TELNET Protocol Specification

INTRODUCTION

The purpose of the TELNET Protocol is to provide a fairly general, bi-directional, eight-bit byte oriented communications facility. Its primary goal is to allow a standard method of interfacing terminal devices and terminal-oriented processes to each other. It is envisioned that the protocol may also be used for terminal-terminal communication ("linking") and process-process communication (distributed computation).

GENERAL CONSIDERATIONS

A TELNET connection consists of a pair of standard Host/Host Protocol connections over which passes data with interspersed TELNET control information. The pair of connections are typically established by the Initial Connection Protocol. Details on the Host/Host and Initial Connection Protocols may be found in NIC #7104.

The TELNET Protocol is built upon three main ideas: first, the concept of a "Network Virtual Terminal"; second, the principle of negotiated options; and third, a symmetric view of terminals and processes.

1) When a TELNET connection is first established, each end is assumed to originate and terminate at a "Network Virtual Terminal", or NVT. An NVT is an imaginary device which provides a standard, network-wide, intermediate representation of a canonical terminal. This eliminates the need for "server" and "user" Hosts* to keep information about the characteristics of each other's terminals and terminal handling conventions. All Hosts, both user and server, map their local device characteristics and conventions so as to appear to be dealing with an NVT over the network, and each can assume a similar mapping by the other party. The NVT is intended to strike a balance between being overly restricted (not providing Hosts a rich enough vocabulary for mapping into their local character sets), and being overly inclusive (penalizing users with modest terminals).

*Note: The "user" Host is the Host to which the physical terminal is normally attached, and the "server" host is the Host which is normally providing some service. As an alternate point of view, applicable even in terminal-to-terminal or process-to-process communications, the "user" Host is the Host which initiated the communication.

2) The principle of negotiated options takes cognizance of the fact that many sites will wish to provide additional services over and above those available within an NVT, and many users will have sophisticated terminals and would like to have elegant, rather than minimal, service. Independent of, but structured within, the TELNET Protocol various "options" will be sanctioned which can be used with the "DO, DON'T, WILL, WON'T" structure (discussed below) to allow a user and server to agree to use a more elaborate (or perhaps just different) set of conventions for their TELNET connection. Such options could include changing the character set, the echo mode, the line width, the page length, etc.

The basic strategy for setting up the use of options is to have either party (or both) initiate a REQUEST that some option take effect. The other party may then either accept or reject the request. If the request is accepted the option immediately takes effect; if it is rejected the associated aspect of the connection remains as specified for an NVT. Clearly, a party may always refuse a request to enable, and must never refuse a request to disable, some option since all parties must be prepared to support the NVT.

The syntax of option negotiation has been set up so that if both parties request an option simultaneously, each will see the other's request as the positive acknowledgment of its own.

The symmetry of the negotiation syntax can potentially lead to nonterminating acknowledgment loops--each party seeing the incoming commands not as acknowledgments but as new requests which must be acknowledged. To prevent such loops, the following rules prevail:

a) Parties may only request a change in option status; i.e., a party may not send out a "request" merely to announce what mode it is in.

b) If a party receives what appears to be a request to enter some mode it is already in, the request should NOT be acknowledged.

c) Whenever one party sends an option command to a second party, whether as a request or an acknowledgment, and use of the option will have any effect on the processing of the data being sent from the first party to the second, then the command must be inserted in the data stream at the point where it is desired that it take effect. (It should be noted that some time will elapse between the transmission of a request and the receipt of an acknowledgment, which may be negative. Thus, a

site may wish to buffer data, after requesting an option, until it learns whether the request is accepted or rejected, in order to hide the "uncertainty period" from the user.)

Option requests are likely to flurry back and forth when a TELNET connection is first established, as each party attempts to get the best possible service from the other party. Beyond that, however, options can be used to dynamically modify the characteristics of the connection to suit changing local conditions. For example, the NVT, as will be explained later, uses a transmission discipline well suited to the many "line at a time" applications such as BASIC, but poorly suited to the many "character at a time" applications such as NLS. A server might elect to devote the extra processor overhead required for a "character at a time" discipline when it was suitable for the local process and would negotiate an appropriate option. However, rather than then being permanently burdened with the extra processing overhead, it could switch (i.e., negotiate) back to NVT when the more "taut" control was no longer necessary.

It is possible for requests initiated by processes to simulate a nonterminating request loop if the process responds to a rejection by merely re-requesting the option. To prevent such loops from occurring, rejected requests should not be repeated until something CHANGES. Operationally, this can mean the process is running a different program, or the user has given another command, or whatever makes sense in the context of the given process and the given option. A good rule of thumb is that a re-request should only occur as a result of subsequent information from the other end of the connection or when demanded by local human intervention.

Option designers should not feel constrained by the somewhat limited syntax available for option negotiation. The intent of the simple syntax is to make it easy to have options--since it is correspondingly easy to profess ignorance about them. If some particular option requires a richer negotiation structure than possible within "DO, DON'T, WILL, WON'T", the proper tack is to use "DO, DON'T, WILL, WON'T" to establish that both parties UNDERSTAND the option, and once this is accomplished a more exotic syntax can be used freely. For example, a party might send a request to alter (establish) line length. If it is accepted, then a different syntax can be used for actually negotiating the line length--such a "sub-negotiation" perhaps including fields for minimum allowable, maximum allowable and desired line lengths. The important concept is that such expanded negotiations should never begin until some prior (standard) negotiation has

established that both parties are capable of parsing the expanded syntax.

In summary, WILL XXX is sent, by either party, to indicate that party's desire (offer) to begin performing option XXX, DO XXX and DON'T XXX being its positive and negative acknowledgments; similarly, DO XXX is sent to indicate a desire (request) that the other party (i.e., the recipient of the DO) begin performing OPTION XXX, WILL XXX and WON'T XXX being the positive and negative acknowledgments. Since the NVT is what is left when no options are enabled, the DON'T and WON'T responses are guaranteed to leave the connection in a state which both ends can handle. Thus, all Hosts may implement their TELNET processes to be totally unaware of options that are not supported, simply returning a rejection to (i.e., refusing) any option request that cannot be understood.

As much as possible, the TELNET protocol has been made server-user symmetrical so that it easily and naturally covers the user-user (linking) and server-server (cooperating processes) cases. It is hoped, but not absolutely required, that options will further this intent. In any case, it is explicitly acknowledged that symmetry is an operating principle rather than an ironclad rule.

A companion document, "TELNET Option Specifications," should be consulted for information about the procedure for establishing new options. That document, as well as descriptions of all currently defined options, is contained in the TELNET section of Current Network Protocols (NIC #7104).

THE NETWORK VIRTUAL TERMINAL

The Network Virtual Terminal (NVT) is a bi-directional character device. The NVT has a printer and a keyboard. The printer responds to incoming data and the keyboard produces outgoing data which is sent over the TELNET connection and, if "echos" are desired, to the NVT's printer as well. "Echos" will not be expected to traverse the network (although options exist to enable a "remote" echoing mode of operation, no Host is required to implement this option). The code set is seven-bit USASCII in an eight-bit field), except as modified herein. Any code conversion and timing considerations are local problems and do not affect the NVT.

Transmission of Data

Although a TELNET connection through the network is intrinsically full duplex, the NVT is to be viewed as a half-duplex device operating in a line-buffered mode. That is, unless and until

options are negotiated to the contrary, the following default conditions pertain to the transmission of data over the TELNET connection:

1) Insofar as the availability of local buffer space permits, data should be accumulated in the Host where it is generated until a complete line of data is ready for transmission, or until some locally-defined explicit signal to transmit occurs. This signal could be generated either by a process or by a human user.

The motivation for this rule is the high cost, to some Hosts, of processing network input interrupts, coupled with the default NVT specification that "echos" do not traverse the network. Thus, it is reasonable to buffer some amount of data at its source. Many systems take some processing action at the end of each input line (even line printers or card punches frequently tend to work this way), so the transmission should be triggered at the end of a line. On the other hand, a user or process may sometimes find it necessary or desirable to provide data which does not terminate at the end of a line; therefore implementers are cautioned to provide methods of locally signalling that all buffered data should be transmitted immediately.

2) When a process has completed sending data to an NVT printer AND has no queued input from the NVT keyboard for further processing (i.e., when a process at one end of a TELNET connection cannot proceed without input from the other end), the process must transmit the TELNET Go Ahead (GA) command.

This rule is NOT intended to require that the TELNET GA command be sent from a terminal at the end of each line, since server Hosts do not normally require a special signal (in ADDITION to end-of-line or other locally-defined characters) in order to commence processing. Rather, the TELNET GA is designed to help a user's local Host operate a physically half duplex terminal which has a "lockable" keyboard such as the IBM 2741. A description of this type of terminal may help to explain the proper use of the GA command.

The terminal-computer connection is always under control of either the user or the computer. Neither can unilaterally seize control from the other; rather the controlling end must relinguish its control explicitly. At the terminal end, the hardware is constructed so as to relinquish control each time that a "line" is terminated (i.e., when the "New Line" key is typed by the user). When this occurs, the attached (local)

computer processes the input data, decides if output should be generated, and if not returns control to the terminal. If output should be generated, control is retained by the computer until all output has been transmitted.

The difficulties of using this type of terminal through the network should be obvious. The "local" computer is no longer able to decide whether to retain control after seeing an end-of-line signal or not; this decision can only be made by the "remote" computer which is processing the data. Therefore, the TELNET GA command provides a mechanism whereby the "remote" (server) computer can signal the "local" (user) computer that it is time to pass control to the user of the terminal. It should be transmitted at those times, and only at those times, when the user should be given control of the terminal. Note that premature transmission of the GA command may result in the blocking of output, since the user is likely to assume that the transmitting system has paused, and therefore he will fail to turn the line around manually.

The foregoing, of course, does not apply to the user-to-server direction of communication. In this direction, GAs may be sent at any time, but need not ever be sent. Also, if the TELNET connection is being used for process-to-process communication, GAs need not be sent in either direction. Finally, for terminal-to-terminal communication, GAs may be required in neither, one, or both directions. If a Host plans to support terminal-to-terminal communication it is suggested that the Host provide the user with a means of manually signalling that it is time for a GA to be sent over the TELNET connection; this, however, is not a requirement on the implementer of a TELNET process.

Standard Representation of Control Functions

As stated in the Introduction to this document, the primary goal of the TELNET protocol is the provision of a standard interfacing of terminal devices and terminal-oriented processes through the network. Early experiences with this type of interconnection have shown that certain functions are implemented by most servers, but that the methods of invoking these functions differ widely. For a human user who interacts with several server systems, these differences are highly frustrating. TELNET, therefore, defines a standard representation for five of these functions, as described below. These standard representations have standard, but not required, meanings (with the exception that the IP function may be required by other protocols which use TELNET); that is, a system which does not provide the function to local users need not

provide it to network users and may treat the standard representation for the function as a No-operation. On the other hand, a system which does provide the function to local users is obliged to provide the same function a network user who transmits the standard representation for the function.

INTERRUPT PROCESS (IP) - Many systems provide a function which suspends, interrupts, aborts, or terminates the operation of a user process. This function is frequently used when a user believes his process is in an unending loop, or when an unwanted process was inadvertently activated. IP is the standard representation for invoking this function. It should be noted by implementers that IP may be REQUIRED by other protocols which use TELNET, and therefore should be implemented if these other protocols are to be supported.

ABORT OUTPUT (AO) - Many systems provide a function which allows a process, which is generating output, to run to completion (or to reach the same stopping point it would reach if running to completion) but without sending the output to the user's terminal. Further, this function typically clears any output already produced but not yet actually printed (or displayed) on the user's terminal. AO is the standard representation for invoking this function. For example, some subsystem might normally accept a user's command, send a long text string to the user's terminal in response, and finally signal readiness to accept the next command by sending a "prompt" character (preceded by <CR><LF>) to the user's terminal. If the AO were received during the transmission of the text string, a reasonable implementation would be to suppress the remainder of the text string, but transmit the prompt character and the preceding <CR><LF>. (This is possibly in distinction to the action which might be taken if an IP were received; the IP might cause suppression of the text string and an exit from the subsystem.)

It should be noted, by systems which provide this function, that there may be buffers external to the system (in the network and the user's "local" Host) which should be cleared; the appropriate way to do this is to transmit the "Synch" signal described below.

ARE YOU THERE (AYT) - Many systems provide a function which provides the user with some visible (e.g., printable) evidence that the system is still up and running. This function may be invoked by the user when the system is unexpectedly "silent" for a long time, because of the unanticipated (by the user) length of a computation, an unusually heavy system load, etc. AYT is the standard representation for invoking this function.

