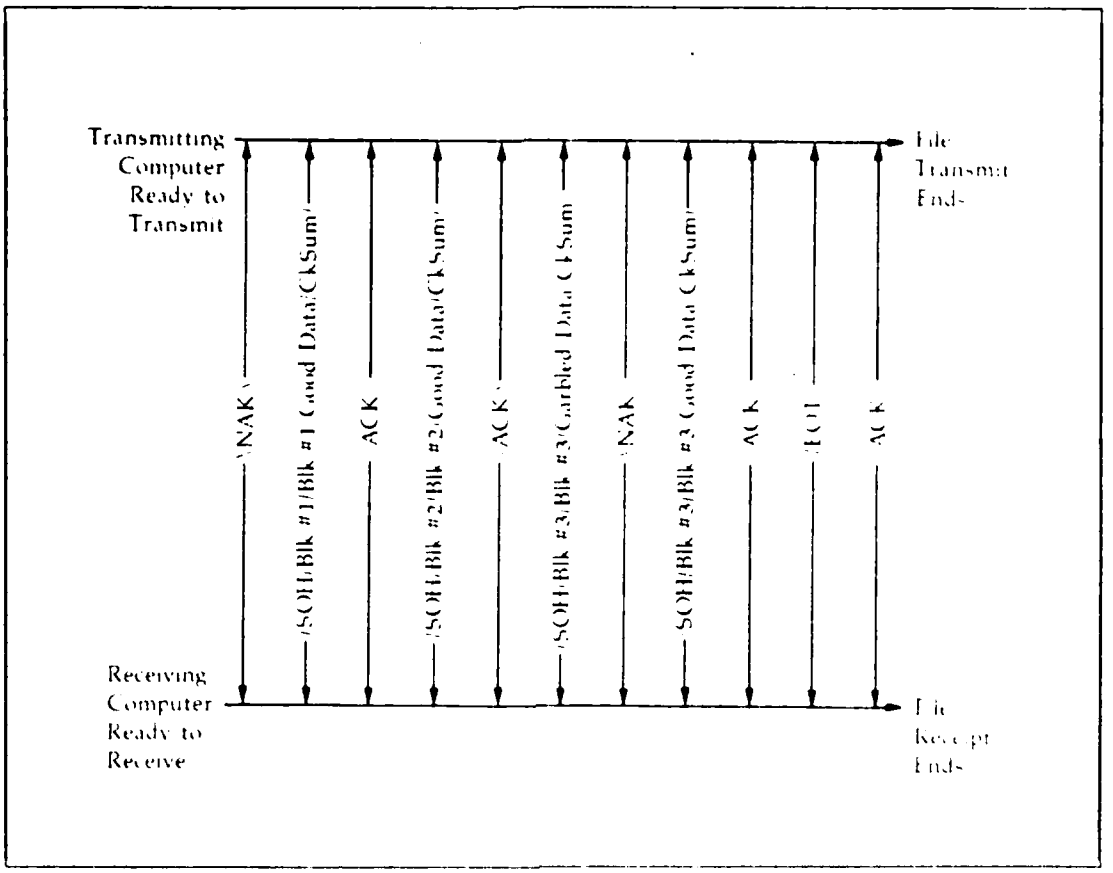

Figure D.1 XMODEM Protocol File Transfer.

the block. If the communications link is noisy, resulting in improper block transmission after nine attempts, the file transfer is aborted.

XMODEM uses two block numbers at the start of each block to be sure the same block is not transmitted twice because of a handshake character loss during the transfer. The receiving computer checks the transmitted block to be sure that it is the one requested. Blocks that are retransmitted by mistake are thrown away. When all data has been successively transmitted, the transmitting computer sends the receiver an End of Transmission (EOT) character to indicate the end of file. [Ref. 7: pp. 267-268]

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