ERASE CHARACTER (EC) - Many systems provide a function which deletes the last preceding undeleted character or "print position"* from the stream of data being supplied by the user. This function is typically used to edit keyboard input when typing mistakes are made. EC is the standard representation for invoking this function.

ERASE LINE (EL) - Many systems provide a function which deletes all the data in the current "line" of input. This function is typically used to edit keyboard input. EL is the standard representation for invoking this function.

*Note: A "print position" may contain several characters which are the result of overstrikes, or of sequences such as <char1> BS <char2>...

The TELNET "Synch" Signal

Most time-sharing systems provide mechanisms which allow a terminal user to regain control of a "runaway" process; the IP and AO functions described above are examples of these mechanisms. Such systems, when used locally, have access to all of the signals supplied by the user, whether these are normal characters or special "out of band" signals such as those supplied by the teletype "BREAK" key or the IBM 2741 "ATTN" key. This is not necessarily true when terminals are connected to the system through the network; the network's flow control mechanisms may cause such a signal to be buffered elsewhere, for example in the user's Host.

To counter this problem, the TELNET "Synch" mechanism is introduced. A Synch signal consists of a Host/Host Protocol INS command, coupled with the TELNET command DATA MARK. The INS command, which is not subject to the flow control pertaining to the TELNET connections, is used to invoke special handling of the data stream by the process which receives it. In this mode, the data stream is immediately scanned for "interesting" signals as defined below, discarding intervening data. The TELNET command DATA MARK (DM) is the synchronizing mark in the data stream which indicates that any special signal has already occurred and the recipient can return to normal processing of the data stream. When a DM arrives before its associated INS, the recipient should not process the data stream further until the matching INS is received, in order to insure that the two ends of the connection remain synchronized. Also, implementers are warned that in some cases several Synch's may be sent in succession. In general, this will require a count of the INS's received so as to properly pair them with the associated DM's. "Interesting" signals are defined

to be: the TELNET standard representations of IP, AO, and AYT (but not EC or EL); the local analogs of these standard representations (if any); all other TELNET commands; other site-defined signals which can be acted on without delaying the scan of the data stream.

Since one effect of the SYNCH mechanism is the discarding of essentially all characters (except TELNET commands) between the sender of the Synch and its recipient, this mechanism is specified as the standard way to clear the data path when that is desired. For example, if a user at a terminal causes an AO to be transmitted, the server which receives the AO (if it provides that function at all) should return a Synch to the user.

Finally, just as the NCP-level INS command is needed at the TELNET level as an out-of-band signal, so other protocols which make use of TELNET may require a TELNET command which can be viewed as an out-of-band signal at a different level.

By convention the sequence [IP, Synch] is to be used as such a signal. For example, suppose that some other protocol, which uses TELNET, defines the character string STOP analogously to the TELNET command AO. Imagine that a user of this protocol wishes a server to process the STOP string, but the connection is blocked because the server is processing other commands. The user should instruct his system to:

1. Send the TELNET IP character;

2. Send the TELNET SYNC sequence, that is:
   a. Send the TELNET Data Mark (DM);
   b. Send the Host-Host Protocol INS;

3. Send the character string STOP; and

4. Send the other protocol's analog of the TELNET DM (if any).

The user (or process acting on his behalf) must transmit the TELNET SYNCH sequence of step 2 above to ENSURE that the TELNET IP gets through to the server's TELNET interpreter.

The NVT Printer and Keyboard

The NVT printer has an unspecified carriage width and page length and can produce representations of all 95 USASCII graphics (codes 32 through 126). Of the 33 USASCII control codes (0 through 31 and 127), and the 128 uncovered codes (128 through 255), the following have specified meaning to the NVT printer:

Name	Code	Meaning
NULL (NUL)	0	A no operation.
Line Feed (LF)	10	Moves the printer to the next print line, keeping the same horizontal position.
Carriage Return (CR)	13	Moves the printer to the left margin of the current line.

In addition, the following codes shall have defined, but not required, effects on the NVT printer. Neither end of a TELNET connection may assume that the other party will take, or will have taken, any particular action upon receipt or transmission of these:

BELL (BEL)	7	Produces an audible or visible signal (which does NOT move the print head).
Back Space (BS)	8	Moves the print head one character position toward the left margin.
Horizontal Tab (HT)	9	Moves the printer to the next horizontal tab stop. It remains unspecified how either party determines or establishes where such tab stops are located.
Vertical Tab (VT)	11	Moves the printer to the next vertical tab stop. It remains unspecified how either party determines or establishes where such tab stops are located.
Form Feed (FF)	12	Moves the printer to the top of the next page, keeping the same horizontal position.

All remaining codes do not cause the NVT printer to take any action.

The sequence "CR LF", as defined, will cause the NVT to be positioned at the left margin of the next print line (as would, for example, the sequence "LF CR"). However, many systems and terminals do not treat CR and LF independently, and will have to go to some effort to simulate their effect. (For example, some terminals do not have a CR independent of the LF, but on such terminals it may be possible to simulate a CR by backspacing.) Therefore, the sequence "CR LF" must be treated as a single "new line" character and used whenever their combined action is intended; the sequence "CR NUL" must be used where a carriage return alone is actually desired; and the CR character must be avoided in other contexts. This rule gives assurance to systems which must decide whether to perform a "new line" function or a multiple-backspace that the TELNET stream contains a character following a CR that will allow a rational decision.

The NVT keyboard has keys, or key combinations, or key sequences, for generating all 128 USASCII codes. Note that although many have no effect on the NVT printer, the NVT keyboard is capable of generating them.

In addition to these codes, the NVT keyboard shall be capable of generating the following additional codes which, except as noted, have defined, but not required, meanings. The actual code assignments for these "characters" are in the TELNET Command section, because they are viewed as being, in some sense, generic and should be available even when the data stream is interpreted as being some other character set.

Synch

This key allows the user to clear his data path to the other party. The activation of this key causes a DM (see command section) to be sent in the data stream and an INS to be sent on the control link. The pair DM-INS is to have required meaning as defined previously.

Break (BRK)

This code is provided because it is a signal outside the USASCII set which is currently given local meaning within many systems. It is intended to indicate that the Break Key or the Attention Key was hit. Note, however, that this is intended to provide a 129th code for systems which require it, not as a synonym for the IP standard representation.

Interrupt Process (IP)

Suspend, interrupt, abort or terminate the process to which the NVT is connected. Also, part of the out-of-band signal for other protocols which use TELNET.

Abort Output (AO)

Allow the current process to (appear to) run to completion, but do not send its output to the user. Also, send a Synch to the user.

Are You There (AYT)

Send back to the NVT some visible (i.e., printable) evidence that the AYT was received.

Erase Character (EC)

The recipient should delete the last preceding undeleted character or "print position" from the data stream.

Erase Line (EL)

The recipient should delete characters from the data stream back to, but not including, the last "CR LF" sequence sent over the TELNET connection.

The spirit of these "extra" keys, and also the printer format effectors, is that they should represent a natural extension of the mapping that already must be done from "NVT" into "local". Just as the NVT data byte 104 should be mapped into whatever the local code for "uppercase D" is, so the EC character should be mapped into whatever the local "Erase Character" function is. Further, just as the mapping for 174 is somewhat arbitrary in an environment that has no "vertical bar" character, the EL character may have a somewhat arbitrary mapping (or none at all) if there is no local "Erase Line" facility. Similarly for format effectors: if the terminal actually DOES have a "Vertical tab", then the mapping for VT is obvious, and only when the terminal does not have a vertical tab should the effect of VT be unpredictable.

TELNET COMMAND STRUCTURE

All TELNET commands consist of at least a two byte sequence: the "Interpret as Command" (IAC) escape character followed by the code for the command. The commands dealing with option negotiation are three byte sequences, the third byte being the code for the option

referenced. This format was chosen so that as more comprehensive use of the "data space" is made--by negotiations from the basic NVT, of course--collisions of data bytes with reserved command values will be minimized, all such collisions requiring the inconvenience, and inefficiency, of "escaping" the data bytes into the stream. With the current set-up, only the IAC need be doubled to be sent as data, and the other 255 codes may be passed transparently.

The following are the defined TELNET commands. Note that these codes and code sequences have the indicated meaning ONLY when immediately preceded by an IAC.

Name	Code	Meaning
SE	240	End of subnegotiation parameters
NOP	241	No operation
Data Mark	242	The data stream portion of a Synch. This should always be accompanied by an INS on the control link
Break	243	NVT character BRK
Interrupt Process	244	The function IP
Abort Output	245	The function AO
Are You There	246	The function AYT
Erase Character	247	The function EC
Erase Line	248	The function EL
Go Ahead	249	The GA signal
SB (option code)	250	Indicates that what follows is subnegotiation of the indicated option
WILL (option code)	251	Indicates the desire to begin performing, or confirmation that you are now performing, the indicated option

WON'T (option code)	252	Indicates the refusal to perform or continue performing, the indicated option
DO (option code)	253	Indicates the request that the other party perform, or confirmation that you are expecting the other party to perform, the indicated option
DON'T (option code)	254	Indicates the demand that the other party stop performing, or confirmation that you are no longer expecting the other party to perform the indicated option
IAC	255	Data byte 255

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TELNET Option Specifications

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TELNET Option Specifications
NIC #18640

The intent of providing for options in the TELNET Protocol is to permit sites to obtain more elegant solutions to the problems of communication between dissimilar devices than is possible within the framework provided by the Network Virtual Terminal (NVT). It should be possible for sites to invent, test, or discard options at will, even though the negotiation method permits the direct use of only 256 option codes. Nevertheless, it is envisioned that options which prove to be generally useful will eventually be supported by many sites; therefore it is desirable that options should be carefully documented and well publicized. In addition, it is necessary to insure that a single option code is not used for several different options.

This document specifies a method of option code assignment and standards for documentation of options. The individual responsible for assignment of option codes may waive the requirement for complete documentation for some cases of experimentation, but in general documentation will be required prior to code assignment. Options will be publicized by including their documentation in the TELNET section of Current Network Protocols (NIC #7104); inventors of options may, of course, publicize them in other ways as well.

Option codes will be assigned by:

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Documentation of options should contain at least the following sections:

Section 1 - Command name (and option code).

Section 2 - Command meanings (definitions). The meaning of each possible TELNET command relevant to this option should be described. Note that for complex options, where "subnegotiation" is required, there may be a large number of possible commands. The concept of "subnegotiation" is described in more detail below.

Section 3 - Default specification. The default assumptions for sites which do not choose to implement, or use, the option must be described.

Section 4 - Motivation. A detailed explanation of the motivation for inventing a particular option, or for choosing a particular form for the option, is extremely helpful to others who are not faced (or don't realize that they are faced) by the problem that the option is designed to solve.

Section 5 - Description (or Implementation Rules). Merely defining the command meanings and providing a statement of motivation are not always sufficient to insure that two implementations of an option will be able to communicate. Therefore, a more complete description should be furnished in most cases. This description might take the form of text, a sample implementation, hints to implementers, etc.

A Note on "Subnegotiation"

Some options will require more information to be passed between sites than a single option code. For example, any option which requires a parameter is such a case. The strategy to be used consists of two steps: first, both parties agree to "discuss" the parameter(s) and, second, the "discussion" takes place.

The first step, agreeing to discuss the parameters, takes place in the normal manner; one party proposes use of the option by sending a DO (or WILL) followed by the option code, and the other party accepts by returning a WILL (or DO) followed by the option code. Once both parties have agreed to use the option,

subnegotiation takes place by using the command SB, followed by the option code, followed by parameter(s), followed by the command SE. Each party is presumed to be able to parse the parameter(s), since each has indicated that the option is supported (via the initial exchange of WILL and DO). On the other hand, the receiver may locate the end of a parameter string by searching for the SE command (i.e., the string IAC SE), even if the receiver is unable to parse the parameters. Of course, either party may refuse to pursue further subnegotiation at any time by sending a WON'T or DON'T to the other party.

Thus, for option "ABC", which requires subnegotiation, the formats of the TELNET commands are:

IAC WILL ABC	Offer to use option ABC (or favorable acknowledgment of other party's request)
IAC DO ABC	Request for other party to use option ABC (or favorable acknowledgment of other party's offer)
IAC SB ABC <parameters> IAC SE	One step of subnegotiation, used by either party.

Designers of options requiring "subnegotiation" must take great care to avoid unending loops in the subnegotiation process. For example, if each party can accept any value of a parameter, and both parties suggest parameters with different values, then one is likely to have an infinite oscillation of "acknowledgments" (where each receiver believes it is only acknowledging the new proposals of the other). Finally, if parameters in an option "subnegotiation" include a byte with a value of 255, it *is* necessary to double this byte in accordance with the general TELNET rules.

The Augmented Knowledge Workshop

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The Augmented Knowledge Workshop

CONCEPT OF THE KNOWLEDGE WORKSHOP 1

This paper discusses the theme of augmenting a knowledge workshop. The first part of the paper describes the concept and framework of the knowledge workshop. The second part describes aspects of a prototype knowledge workshop being developed within this framework. 1a

The importange and implications of the idea of knowledge work have been described by Drucker *[3, 4]*. Considering knowledge to be the systematic organization of information and concepts, he defines the knowledge worker as the person who creates and applies knowledge to productive ends, in contrast to an "intellectual" for whom information and concepts may only have importance because they interest him, or to the manual worker who applies manual skills or brawn. In those two books Drucker brings out many significant facts and considerations highly relevant to the theme here, one among them (paraphrased below) being the accelerating rate at which knowledge and knowledge work are coming to dominate the working activity of our society: 1b

> In 1900 the majority and largest single group of Americans obtained their livelihood from the farm. By 1940 the largest single group was industrial workers, especially semiskilled machine operators. By 1960, the largest single group was professional, managerial, and technical -- that is, knowledge workers. By 1975-80 this group will embrace the majority of Americans. The productivity of knowledge has already become the key to national productivity, competitive strength, and economic achievement, according to Drucker. It is knowledge, not land, raw materials, or capital, that has become the central factor in production. 1b1

In his provocative discussions, Drucker makes extensive use of such terms as "knowledge organizations," "knowledge technologies," and "knowledge societies." It seemed a highly appropriate extension for us to coin "knowledge workshop" for re-naming the area of our special interest: the place in which knowledge workers do their work. Knowledge workshops have existed for centuries, but our special concern is their systematic improvement, toward increased effectiveness of this new breed of craftsmen. 1c

Workshop improvement involves systematic change not only in the tools that help handle and transform the materials, but in the customs, conventions, skills, procedures, working methods, organizational roles, training, etc. by which the workers and their organizations harness their tools, their skills, and their knowledge. 1d

Over the past ten years, the explicit focus in the Augmentation

Research Center (ARC) has been upon the effects and possibilities of new knowledge workshop tools based on the technology of computer timesharing and modern communications [18 - 41]. Since we consider automating many human operations, what we are after could perhaps be termed "workshop automation." But the very great importance of aspects other than the new tools (i.e., conventions, methods, roles) makes us prefer the "augmentation" term that hopefully can remain "whole-scope." We want to keep tools in proper perspective within the total system that augments native human capacities toward effective action [1 - 3, 10, 16, 18, 24]. 1e

Development of more effective knowledge workshop technology will require talents and experience from many backgrounds: computer hardware and software, psychology, management science, information science, and operations research, to name a few. These must come together within the framework of a new discipline, focused on the systematic study of knowledge work and its workshop environments. 1f

TWO WAYS IN WHICH AUGMENTED KNOWLEDGE WORKSHOPS ARE EVOLVING 2

INTRODUCTION 2a

First, one can see a definite evolution of new workshop architecture in the trends of computer application systems. An "augmented workshop domain" will probably emerge because many special-purpose application systems are evolving by adding useful features outside their immediate special application area. As a result, many will tend to overlap in their general knowledge work supporting features. 2a1

Second, research and development is being directed toward augmenting a "Core" Knowledge Workshop domain. This application system development is aimed expressly at supporting basic functions of knowledge work. An important characteristic of such systems is to interface usefully with specialized systems. This paper is oriented toward this second approach. 2a2

NATURAL EVOLUTION BY SCATTERED NUCLEI EXPANDING TOWARD A COMMON "KNOWLEDGE WORKSHOP" DOMAIN 2b

Anderson and Coover *[15]* point out that a decade or more of application-system evolution is bringing about the beginning of relatively rational user-oriented languages for the control interfaces of advanced applications software systems. What is interesting to note is that the functions provided by the "interface control" for the more advanced systems are coming to include editors and generalized file-management facilities, to make easier the preparation, execution, and management of the special-purpose tools of such systems. 2b1

It seems probable that special application-oriented systems (languages) will evolve steadily toward helping the user with such associated work as formulating models, documenting them, specifying the different trial runs, keeping track of intermediate results, annotating them and linking them back to the users' model(s), etc. When the results are produced by what were initially the core application programs (e.g., the statistical programs), he will want ways to integrate them into his working notes, illustrating, labeling, captioning, explaining and interpreting them. Eventually these notes will be shaped into memoranda and formal publications, to undergo dialogue and detailed study with and by others *[15]*. 2b2

Once a significant user-oriented system becomes established, with a steady growth of user clientele, there will be natural forces steadily increasing the effectiveness of the system services and steadily decreasing the cost per unit of service. And it will also be natural that the functional domain of an application system will

steadily grow outward: "as long as the information must be in computer form anyway for an adjacent, computerized process, let's consider applying computer aid to Activity X also." 2b3

Because the boundary of the Application System has grown out to be "next to" Activity X, it has become relatively easy to consider extending the computerized-information domain a bit so that a new application process can support Activity X. After all, the equipment is already there, the users who perform Activity X are already oriented to use integrated computer aid, and generally the computer facilitation of Activity X will prove to have a beneficial affect on the productivity of the rest of the applications system. 2b3a

This domain-spreading characteristic is less dependent upon the substantive work area a particular application system supports than it is upon the health and vitality of its development and application (the authors of [15] have important things to say on these issues); however, it appears that continuing growth is bound to occur in many special application domains, inevitably bringing about overlap in common application "sub-domains" (as seen from the center of any of these nuclei). These special subdomains include formulating, studying, keeping track of ideas, carrying on dialogue, publishing, negotiating, planning, coordinating, learning, coaching, looking up in the yellow pages to find someone who can do a special service, etc. 2b4

CONSIDERING THE CORE KNOWLEDGE WORKSHOP AS A SYSTEM DOMAIN IN ITS OWN RIGHT 2c

A second approach to the evolution of a knowledge workshop is to recognize from the beginning the amount and importance of human activity constantly involved in the "core" domain of knowledge work -- activity within which more specialized functions are embedded. 2c1

If you asked a particular knowledge worker (e.g., scientist, engineer, manager, or marketing specialist) what were the foundations of his livelihood, he would probably point to particular skills such as those involved in designing an electric circuit, forecasting a market based on various data, or managing work flow in a project. If you asked him what tools he needed to improve his effectiveness he would point to requirements for aids in designing circuits, analyzing his data, or scheduling the flow of work. 2c2

But, a record of how this person used his time, even if his work was highly specialized, would show that specialized work such as mentioned above, while vital to his effectiveness, probably occupied a small fraction of his time and effort. 2c2a

The bulk of his time, for example, would probably be occupied by more general knowledge work: writing a planning or design document; carrying on dialogue with others in writing, in person, or on the telephone; studying documents; filing ideas or other material; formulating problem-solving approaches; coordinating work with others; and reporting results. 2c2b

There would seem to be a promise of considerable payoff in establishing a healthy, applications oriented systems development activity within this common, "core" domain, meeting the special-application systems "coming the other way" and providing them with well-designed services at a natural system-to-system interface. 2c3

It will be much more efficient to develop this domain explicitly, by people oriented toward it, and hopefully with resources shared in a coordinated fashion. The alternative of semi-random growth promises problems such as: 2c4

1) Repetitive solutions for the same functional problems, each within the skewed perspective of a particular special-applications area for which these problems are peripheral issues, 2c4a

2) Incompatibility between different application software systems in terms of their inputs and outputs, 2c4b

3) Languages and other control conventions inconsistent or based on different principles from one system to another, creating unnecessary learning barriers or other discouragements to cross usage. 2c4c

In summary, the two trends in the evolution of knowledge workshops described above are each valuable and are complementary. Experience and specific tools and techniques can and will be transferred between them. 2c5

There is a very extensive range of "core" workshop functions, common to a wide variety of knowledge work, and they factor into many levels and dimensions. In the sections to follow, we describe our developments, activities, and commitments from the expectation that there soon will be increased activity in this core knowledge workshop domain, and that it will be evolving "outward" to meet the other application systems "heading inward." 2c6

BASIC ASSUMPTIONS ABOUT AUGMENTED KNOWLEDGE WORKSHOPS 3

EMBEDDED IN A COMPUTER NETWORK 3a

The computer-based "tools" of a knowledge workshop will be provided in the environment of a computer network such as the ARPANET [7, 8, 14]. For instance, the core functions will consist of a network of cooperating processors performing special functions such as editing, publishing, communication of documents and messages, data management, and so forth. Less commonly used but important functions might exist on a single machine. The total computer assisted workshop will be based on many geographically separate systems. 3a1

Once there is a "digital-packet transportation system," it becomes possible for the individual user to reach out through his interfacing processor(s) to access other people and other services scattered throughout a "community," and the "labor marketplace" where he transacts his knowledge work literally will not have to be affected by geographical location [27]. 3a2

Specialty application systems will exist in the way that specialty shops and services now do -- and for the same reasons. When it is easy to transport the material and negotiate the service transactions, one group of people will find that specialization can improve their cost/effectiveness, and that there is a large enough market within reach to support them. And in the network-coupled computer-resource marketplace, the specialty shops will grow; -- e.g., application systems specially tailored for particular types of analyses, or for checking through text for spelling errors, or for doing the text-graphic document typography in a special area of technical portrayal, and so on. There will be brokers, wholesalers, middle men, and retailers. 3a3

COORDINATED SET OF USER INTERFACE PRINCIPLES 3b

There will be a common set of principles, over the many application areas, shaping user interface features such as the language, control conventions, and methods for obtaining help and computer-aided training. 3b1

This characteristic has two main implications. One, it means that while each domain within the core workshop area or within a specialized application system may have a vocabulary unique to its area, this vocabulary will be used within language and control structures common throughout the workshop system. A user will learn to use additional functions by increasing vocabulary, not by having to learn separate "foreign" languages. Two, when in trouble, he will invoke help or tutorial functions in a standard way. 3b2

GRADES OF USER PROFICIENCY 3c

Even a once-in-a-while user with a minimum of learning will want to be able to get at least a few straightforward things done. In fact, even an expert user in one domain will be a novice in others that he uses infrequently. Attention to novice-oriented features is required. 3c1

But users also want and deserve the reward of increased proficiency and capability from improvements in their skills and knowledge, and in their conceptual orientation to the problem domain and to their workshop's system of tools, methods, conventions, etc. "Advanced vocabularies" in every special domain will be important and unavoidable. 3c2

A corollary feature is that workers in the rapidly evolving augmented workshops should continuously be involved with testing and training in order that their skills and knowledge may harness available tools and methodology most effectively. 3c3

EASE OF COMMUNICATION BETWEEN, AND ADDITION OF, WORKSHOP DOMAINS 3d

One cannot predict ahead of time which domains or application systems within the workshop will want to communicate in various sequences with which others, or what operations will be needed in the future. Thus, results must be easily communicated from one set of operations to another, and it should be easy to add or interface new domains to the workshop. 3d1

USER PROGRAMMING CAPABILITY 3e

There will never be enough professional programmers and system developers to develop or interface all the tools that users may need for their work. Therefore, it must be possible, with various levels of ease, for users to add or interface new tools, and extend the language to meet their needs. They should be able to do this in a variety of programming languages with which they may have training, or in the basic user-level language of the workshop itself. 3e1

AVAILABILITY OF PEOPLE SUPPORT SERVICES 3f

An augmented workshop will have more support services available than those provided by computer tools. There will be many people support services as well: besides clerical support, there will be extensive and highly specialized professional services, e.g. document design and typography, data base design and administration, training, cataloging, retrieval formulation, etc. In fact, the marketplace for human services will become much more diverse and active [27]. 3f1

COST DECREASING, CAPABILITIES INCREASING 3g

The power and range of available capabilities will increase and costs will decrease. Modular software designs, where only the software tools needed at any given moment are linked into a person's run-time computer space, will cut system overhead for parts of the system not in use. Modularity in hardware will provide local configurations of terminals and miniprocessors tailored for economically fitting needs. It is obvious that cost of raw hardware components is plummeting; and the assumed large market for knowledge workshop support systems implies further help in bringing prices down. 3g1

The argument given earlier for the steady expansion of vital application systems to other domains remains valid for explaining why the capabilities of the workshop will increase. Further, increasing experience with the workshop will lead to improvements, as will the general trend in technology evolution. 3g2

RANGE OF WORKSTATIONS AND SYMBOL REPRESENTATIONS 3h

The range of workstations available to the user will increase in scope and capability. These workstations will support text with large, open-ended character sets, pictures, voice, mathematical notation, tables, numbers and other forms of knowledge representation. Even small portable hand-held consoles will be available *[13]*. 3h1

CAREFUL DEVELOPMENT OF METHODOLOGY 3i

As much care and attention will be given to the development, analysis, and evaluation of procedures and methodology for use of computer and people support services as to the development of the technological support services. 3i1

CHANGED ROLES AND ORGANIZATIONAL STRUCTURE 3j

The widespread availability of workshop services will create the need for new organizational structures and roles. 3j1

SELECTED DESCRIPTION OF AUGMENTED WORKSHOP CAPABILITIES 4

INTRODUCTION 4a

Within the framework described above, ARC is developing a prototype workshop system. Our system does not meet all the requirements outlined previously, but it does have a powerful set of core capabilities and experience that leads us to believe that such goals can be achieved. 4a1

Within ARC we do as much work as possible using the range of online capabilities offered. We serve not only as researchers, but also as the subjects for the analysis and evaluation of the augmentation system that we have been developing. 4a2

Consequently, an important aspect of the augmentation work done within ARC is that the techniques being explored are implemented, studied, and evaluated with the advantage of intensive everyday usage. We call this research and development strategy "bootstrapping." 4a3

In our experience, complex man-machine systems can evolve only in a pragmatic mode, within real-work environments where there is an appropriate commitment to conscious, controlled, exploratory evolution within the general framework outlined earlier. The plans and commitments described later are a consistent extention of this pragmatic bootstrapping strategy. 4a4

To give the reader more of a flavor of some of the many dimensions and levels of the ARC workshop, four example areas are discussed below in more detail, following a quick description of our physical environment. 4a5

The first area consists of mechanisms for studying and browsing through NLS files as an example of one functional dimension that has been explored in some depth. 4a6

The second area consists of mechanisms for collaboration support -- a subsystem domain important to many application areas. 4a7

The third and fourth areas, support for software engineers and the ARPANET Network Information Center (NIC), show example application domains based on functions in our workshop. 4a8

GENERAL PHYSICAL ENVIRONMENT 4b

Our computer-based tools run on a Digital Equipment Corporation PDP-10 computer, operating with the Bolt, Beranek, and Newman TENEX

timesharing system [9]. The computer is connected via an Interface Message Processor (IMP) to the ARPANET [7, 8]. There is a good deal of interaction with Network researchers, and with Network technology, since we operate the ARPA Network Information Center (see below) [39]. 4b1

There is a range of terminals: twelve old, but serviceable, display consoles of our own design [26], an IMLAC display, a dozen or so 30 ch/sec portable upper/lower case typewriter terminals, five magnetic tape-cassette storage units that can be used either online or offline, and a 96-character line printer. There are 125 million characters of online disk storage. 4b2

The display consoles are equipped with a typewriter-like keyboard, a five-finger keyset for one-handed character input, and a "mouse" -- a device for controlling the position of a cursor (or pointer) on the display screen and for input of certain control commands. Test results on the mouse as a screen-selection device have been reported in [25], and good photographs and descriptions of the physical systems have appeared in [20, 21]. 4b2a

The core workshop software system and language, called NLS, provides many basic tools, of which a number will be mentioned below. It is our "core-workshop application system." 4b3

During the initial years of workshop development, application and analysis, the basic knowledge-work functions have centered around the composition, modification, and study of structured textual material [26]. Some of the capabilities in this area are described in detail in [26] and are graphically shown in a movie available on loan -- [41]. 4b4

The structured-text manipulation has been developed extensively because of its high payoff in the area of applications-system development to which we have applied our augmented workshop. We have delayed addition of graphic-manipulation capabilities because there were important areas associated with the text domain needing exploration and because of limitations in the display system and hardcopy printout. 4b4a

To build the picture of what our Core Knowledge Workshop is like, we first give several in-depth examples, and then list in the section on workshop utility service some "workshop subsystems" that we consider to be of considerable importance to general knowledge work. 4b5

STUDYING ONLINE DOCUMENTS 4c

INTRODUCTION 4c1

The functions to be described form a set of controls for easily moving one around in an information space and allowing one to adjust the scope, format, and content of the information seen [26, 41]. 4c1a

Given the addition of graphical, numerical, and vocal information, which are planned for addition to the workshop, one can visualize many additions to the concepts below. Even for strictly textual material there are yet many useful ideas to be explored. 4c1b

VIEW SPECIFICATIONS 4c2

One may want an overview of a document in a table-of-contents like form on the screen. To facilitate this and other needs, NLS text files are hierarchically structured in a tree form with subordinate material at lower levels in the hierarchy [26]. 4c2a

The basic conceptual unit in NLS, at each node of the hierarchical file, is called a "statement" and is usually a paragraph, sentence, equation, or other unit that one wants to manipulate as a whole. 4c2a1

A statement can contain many characters -- presently, up to 2000. Therefore, a statement can contain many lines of text. Two of the "view-specification" parameters -- depth in the hierarchy, and lines per statement -- can be controlled during study of a document to give various overviews of it. View specifications are given with highly abbreviated control codes, because they are used very frequently and their quick specification and execution make a great deal of difference in the facility with which one studies the material and keeps track of where he is. 4c2a2

Examples of other view specifications are those that control spacing between statements, and indentation for levels in the hierarchy, and determine whether the identifications associated with statements are to be displayed, which branch(es) in the tree are to be displayed, whether special filters are to be invoked to show only statements meeting specified content requirements or whether statements are to be transformed according to special rules programmed by the user. 4c2b

MOVING IN INFORMATION SPACE 4c3

A related viewing problem is designating the particular location (node in a file hierarchy) to be at the top of the screen. The computer then creates a display of the information from that point according to the view specifications currently in effect. 4c3a

The system contains a variety of appropriate commands to do this; they are called jump commands because they have the effect of "jumping" or moving one from place to place in the network of files available as a user's information space [26,33 - 39]. 4c3b

One can point at a particular statement on the screen and command the system to move on to various positions relative to the selected one, such as up or down in the hierarchical structure, to the next or preceding statement at the same hierarchical level, to the first or last statement at a given level, etc. 4c3b1

One can tell the system to move to a specifically named point or go to the next occurrence of a statement with a specific content. 4c3b2

Each time a jump or move is made, the option is offered of including any of the abbreviated view specifications -- a very general, single operation is "jump to that location and display with this view." 4c3b3

As one moves about in a file one may want to quickly and easily return to a previous view of the file. This is accomplished by saving a piece of the path as one traverses through the file and the specific view at each point, and then allowing return movement to the most recent points saved. 4c3c

Another important feature in studying or browsing in a document is being able to quickly move to other documents cited. 4c3d

There is a convention (called a "link") for citing documents that allows the user to specify a particular file, statement within the file and view specification for initial display when arriving in the cited file. 4c3d1

A single, quickly executed command (Jump to Link) allows one to point at such a citation, or anywhere in the statement preceding the citation, and the system will go to the specific file and statement cited and show the associated material with the specified view parameters. This allows systems of interlinked documents and highly specific citations to be created. 4c3d2

A piece of the path through the chain of documents is saved so that one can return easily a limited distance back along his "trail," to previously referenced documents. Such a concept was originally suggested by Bush [1] in a fertile paper that has influenced our thinking in many ways. 4c3e

MULTIPLE WINDOWS 4c4

Another very useful feature is the ability to "split" the viewing screen horizontally and/or vertically in up to eight rectangular display windows of arbitrary size. Generally two to four windows are all that are used. Each window can contain a different view of the same or different locations, within the same or different files *[39]*. 4c4a

COLLABORATIVE DIALOGUE AND TELECONFERENCING 4d

INTRODUCTION 4d1

The approach to collaboration support taken at ARC to date has two main thrusts: 4d1a

1) Support for real-time dialogue (teleconferencing) for two or more people at two terminals who want to see and work on a common set of material. The collaborating parties may be further augmented with a voice telephone connection as well. 4d1a1

2) Support for written, recorded dialogue, distributed over time. 4d1a2

These two thrusts give a range of capabilities for support of dialogue distributed over time and space. 4d1b

TELECONFERENCING SUPPORT 4d2

Consider two people or groups of people who are geographically separated and who want to collaborate on a document, study a computer program, learn to use a new aspect of a system, or perform planning tasks, etc. 4d2a

The workshop supports this type of collaboration by allowing them to link their terminals so that each sees the same information and either can control the system. This function is available for both display and typewriter terminal users over the ARPANET. 4d2b

The technique is particularly effective between displays because of the high speed of information output and the flexibility of being able to split the screen into several windows, allowing more than one document or view of a document to be displayed for discussion. 4d2c

When a telephone link is also established for voice communication between the participants, the technique comes as close as any we

know to eliminating the need for collaborating persons or small groups to be physically together for sophisticated interaction. 4d2d

A number of other healthy approaches to teleconferencing are being explored elsewhere [11, 12, 16, 17]. It would be interesting to interface to such systems to gain experience in their use within workshops such as described here. 4d2e

RECORDED DIALOGUE SUPPORT 4d3

INTRODUCTION 4d3a

As ARC has become more and more involved in the augmentation of teams, serious consideration has been given to improving intra- and inter-team communication with whatever mixture of tools, conventions, and procedures will help [27, 36, 39]. 4d3a1

If a team is solving a problem that extends over a considerable time, the members will begin to need help in remembering some of the important communications -- i.e., some recording and recalling processes must be invoked, and these processes become candidates for augmentation. 4d3a2

If the complexity of the team's problem relative to human working capacity requires partitioning of the problem into many parts -- where each part is independently attacked, but where there is considerable interdependence among the parts -- the communication between various people may well be too complex for their own accurate recall and coordination without special aids. 4d3a3

Collaborating teams at ARC have been augmented by development of a "Dialogue Support System (DSS)," containing current and thoroughly used working records of the group's plans, designs, notes, etc. The central feature of this system is the ARC Journal, a specially managed and serviced repository for files and messages. 4d3a4

The DSS involves a number of techniques for use by distributed parties to collaborate effectively both using general functions in the workshop and special functions briefly described below and more fully in [39]. Further aspects are described in the section on Workshop Utility Service. 4d3a5

DOCUMENT OR MESSAGE SUBMISSION 4d3b

The user can submit an NLS file, a part of a file, a file prepared on another system in the ARPANET (document), or text

typed at submission time (message) to the Journal system. When submitted, a copy of the document or message is transferred to a read-only file whose permanent safekeeping is guaranteed by the Journal system. It is assigned a unique catalog number, and automatically cataloged. Later, catalog indices based on number, author, and "titleword out of context" are created by another computer process. 4d3b1

Nonrecorded dialogue for quick messages or material not likely to be referenced in the future is also permitted. 4d3b2

One can obtain catalog numbers ahead of time to interlink document citations for related documents that are being prepared simultaneously. Issuing and controlling of catalog numbers is performed by a Number System (an automatic, crash-protected computer process). 4d3b3

At the time of submission, the user can contribute such information as: title, distribution list, comments, keywords, catalog numbers of documents this new one supersedes (updates), and other information. 4d3b4

The distribution is specified as a list of unique identification terms (abbreviated) for individuals or groups. The latter option allows users to establish dialogue groups. The system automatically "expands" the group identification to generate the distribution list of the individuals and groups that are its members. Special indices of items belonging to subcollections (dialogue groups) can be prepared to aid their members in keeping track of their dialogue. An extension of the mechanisms available for group distribution could give a capability similar to one described by Turoff [17]. 4d3b5

Entry of identification information initially into the system, group expansion, querying to find a persons or groups identification, and other functions are performed by an Identification System. 4d3b6

DOCUMENT DISTRIBUTION 4d3c

Documents are distributed to a person in one, two, or all of three of the following ways depending on information kept by the Identification System. 4d3c1

1) In hardcopy through the U.S. or corporation mail to those not having online access or to those desiring this mode, 4d3c1a

2) Online as citations (for documents) or actual text (for messages) in a special file assigned to each user. 4d3c1b

3) Through the ARPANET for printing or online delivery at remote sites. This delivery is performed using a standard Network wide protocol. 4d3c1c

Document distribution is automated, with online delivery performed by a background computer process that runs automatically at specified times. Printing and mailing are performed by operator and clerical support. With each such printed document, an address cover sheet is automatically printed, so that the associated printout pages only need to be folded in half, stapled, and stamped before being dropped in the mail. 4d3c2

DOCUMENT ACCESS 4d3d

An effort has been made to make convenient both online and offline access to Journal documents. The master catalog number is the key to accessing documents. Several strategically placed hardcopy master and access collections (libraries) are maintained, containing all Journal documents. 4d3d1

Automatic catalog-generation processes generate author, number, and titleword indices, both online and in hardcopy [38]. The online versions of the indices can be searched conveniently with standard NLS retrieval capabilities [37, 39, 41]. 4d3d2

Online access to the full text of a document is accomplished by using the catalog number as a file name and loading the file or moving to it by pointing at a citation and asking the system to "jump" there as described earlier. 4d3d3

SOFTWARE ENGINEERING AUGMENTATION SYSTEM 4e

INTRODUCTION 4e1

One of the important application areas in ARC's work is software engineering. The economics of large computer systems, such as NLS, indicate that software development and maintenance costs exceed hardware costs, and that software costs are rising while hardware costs are rapidly decreasing. The expected lifetime of most large software systems exceeds that of any piece of computer hardware. Large software systems are becoming increasingly complex, difficult to continue evolving and maintain. Costs of additional enhancements made after initial implementation generally exceed the initial cost over the lifetime of the system.

It is for these reasons that it is important to develop a powerful application area to aid software engineering. Areas of software engineering in which the ARC workshop offers aids are described below. 4e1a

DESIGN AND REVIEW COLLABORATION 4e2

During design and review, the document creation, editing, and studying capabilites are used as well as the collaboration, described above. 4e2a

USE OF HIGHER LEVEL SYSTEM PROGRAMMING LANGUAGES 4e3

Programming of NLS is performed in a higher level ALGOL-like system programming language called L-10 developed at ARC. The L-10 language compiler takes its input directly from standard NLS structured files. The PDP-10 assembler also can obtain input from NLS files. 4e3a

It is planned to extend this capability to other languages, for example, by providing an interface to the BASIC system available in our machine for knowledge workers wishing to perform more complex numerical tasks. 4e3b

We are involved with developing a modular runtime-linkable programming system (MPS), and with planning a redesign of NLS to utilize MPS capabilities, both in cooperation with the Xerox Palo Alto Research Center. MPS will: 4e3c

1) Allow a workshop system organization that will make it easier for many people to work on and develop parts of the same complex system semi-independently. 4e3c1

2) Make it easier to allow pieces of the system to exist on several processors. 4e3c2

3) Allow individual users or groups of users to tailor versions of the system to their special needs. 4e3c3

4) Make it easier to move NLS to other computers since MPS is written in itself. 4e3c4

5) Speed system development because of MPS's improved system building language facilities, integrated source-level debugging, measurement facilities, the ability to construct new modules by combining old ones, and to easily modify the system by changing module interconnection. 4e3c5

SYSTEM DOCUMENTATION AND SOURCE-CODE CREATION 4e4

Source-code creation uses the standard NLS hierarchical file structures and allows documentation and other programming conventions to be established that simplify studying of source-code files. 4e4a

DEBUGGING 4e5

A form of source-level debugging is allowed through development of several tools, of which the following are key examples: 4e5a

1) A user program compilation and link loading facility that allows new or replacement programs to be linked into the running system to create revised versions for testing or other purposes. 4e5b

2) NLS-DDT, a DDT like debugging facility with a command language more consistent with the rest of NLS, and simplifies display of system variables and data structures, and allows replacement of system procedures by user supplied procedures. 4e5c

3) Use of several display windows so as to allow source code in some windows and control of DDT in others for the setting of breakpoints and display of variables and data structures. 4e5d

MEASUREMENT AND ANALYSIS 4e6

A range of measurement tools has been developed for analyzing system operation. These include the following: 4e6a

1) Capabilities for gathering and reporting statistics on many operating system parameters such as utilization of system components in various modes, queue lengths, memory utilization, etc. 4e6b

2) The ability to sample the program counter for intervals of a selectable area of the operating system or any particular user subsystem to measure time spent in the sampled areas; 4e6c

3) Trace and timing facilities to follow all procedure calls during execution of a specified function. 4e6d

4) The ability to study page-faulting characteristics of a subsystem to check on its memory use characteristics. 4e6e

5) The ability to gather NLS command usage and timing information. 4e6f

6) The ability to study user interaction on a task basis from the point of view of the operating-system scheduler. 4e6g

7) The ability to collect sample user sessions for later playback to the system for simulated load, or for analysis. 4e6n

MAINTENANCE 4e7

Maintenance programmers use the various functions mentioned above. The Journal is used for reporting bugs; NLS structured source code files simplify the study of problem areas and the debugging tools permit easy modification and testing of the modifications. 4e7a

THE ARPA NETWORK INFORMATION CENTER (NIC) 4f

INTRODUCTION 4f1

The NIC is presently a project embedded within ARC [39]. Workshop support for the NIC is based on the capabilities within the total ARC workshop system. 4f1a

As useful as is the bootstrapping strategy mentioned earlier, there are limits to the type of feedback it can yield with only ARC as the user population. The NIC is the first of what we expect will be many activities set up to offer services to outside users. The goal is to provide a useful service and to obtain feedback on the needs of a wider class of knowledge workers. Exercised within the NIC are also prototypes of information services expected to be normal parts of the workshop. 4f1b

The NIC is more than a classical information center, as that term has come to be used, in that it provides a wider range of services than just bibliographic and "library" type services. 4f1c

The NIC is an experiment in setting up and running a general purpose information service for the ARPANET community with both online and offline services. The services offered and under development by the NIC have as their initial basic objectives: 4f1d

1) To help people with problems find the resources (people, systems, and information) available within the network community that meet their needs. 4f1d1

2) To help members of geographically distributed groups collaborate with each other. 4f1d2

Following are the NIC services now provided to meet the above goals in serving the present clientele: 4f1e

CURRENT ONLINE SERVICES 4f2

1) Access to the typewriter version (TNLS) and display version (dnls) of the Augmentation Research Center's Online System (NLS) for communique creation, access, and linking between users, and for experimental use for any other information storage and manipulation purpose suitable for NLS and useful to Network participants. 4f2a

2) Access to Journal, Number, and Identification Systems to allow messages and documents to be transmitted between network participants. 4f2b

3) Access to a number of online information bases through a special Locator file using NLS link mechanisms and through a novice-oriented query system. 4f2c

CURRENT OFFLINE SERVICES 4f3

1) A Network Information Center Station set up at each network site. 4f3a

2) Techniques for gathering, producing and maintaining data bases such as bibliographic catalogs, directories of network participants, resource information, and user guides. 4f3b

3) Support of Network dialogue existing in hardcopy through duplication, distribution, and cataloging. 4f3c

4) General Network referral and handling of document requests. 4f3d

5) Building of a collection of documents potentially valuable to the Network Community. Initial concentration has been on obtaining documents of possible value to the Network builders. 4f3e

6) As yet primitive selective document distribution to Station Collections. 4f3f

7) Training in use of NIC services and facilities. 4f3g

CONCLUSION 4f4

The Network Information Center is an example prototype of a new type of information service that has significant future potential. Even though it is presently in an experimental and developmental phase, it is providing useful online and offline services to the ARPANET community. 4f4a

PLANS FOR A WORKSHOP UTILITY SERVICE 5

MOTIVATION 5a

It is now time for a next stage of application to be established. We want to involve a wider group of people so that we can begin to transfer the fruits of our past work to them and with their assistance, to others, and so that we can obtain feedback needed for further evolution from wider application than is possible in our project alone [28]. We want to find and support selected groups who are willing to take extra trouble to be exploratory, but who: 5a1

1) Are not necessarily oriented to being core-workshop developers (they have their own work to do). 5a1a

2) Can see enough benefit from the system to be tried and from the experience of trying it so that they can justify the extra risk and expense of being "early birds". 5a1b

3) Can accept assurance that system reliability and stability, and technical/application help will be available to meet their conditions for risk and cost. 5a1c

ARC is establishing a Workshop Utility Service, and promoting the type of workshop service described above as part of its long-term commitment to pursue the continued development of augmented knowledge workshops in a pragmatic, evolutionary manner. 5a2

It is important to note that the last few years of work have concentrated on the means for delivering support to a distributed community, for providing teleconferencing and other basic processes of collaborative dialogue, etc. ARC has aimed consciously toward developing experience and capabilities especially applicable to support remote and distributed groups of exploratory users for this next stage of wider-application bootstrapping. 5a3

One aspect of the service is that it will be an experiment in harnessing the new environment of a modern computer network to increase the feasibility of a wider community of participants cooperating in the evolution of an application system. 5a4

CHARACTERISTICS OF THE PLANNED SERVICE 5b

The planned service offered will include: 5b1

1) Availability of Workshop Utility computer service to the user community from a PDP-10 TENEX system operated by a commercial supplier. 5b2

2) Providing training as appropriate in the use of Display NLS (DNLS), Typewriter NLS (TNLS), and Deferred Execution (DEX) software subsystems. 5b3

3) Providing technical assistance to a user organization "workshop architect" in the formulation, development, and implementation of augmented knowledge work procedures within selected offices at the user organization *[6]*. 5b4

This assistance will include help in the development of NLS use strategies suitable to the user environments, procedures within the user organization for implementing these strategies, and possible special-application NLS extensions (or simplifications) to handle the mechanics of particular user needs and methodologies. 5b4a

4) Providing "workshop architect" assistance to help set up and assist selected geographically distributed user groups who share a special discipline or mission orientation to utilize the workshop utility services and to develop procedures, documentation, and methodology for their purposes. 5b5

GENERAL DESCRIPTION OF SOME WORKSHOP UTILITY SUBSYSTEMS 5c

INTRODUCTION 5c1

Within a particular professional task area (mission- or discipline-oriented) there are often groups who could be benefitted by using special workshop subsystems. These subsystems may be specialized for their specific application or research domain or for support of their more general knowledge work. Our goal is to offer a workshop utility service that contains a range of subsystems and associated methodology particularly aimed at aiding general knowledge work, and that also supports in a coordinated way special application subsystems either by interfacing to subsystems already existing, or by developing new subsystems in selected areas. 5c1a

In the descriptions to follow are a number of workshop subsystem domains that are fundamental to a wide range of knowledge work in which ARC already has extensive developments or is committed to work. For each subsystem we include some general comments as well as a brief statement of current ARC capabilities in the area. 5c1b

DOCUMENT DEVELOPMENT, PRODUCTION, AND CONTROL 5c2

Here a system is considered involving authors, editors, supervisors, typists, distribution-control personnel, and

technical specialists. Their job is to develop documents, through successive drafts, reviews, and revisions. Control is needed along the way of bibliography, who has checked what point, etc. . Final drafts need checkoff, then production. Finally distribution needs some sort of control. If it is what we call a "functional document" such as a user guide, then it needs to be kept up to date [39]. There is a further responsibility to keep track of who needs the documents, who has what version, etc. 5c2a

Within the ARC workshop, documents ranging from initial drafts to final high-quality printed publications can be quickly produced with a rich set of creation and editing functions. All of ARC's proposals, reports, designs, letters, thinkpieces, user documentaion, and other such information are composed and produced using the workshop. 5c2b

Documents in a proof or finished form can be produced with a limited character set and control on a line printer or typewriter, or publication-quality documents can be produced on a photocomposer microfilm unit. 5c2c

Presently there are on the order of two hundred special directives that can be inserted in text to control printing. These directives control such features as typefont, pagination, margins, headers, footers, statement spacing, typefont size and spacing, indenting, numbering of various hierarchical levels, and many other parameters useful for publication quality work. 5c2c1

Methodology to perform the creation, production, and controlling functions described above has been developed, although much work at this level is still needed. 5c2c2

In terms of future goals, one would like to have display terminals with a capability for the range of fonts available on the photocomposer so that one could study page layout and design interactively, showing the font to be used, margins, justification, columnization, etc. on the screen rather than having to rely on hardcopy proofsheets. 5c2d

To prepare for such a capability, plans are being made to move toward an integrated portrayal mechanism for both online and hardcopy viewing. 5c2d1

COLLABORATIVE DIALOGUE AND TELECONFERENCING 5c3

Effective capabilities have already been developed and are in application, as discussed above. There is much yet to do. The

Dialogue support system will grow to provide the following additional general online aids: 5c3a

Link-setup automation; back-link annunciators and jumping; aids for the formation, manipulation, and study of sets of arbitrary passages from among the dialogue entries; and integration of cross-reference information into hardcopy printouts. Interfaces will probably be made to other teleconferencing capabilities that come into existence on the ARPANET. 5c3b

It also will include people-system developments: conventions and working procedures for using these aids effectively in conducting collaborative dialogue among various kinds of people, at various kinds of terminals, and under various conditions; working methodology for teams doing planning, design, implementation coordination; and so on? 5c3c

MEETINGS AND CONFERENCES 5c4

Assemblies of people are not likely for a long time, if ever, to be supplanted in total by technological aids. Online conferences are held at ARC for local group meetings and for meetings where some of the participants are located across the country. 5c4a

Use is made of a large-screen projection TV system to provide a display image that many people in a conference room can easily see. This is controlled locally or remotely by participants in the meeting, giving access to the entire recorded dialogue data base as needed during the meeting and also providing the capability of recording real-time meeting notes and other data. The technique also allows mixing of other video signals. 5c4b

MANAGEMENT AND ORGANIZATION 5c5

The capabilities offered in the workshop described in this paper are used in project management and administration *[39]*. Numerical calculations can also be performed for budget and other purposes, obtaining operands and returning results to NLS files for further manipulation. 5c5a

Where an organization has conventional project management operations, their workshop can include computer aids for techniques such as PERT and CPM. We want to support the interfacing that our Core Workhop can provide to special application systems for management processes. 5c5b

We are especially interested, at this stage, in management of

project teams -- particularly, of application-systems development teams. 5c5c

HANDBOOK DEVELOPMENT 5c6

Capabilities described above are being extended toward the coordinated handling of a very large and complex body of documentation and its associated external references. The goal is that a project or discipline of ever-increasing size and complexity can be provided with a service that enables the users to keep a single, coordinated "superdocument" in their computer; that keeps up to date and records the state of their affairs; and provides a description of the state of the art in their special area. 5c6a

Example contents would be glossaries, basic concept structure, special analytic techniques, design principles, actual design, and implementation records of all developments. 5c6b

RESEARCH INTELLIGENCE 5c7

The provisions within the Dialogue Support System for cataloging and indexing internally generated items also support the management for externally generated items, bibliographies, contact reports, clippings, notes, etc. Here the goal is to give a human organization (distributed or local) an ever greater capability for integrating the many input data concerning its external environment; processing (filtering, transforming, integrating, etc.) the data so that it can be handled on a par with internally generated information in the organization's establishing of plans and goals; and adapting to external opportunities or dangers [38]. 5c7a

COMPUTER-BASED INSTRUCTION 5c8

This is an important area to facilitate increasing the skills of knowledge workers. ARC has as yet performed little direct work in this area. We hope in the future to work closely with those in the computer-based instruction area to apply their techniques and systems in the workshop domain. 5c8a

In training new and developing users in the use of the system, we have begun using the system itself as a teaching environment. This is done locally and with remote users over the ARPANET. 5c8b

SOFTWARE ENGINEERING AUGMENTATION 5c9

A major special application area described above, that has had considerable effort devoted to it, is support of software

engineers. The software-based tools of the workshop are designed and built using the tools previously constructed. It has long been felt [24, 29] that the greatest "bootstrapping" leverage would be obtained by intensively developing the augmented worksnop for software engineers, and we hope to stimulate and support more activity in this area. 5c9a

KNOWLEDGE WORKSHOP ANALYSIS 5c10

Systematic analysis has begun of the workshop environment at internal system levels, at user usage levels, and at information-handling procedure and methodology levels. The development of new analytic methodology and tools is a part of this process. The analysis of application systems, and especially of core-workshop systems, is a very important capability to be developed. To provide a special workshop subsystem that augments this sort of analytic work is a natural strategic goal. 5c10a

CONCLUSION -- THE NEED FOR LONG-TERM COMMITMENT 6

As work progresses day-to-day toward the long-term goal of helping to make the truly augmented knowledge workshop, and as communities of workshop users become a reality, we at ARC frequently reflect on the magnitude of the endeavor and its long-term nature *[22]*. 6a

Progress is made in steps, with hundreds of short-term tasks directed to strategically selected subgoals, together forming a vector toward our higher-level goals. 6a1

To continue on the vector has required a strong commitment to the longer-range goals by the staff of ARC. 6b

In addition, we see that many of the people and organizations we hope to enlist in cooperative efforts will need a similar commitment if they are to effectively aid the process. 6c

One of ARC's tasks is to make the long-term objectives of the workshop's evolutionary development, the potential value of such a system, and the strategy for realizing that value clear enough to the collaborators we seek, so that they will have a strong commitment to invest resources with understanding and patience. 6c1

One key for meeting this need will be to involve them in serious use of the workshop as it develops. The plans for the Workshop Utility are partly motivated by this objective. 6c2

Although the present ARC workshop is far from complete, it does have core capabilities that we feel will greatly aid the next communities of users in their perception of the value of the improved workshops of the future. 6c3

ACKNOWLEDGEMENTS 7

During the 10 year life of ARC many people have contributed to the development of the workshop described here. There are presently some 35 people -- clerical, hardware, software, information specialists, operations researchers, writers, and others -- all contributing significantly toward the goals described here. 7a

The work reported here is currently supported primarily by the Advanced Research Projects Agency of the Department of Defense, and also by the Rome Air Development Center of the Air Force and by the Office of Naval Research. 7b

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The Augmented Knowledge Workshop

MOVIE AVAILABLE FROM ARC FOR LOAN 8f

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SUPPORTIVE DATA 9

TITLE: 9a

THE AUGMENTED KNOWLEDGE WORKSHOP

AUTHORS: 9b

Dr. Douglas C. Engelbart, Director
Augmentation Research Center

Dr. Richard W. Watson, Assistant Director
Augmentation Research Center

James C. Norton, Assistant Director
Augmentation Research Center

AFFILIATION: 9c

Stanford Research Institute
Menlo Park, California

PUBLICATION: 9d

This paper was written on-line in NLS and directly printed via Computer Outut to Microfilm.

18641 Distribution

The Augmented Knowledge Workshop

(J18641) 24-AUG-73 09:47; Title: Author(s): N. Dean Meyer/NDM;
Sub-Collections: COM ; Clerk: NDM;
Origin: <MEYER>NCCPAPER.NLS;3, 2-AUG-73 16:28 NDM ; Title:
Author(s):DCE RWW JCN; Distribution: /; Sub-Collections: SRI-ARC;
Clerk: LLL; .D=Print; .LMBase=0,1.1; .RM=,6.5; .TM=4,0.75;
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.H1Font=10p,6,Medium; .H1P=OddR; .FSw=On; .F="National Computer
Conference, June 1973 .Split; page .GPN;"; .FP=FR;
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.SNFFont=6p,1,Light; .SNFFontShow=All; .YBS=1,8p; .YBL=0,2p;
.PxFShow=1; .PxFYD=0; .PxFYU=2,28p; .PxFYS=2,28p; .BP=J;
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.PxIShOw=<=5; .IMax=9,0.75; .PxPShow=1; .Leading=Off; .XBC=,0.6;
.YFC=0,4p; .SP=C; .PN=0; .PES;

Daughter of Failure to Log into ARC

Nancy,
<journal,18631,) has come to my attention because I am in charge of helping the people at Rome under a separate support contract. We (Martin Hardy (MEH) for hardware and Bill Fergeson (WRF) for TENEX) are checking it out, but there is some other evidence I though you should know about. From time to time people have reported failing to long into us frm their own tip, then succeeding by going through some othr host, <journal,17838,>, for example. 1

That makes no sene, of course. 2

Chiauo, as Mario says. 3

18642 Distribution
Nancy J. Neigus, James H. Bair, Duane L. Stone, Martin E. Hardy, Ferg R. Ferguson, I. Larry Avrunin, James C. Norton,

Daughter of Failure to Log into ARC

(J18642) 24-AUG-73 10:44; Title: Author(s): Dirk H. Van Nouhuys/DVN; Distribution: /NJN JHB DLS MEH WRF ILA JCN; Sub-Collections: NIC SRI-ARC RADC; Clerk: DVN;

Timing of Text Insertion with Network TNLS

(J18643) 24-AUG-73 10:53; Title: Author(s): Susan R. Lee/SRL;
Distribution: /SSP NJN MDK RWW JCN DIA DCE PR CHI DHC; Sub-Collections:
SRI-ARC; Clerk: SRL;
Origin: <LEE>NET.NLS;8, 24-AUG-73 10:46 SRL ;

Timing of Text Insertion with Network TNLS 1

INTRODUCTION 2

Measurements of the time required for text insertion have been made at SRI-ARC to determine where improvements should be made and also the effect of improvements which have been implemented. 2a

During the first few weeks in April interest was generated here as to whether there would be any difference in time for text insertions over the net. As a result, measures were collected at MITRE Corporation and Bolt Beranek and Newman, and are summarized below. 2b

SUMMARY OF RESULTS 3

Tests were made under several different conditions, varying loads and CPS settings of 15 and 30. A low load average was one less than 2, a medium was between 2 and 6 and a high was greater than 6. (During these tests, all high loads were greater than 10.) Tests at MITRE were done on a TI and those at BBN were done on a Model 37. All tests were done through TIPs. 3a

The two things measured were the average CPU and connect for executing the Insert Character command, and also the times for actually inserting characters. 3b

A copy of the instructions for the testing is included in the Appendix. 3b1

Results of tests at BBN (CPS settings could not be varied)
All units in the tables below are seconds. 3c

	Load Average			
	low	medium	high	
Avg Cpu for IC	.21	.23	.30	3c3
Avg Con for IC	13	19	20	3c4
Avg CPU/char	.006	.007	.0085	3c5
Avg Con/char	31	32	32	3c6
No. of tests	7	7	4	3c7

Load Average 3c1

low medium high 3c2

Results of tests at MITRE
All units in the tables below are seconds. 3d

Timing of Text Insertion with Network TNLS

	CPS Setting - Load Average				
	15-low	30-low	15-high	30-high	3d1
Avg CPU for IC	.13	.18	.26	.23	3d2
Avg Con for IC	06	09	14	16	3d3
Avg CPU/char	.005	.007	.0096	.010	3d4
Avg Con/char	23	45	39	41	3d5
No. of tests	3	7	5	4	3d6

3d7

COMMENTS ABOUT RESULTS 4

The times for inserting a character over the net are in general twice as large as those measured at SRI. 4a

See (15466,) and (14351,) for measures taken at SRI. 4a1

Since many people had a part in collecting this data, typing speed is no doubt a factor although an attempt was made to control it. It appears however that the data collected at BBN was collected at a fairly constant typing rate as the connect time per character is essentially unchanged. 4b

The network results are very similar to the measurements made at SRI using a very slow typing speed (approximately one character per second). 4c

Since the page fault rate is 3 times higher for network TNLS than local TNLS (based on statistics for the last 10 months), it is possible that the differences in CPU times are due to that cause. 4d

However, this is only a conjecture which must be checked by further measurements. More sophisticated methods of measurement are available at ARC which would allow us to analyze exactly the cause of these differences. 4e

Simultaneous testing over the network and at ARC is planned to insure equal load conditions. 4e1

If any person over the net is interested in pursuing this question further please contact me (SRL). 4f

APPENDIX 5

Copy of Instructions Given to Network Participants 5a

Timing of Text Insertion with Network TNLS

In order to be able to compare the data gathered on the network with what has already been done at ARC, a method similar to the one used before will be used again, at least at the onset. Basically, this consists of logging into NLS, and using a control T (↑T) to determine the amount of CPU time as well as connect time used to insert a series of characters. (In the following detailed example, pretend that the series of dashes are blanks.) 5a1

In order to conduct these tests, information should be recorded in the following manner: 5a2

Ident ----- 5a2a

Date ---------- 5a2b

↑T USED -------- IN--------- Load Avg. ---------- 5a2c

I(nsert) C(haracter) (address) 5a2d

↑T USED -------- IN -------- 5a2e

(Type in 100-200 characters, or whatever you feel like! Specify exact character count.) ---------- 5a2f

↑T USED -------- IN -------- 5a2g

When entering the characters, a normal typing speed should be used (approximately 40-50 wpm). If possible conduct your tests during times of low load average (<2) and normal load average (>3), possibly in early morning and during normal working hours. Also vary the CPS setting so that you have records at both 30 and 15 CPS. (The switch to vary this setting should be located inside your terminal.) Please repeat each test several times (at least 3). When finished, please send your data to me (SRL). If you have any comments or questions, please feel free to contact me. 5a3

18643 Distribution
Susan S. Poh, Nancy J. Neigus, Michael D. Kudlick, Richard W. Watson, James C. Norton, Don I. Andrews, Douglas C. Engelbart, Paul Rech, Charles H. Irby, David H. Crocker,

18643 Distribution
Susan S. Poh, Nancy J. Neigus, Michael D. Kudlick, Richard W. Watson, James C. Norton, Don I. Andrews, Douglas C. Engelbart, Paul Recn, Charles H. Irby, David H. Crocker,

LPD 24-AUG-73 11:11 18644

NIC NCP Statistics Experiment

distribute as an RFC

NIC NCP Statistics Experiment

For the past couple of weeks, the NIC NCP has been keeping statistics on total incoming messages, incoming host-host control opcodes, and size of outgoing messages. The results have been rather enlightening and, I think, should be carefully considered by future implementors of NCP's for servers. The statistics will be presented in a rather qualitative fashion, since they were reset each time the system came up, but they represent a total of about 100 hours of uptime, most of it during the working day. 1

The total numbers of incoming and outgoing messages were almost identical. There were about 5% more outgoing. There were slightly over half as many incoming control opcodes processed as incoming messages; on the assumption that no incoming control message had more than one opcode, slightly over half the incoming messages were control messages. 2

The opcode statistics were somewhat variable. In all cases the ALL opcode accounted for the great majority, from a low of about 50% on weekends to a high of 98% on a busy weekday. Almost all of the remainder were NOPs. No other opcode ever accounted for more than 5%. 3

The output message statistics were taken as log2(message size): this included 1 word of buffer header, 1 word of IMP header, and 1 word of host header. As might be expected, 95% of all outgoing messages had 1 to 4 PDP-10 words (36-bit) of data. However, if one multiplies the count for each bucket by the average message size for that bucket, the result is that only 75% of all outgoing data was in the smallest message size: the remaining data was spread out fairly evenly between the other buckets. 4

I would draw the following conclusions from these statistics. First, half the messages on the network appear to be ALLs. This suggests that NCPs should give some thought to processing control messages efficiently. Second, 95% of the messages are very short. This suggests that elaborate buffering and queuing schemes are not likely to be valuable, since the hypothetical gain in efficient use of the IMP is probably swamped by the overhead within the host. Third, a sufficiently large fraction of all data is in large messages (presumably file transfers) that it is also necessary to deal with this situation efficiently, e.g. a NCP which always sent 1-character messages would not be satisfactory. 5

The ARPANET has been in vigorous operation for a year or two, and many NCPs have been written during this time (including a rewrite of the TENEX NCP, which probably handles more traffic than all other NCPs combined); to my knowledge, no one has bothered to gather these statistics before. The total time invested in putting these measurements into the NIC system was about half an hour (10

instructions). I find it regrettable that even those of us presumably engaged in "computer science" have not found it necessary to confirm our hypotheses about network operation by experiment and to improve our theories on the basis of evidence. 6

18644 Distribution
Marcia Lynn Keeney,

NIC NCP Statistics Experiment

(J18644) 24-AUG-73 11:11; Title: Author(s): L. Peter Deutsch/LPD;
Distribution: /MLK; Sub-Collections: NIC; Clerk: LPD;
Origin: <DEUTSCH>IMPSTATS.NLS;3, 24-AUG-73 10:48 LPD ;

info on phone numbers

for those of you who do not have the complete list, the following are valid phone numbers (as of this date) for accessing the TIP and the ARPAnet: 1

4172 1a

4173 1b

4174 1c

4175 1d

4176 1e

4177 1f

4293 1g

2073 1h

4777 1i

2884 1j

18645 Distribution

Donna R. Robilotta, David L. Daughtry, Richard H. Thayer, Frank J. Tomaini, Mike A. Wingfield, Edmund J. Kennedy, Ray A. Liuczi, Richard Calicchia, John W. Johnson, Donald Van Alstine, Dean F. Bergstrom, William P. Bethke, Frank S. LaMonica, William E. Rzepka, Rocco F. Iuorno, Frank P. Sliwa, Thomas J. Bucciero, Robert E. Doane, David A. Luther, Roger B. Panara, John L. McNamara, Joe P. Cavano, Duane L. Stone, Marcelle D. Petell, Josephine R. Stellato, Robert K. Walker, Thomas F. Lawrence, James H. Bair,

EJK 24-AUG-73 11:14 18645

info on phone numbers

(J18645) 24-AUG-73 11:14; Title: Author(s): Edmund J. Kennedy/EJK; Distribution: /RADC; Sub-Collections: RADC; Clerk: EJK;

sorry about that

mel, sorry about the link, but i was having considerable problems and wanted to see if you were also. apparently you were not. robert 1

18646 Distribution
Melvin E. Haas,

sorry about that

(J18646) 24-AUG-73 11:49; Title: Author(s): Robert N. Lieberman/RLL; Distribution: /MH; Sub-Collections: NIC; Clerk: RLL;

john, put a branch in your initial file and name the brahcn (nlscontrolcharacters). at the first level of the branch insert a statement that says: eol=null; . that should solve your cr problem. ernie.

1

18647 Distribution
Jean Iseli,

(J18647) 24-AUG-73 11:57; Title: Author(s): Ernest H. Forman/EHF;
Distribution: /JI; Sub-Collections: NIC; Clerk: EHF;

proj.5550 steering group meeting

This file provides information on what was presented and proposed for Project 5550 at the 15/16 Aug 73 Steering Group meeting. It has been developed to assist the Steering Group members in arriving at recommendations and guidance for the project. The years FY74-FY76 are covered. 1

The file consists of two sections. The first section presents funding on a task basis. For the year FY74, three situations are presented: 2

(a) The $1.0 Million level which is already released.
(b) The $2.9 Million level as directed in the PMD.
(c) The funding level as proposed to the Steering Group as being that which is required and can be expended by 30June74 (Except as in the notes below). The funding requirements for the approved PMD tasks totaled $2,694,000. 2a

The second section is a breakdown by effort and provides the details for the first section above. It consists of two subsections: 3

(a) Subsection 1 provides the information by effort on how the released $1.0 million will be spent.
(b) Subsection 2 provides the information by effort as presented at the meeting above the $1.0 million in FY74 and FY75 and FY76 programs with no ceiling limitations. (In some cases, more current information has been supplied by task engineers. These cases are identified in the notes below.) 3a

MITRE and Aerospace efforts are considered new efforts each year. Such is the case because contracts and their contents are negotiated each year. Also, efforts are structured so that a product results each year. It should be realized however, that these products are usually interim products and that a level must be maintained to insure continuity of effort. 4

The funding requirements for FY74 are based on three assumptions: 5

(a) Funds will be released by 1 Jan.
(b) D&F's will be submitted by Oct to AFSC and action on them will be expedited.
(c) Authority will be received from headquarters to go forward with procurements at least to commitment of funds (i.e. to negotiations). 5a

Some flexibility should be built into the PMD and Form 56 so that all funds are expended by year end. The funding requirements are estimates for cost of work and are on a fiscal year expenditure basis. Procurements have their unexpected ways of slipping and thus effect each year's estimate. Further, requests for forward financing

are being scrutinized and AFSC Comptroller decisions could affect the following year's plans. 6

Notes which are appropriate as added information are: 7

Associative Processor- $12,000 & $1,000 for RADC travel and tech reports respectively are included in the task funds. $30,000 was not presented as being required for the new Syracuse U. contract to be awarded in March74. 7a

Spacecraft Computer- Final report was given. In further discussion with SAMSO personnel on 16Aug, they said that although Preprocessor effort was presented, they did not expect to get funds from 63728F because of history of transfer of task. They will gladly accept 5550 funds if they are available ($50K each in 74 & 75) since it appears there is no other source for funds. Procurement package has been ready since Dec72 when it looked as if additional FY73 5550 funds would become available. The task has not been officially terminated in the project. 7b

On-Line Decision Aids was presented as Augmented Knowledge Workshop. Funds can be expended for terminals in FY74 if the funds become available. 7c

Software First is a part of Task 08-Software C R & T and is included as such. 7d

ADP System Security - Only new starts are shown in FY75 and $1.0 million is shown as 01R in FY76. This task is an excellent example in which interim products are scheduled for the end of the fiscal year. The $1.0 million 01R in FY76 represents estimated computer rental cost if approved as requested in FY75. This 01R will carry through FY77. It is felt that a level of effort must be maintained and only further definition of the task will make the level determinable. The funds above the $900,000 shown on the flow charts for FY74 ($750,000) have been added to FY75 needs. 7e

Requirements Analysis was presented as Semi-Automated Requirements Analysis. Although there are no new starts for FY76, the task will run through FY78 with new starts in FY77. 7f

The priority of work in Task 11 as seen by the task engineer is CPU, memory, power supply, and I/O. 7g

Transferability Aids and PEM-Aids are 6.4 fold-ins which were also presented at the March73 Steering Group meeting . 7h

proj.5550 steering group meeting

FY74 SUMMARY OF P5550 EFFORTS BY TASK BASED ON 15/16Aug73 STEERING GROUP MEETING FUNDS(x1000)

No	SHORT TASK TITLE	$1.0M	$2.9M	REQMT
1	Associative Processor	311	345	675
3	Spacecraft Computer	See Note		
4	Data Mgt Systems	164	170	164
6	On-Line Decision Aids	See Note		
8	Software C,R,&T	245	725	1,145
9	ADP Systems Security	280	900	900
10	Req'ts Analysis	-0-	-0-	15
11	HiCap Aero Components	-0-	335	335
13	Data Fusion	-0-	-0-	40
14	Source Data Auto	-0-	50	200
	Transferability Aids	-0-	375	175
	PEM Aids	-0-	-0-	300
	HOL Computer (SPLM)	-0-	-0-	100
	TOTALS	1,000	2,900	4,049

proj.5550 steering group meeting

FY75-76 SUMMARY OF P5550 EFFORTS BY TASK BASED ON 15/16Aug73 STEERING GROUP MEETING FUNDS(x1000)

No	SHORT TASK TITLE	75 O1R	75 NEW	76 O1R	76 NEW
1	Associative Processor	20/50/150	378	0/100/175	-0-
3	Spacecraft Computer	See Note			
4	Data Mgt Systems	0/0/0	355	0/0/190	65
6	On-Line Decision Aids	0/0/0	500	0/0/500	-0-
8	Software C,R,&T	0/750/140	825	330/0/200	425
9	ADP Systems Security	See Note	4,200	0/0/1,000	2,950
10	Req'ts Analysis	0/0/15	111	0/0/241	-0-
11	HiCap Aero Components	0/405/0	245	0/0/200	250
13	Data Fusion	0/0/60	40	0/0/300	40
14	Source Data Auto	0/180/50	250	120/0/400	-0-
	Transferability Aids	0/225/0	150	285/0/200	145
	PEM Aids	0/0/145	180	0/0/0	135
	HOL Computer (SPLM)	0/0/0	400	0/0/0	1,750
	TOTALS	20/1,610/560	7,634	735/100/3,406	5,760

FY74 LINE ITEMS (5550) ($1.0 Million)

O1R EFFORTS

TASK	EFFORT TITLE	74 COST	75 O1R	76 O1R
01	Assoc. Proc. R & M Study	71,000		
01	Syracuse U.	91,377		
01	SIMDA Procurement	25,000		
04	(JTSA) DMS Eval Methodology	15,216		
04	DM-1 Query & Report Production	147,800		
	TOTAL	350,393	-0-	-0-

NEW EFFORTS :

01	Assoc Proc Appli Study	73,000	20,000	
01	Terminals Rental	2,472		
01	Assoc Proc Test Equip	36,135		
08	Software C, R, & T (MITRE)	195,000		
08	Software First Design (MITRE)	50,000		
09	ADP System Security (MITRE)	200,000		
09	ADPE & Services	30,000		
09	Security Kernel (Case)	50,000		
	Travel	12,000		
	T D R's	1,000		
	TOTALS	649,607	20,000	-0-

FUNDING (x1000) ABOVE $1.0 MILLION IN FY74 AND FOR FY75 & FY76

EFFORT TITLE	FY74	FY75	FY76	
Task 01 Associative Processor				66
Display Interface	40	50	x	66a
Syracuse U (New Contract)	30	100	100	66b
Library Routines	50	x		66c
Appli Studies (MITRE)	160	160	x	66d
Fast APL	50	x		66e
Signal Proc Study	40	50	x	66f
Signal Proc Implement (D&F)	x	75	75	66g
Appli Study II (D&F)	x	80	100	66h
Bubble Memory Organ Study		60	x	66i
Terminal Rentals		3	x	66j
Task 04 Data Management Systems				67
DMS Modeling/Simulation	x	355	190	67a
DMS Test Method Consolidation	x	x	65	67b
Task 06 On-Line Decision Aids				68
RADC Terminals	x	100	x	68a
ESD/MCI Terminals	x	100	x	68b
NLS Service Tymshare Corp)	x	300	500	68c

FUNDING (x1000) ABOVE $1.0 MILLION IN FY74 AND FOR FY75 & FY76

EFFORT TITLE	FY74	FY75	FY76
Task 08 Software C R & T			
Software Studies (MITRE)	50	150	150
Error Data Collect (Aerospace)	75	75	75
Structured Prog Sys (D&F)	190	150	x
JOCIT / J73 (D&F)	250	600	330
SEMANOL / J73	60	40	x
HOL Optimization	90	x	
SEMANOL / COBOL Fortran	50	100	x
S/W First Concept Study (MITRE)	40	x	
S/W First Arch Study	95	x	
S/W First Facility Devel	x	400	200
S/W First Appli Studies	x	200	200
Task 09 ADP System Security			
FY74 Carry-over (See Note)	x	750	x
Central Computer Security Cont	980	2,400	2,650
Audit & Surveillance	40	100	300
Front End Processor	125	350	350
Secure Terminal	125	400	350
Data Mgt System	100	200	300

proj.5550 steering group meeting

FUNDING (x1000) ABOVE $1.0 MILLION IN FY74 AND FOR FY75 & FY76

EFFORT TITLE	FY74	FY75	FY76
Task 10 Requirements Analysis			
Handbook & Documentation	15	x	
Real Problem Test	x	15	x
Formal Reqts Statement Lang(D&F)	x	60	70
Database Structure	x	26	40
Analysis Algorithms	x	15	85
Validity/ Feas of Database	x	10	46
Task 11 High Cap Aerospace Components			
CPU Chips Design & Fab (D&F)	100	200	x
Build & Test CPU	x	50	100
2000 Word Data Memory Design	30	x	
PMNOS Memory Devices on Sapphire	55	x	
Build CMOS Memory Control Chips	25	75	x
Procure MNOS Memory Chips	80	x	
Fab & Test Memory	x	40	80
Fab & Test Power Supply (D&F)	45	130	x
Design & Fab MOS A/D Ckts	x	100	x
Fab RadHard A/D Converter(I/O)	x	55	20
Fab & Test I/O Subsystem	x	x	250
Task 13 Multi-Source Data Fusion			
Fusion Usage Study	40	60	x
Technique Development	x	40	300

Experimental Systems	x	x	40	77c

proj.5550 steering group meeting

FUNDING (x1000) ABOVE $1.0 MILLION IN FY74 AND FOR FY75 & FY76

EFFORT TITLE	FY74	FY75	FY76
Task 14 Source Data Automation			
Global Weather Central (D&F)	150	50	x
Abn C&C Display Console (D&F)	50	180	120
Multi-Term Raster Graphics Sys	x	200	200
Militarized C&C Group Display	x	50	200
PROPOSED New Task - Transferability Aids			
Initiate Aids Study	75	x	
Spec of Experimental System	x	65	x
Acquire & Test System	x	75	20
Evaluate Aids	x	10	5
Anal of Data & Spec for Library	80	x	
Implementation	20	225	285
Expand to AFSC	x	x	140

FUNDING (x1000) ABOVE $1.0 MILLION IN FY74 AND FOR FY75 & FY76

EFFORT TITLE	FY74	FY75	FY76	
PROPOSED New Task - PEM-Aids				
Dev Performance Ana Procedures	80	x		
Management Guide	25	x		
Certification Stds	25	x		
MMRUE	30	25	x	
Language Optimizer	20	50	x	
Language Validator	20	20	x	
MMAPE	40	25	x	
UDB Analyzer / Optimizer	25	25	x	
Language Analyzers				
COBOL Specs	15	x		
Fortran Specs	x	10	x	
COBOL Lang Supp Sys & Anal	x	95	x	
Advanced Analyzer	x	x	65	
Analyzer Fortran	x	x	35	
Program Specs & Documentations				
COBOL Specs	20	x		
Fortran Specs	x	10	x	
COBOL Implementation	x	65	x	
Fortran Implementation	x	x	35	
PROPOSED New Task - HOL Computer (SPLM)				
Model Eval & Conversion	100	x		

proj.5550 steering group meeting

Optimize & Specify Design	x	400	x	85b
Breadboard & Eval	x	x	1,750	85c

18648 Distribution

RBP 24-AUG-73 12:22 18648

proj.5550 steering group meeting

(J18648) 24-AUG-73 12:22; Title: Author(s): Roger B. Panara/RBP;
Distribution: /; Sub-Collections: RADC; Clerk: RBP;

sample test

this is a sample test of a message that is more than
this is the second line. 1

18649 Distribution
James D. Guyton,

sample test

(J18649) 24-AUG-73 12:25; Title: Author(s): James D. Guyton/JDG;
Distribution: /JDG; Sub-Collections: NIC; Clerk: JDG;

AAM 24-AUG-73 13:11 18650

Correction of the address of the second Host at Belvoir

In my note of August 22 describing forthcoming Network changes, I erroneously gave the address of the second Host interface at Belvoir as 71. The correct address is 91. 1

18650 Distribution 1

Derek Leslie Arthur Barber, Tjaart Schipper, Richard M. Van Slyke, E. M. Aupperle, Hubert Lipinski, Robert F. Hargraves, C. D. (Terry) Shephard, Maurice P. Brown, Robert L. Ashenhurst, 1a

Linda M. Webster, Anita L. Coley, Carol J. Mostrom, Harold F. Arthur, Peter R. Radford, Wayne R. Robey, Joshua Lederberg, Connie Hoog, Leonard B. Fall, James A. Blumke, David Hsiao, Michael L. Marrah, Vinton G. Cerf, Richard G. Powell, Gerald L. Kinnison, Paul Baran, Henry Chauncey, J. T. Sartain, Robert N. Lieberman, Ralph Alter, Nils Maras, Philip H. Enslow, Robert M. Dunn, Joseph B. Reid, William T. Misencik, Toshiyuki Sakai, Louis Pouzin, Yngvar Lundh, Robert H. Hinckley, Marvin Zelkowitz, Don D. Cowan, Louis F. Dixon, Michael O'Malley, Peter Kirstein, David J. Farber, Dave Twyver, Art J. Bernstein, Dave E. Liddle, A. Kenneth Showalter, D. D. Aufenkamp 1b

Nancy C. Thies, Robert Silberski, Marcia Lynn Keeney, Margaret A. (Maggie) Bassett, J. A. Smith, Leina M. Boone, Diana L. Jones, Nancy J. Neigus, Terry Sack, Frances A. (Toni) McHale, Lucille C. (Lucy) Gilliard, Ed J. Collins, Gary Blunck, John F. Heafner, Kathy Beaman, David J. King, C. Jane Moody, Sue Pitkin, Jerry Fitzsimmons, Gregory P. Hicks, Gloria Jean Maxey, Roberta J. Peeler, Craig Fields, Ermalee R. McCauley, Margaret Iwamoto, Dee Larson, Robert E. Doane, Brenda Monroe, Jeanne B. North, Pam J. Klotz Cutler, Barbara Barnett, Stan Golding, Steve G. Chipman, John P. Barden, Martha A. Ginsberg, Shirley W. Watkins, Janet W. Troxel, Connie D. Rosewall 1c

L. Peter Deutsch, John Davidson, Thomas O'Sullivan, Sol F. Seroussi, Scott Bradner, Robert H. Thomas, Michael J. Romanelli, Ronald M. Stoughton, A. D. (Buz) Owen, Robert L. Fink, Jeanne B. North, Steve D. Crocker, Thomas F. Lawrence, John W. McConnell, James E. (Jim) White, A. Wayne Hathaway, Patrick W. Foulk, Richard A. Winter, Harold R. Van Zoeren, Alex A. McKenzie, Abhay K. Bhushan, B. Michael Wilber, Edward A. Feigenbaum, Robert T. Braden, James M. Pepin, John T. Melvin, Peggy D. Irving, Roy Levin, M. P. McCluskey, Pitts Jarvis, Barbara A. Nicholas, Jacquie A. Priest, Terence E. Devine, Paul M. Rubin, Paula L. Cotter, O. A. Hansen, Dan Dechatelets 1d

Tom P. Milke, Alan H. Wells, Chuck R. Pierson, Carl M. Ellison, Robert P. Blanc, Jay R. Walton, Terence E. Devine, David J. King, William L. Andrews, Milton H. Reese, Kenneth M. Brandon, Lou C. Nelson, Jeffrey P. Golden, Richard B. Neely, Dan Odom, Ralph E. Gorin, Robert G. Merryman, P. Tveitane, Adrian V. Stokes, David L. Retz, Reg E. Martin, Gene Leichner, Jean Iseli, James E. (JED) Donnelley, William Kantrowitz, Michael S. Wolfberg, Yeshiah S. Feinroth, James Hurt, Anthony C. Hearn, Eric F. Harslem, Robert M. (Bob) Metcalfe, Bradley A. Reussow, Daniel L. Kadunce, George N. Petregal, Michael B. Young, Michael A. Padlipsky, Schuyler Stevenson 1e

AAM 24-AUG-73 13:11 18650

Correction of the address of the second Host at Belvoir

(J18650) 24-AUG-73 13:11; Title: Author(s): Alex A. McKenzie/AAM; Distribution: /NLG NSAG NAG; Sub-Collections: NIC NLG NSAG NAG; Clerk: AAM;

DCE 8/27 Monday Meetings Cox, Brown and SRI Photos

Doug: re your Monday 8/27 Meetings 1

1. The meeting with Cox, Brown, You, and Norton on the Utility-SRI use is set up for 1:30 in Cox' office. 1a

2. The SRI photographer will call you Monday late am to confirm a session I set up starting at 3:00 Monday. They are expecting to take black-white pics of 5" tv screens and/or over your shoulder and possibly color environmental shots. I set it for 3:00 to 5:00 tentatively. Carl Moore is the person who I talked with. See me if any questions. 1b

18651 Distribution
Douglas C. Engelbart,

JCN 24-AUG-73 13:19 18651

DCE 8/27 Monday Meetings Cox, Brown and SRI Photos

(J18651) 24-AUG-73 13:19; Title: Author(s): James C. Norton/JCN; Distribution: /DCE; Sub-Collections: SRI-ARC; Clerk: JCN;

Augmentation Research Center
Stanford Research Institute
Menlo Park, California 94025

Peter T. Kirstein
University of London
Institute of Computer Science
44 Gordon Square
London, WCIH OPD
ENGLAND

Dear Peter:

Your 31 July letter answered all of the points in my 31 July letter (18131,). 1

Regarding your borrowed IMLAC: 2

I will appreciate whatever use of it that works out down at Brighton, and I am very pleased that it will be at Gordon Square during the NIC/NLS course. 2a

I don't assume that the course will have its use for all three days -- being able to give several demonstrations to the group will be very useful, if you have other uses to put the IMLAC during those three days. But, if it were to be available during more of that period, I could be giving various people some supervised DNLS experience that perhaps would be helpful. We can discuss this further at short range sometime before that week. 2a1

I am asking Ken Victor to deal with you directly regarding getting NLS to work in your IMLAC. Ken's IDENT, for using NLS Journal communications, is KEV; and for SNDMSG he is addressed by VICTOR@SRI-ARC. (Incidentally, my IDENT is DCE; SNDMSG address, ENGELBART@SRI-ARC) 2b

Following is a passage contributed for you by Ken: 2b1

"Our plans for the IMLAC are as follows: 2b1a

(a) "We will be generating an IMLAC program, called IMNLS, for your IMLAC configuration. 2b1a1

"After IMNLS has been generated, it will be

neccessary to load it into your IMLAC (see below) and then dump it out onto a cassette tape for future uses. 2b1a2

"We do not have the facilities for making cassette tapes locally, thus it will be necessary to use your IMLAC to make the tape. 2b1a2a

"(Also, we have been told that tapes made on one cassette recorder are not always readable by another recorder) 2b1a2a1

(b) "We will be placing a line processor (an MCS4 computer), with a mouse and keyset, between the TIP and your IMLAC using standard TTY connectors. 2b1a3

"Concerning loading your IMLAC, you indicate that you have a cassette and that you have TTY ROM loader 01. I assume that you also have ROM 04, the Serial Bit Bootstrap loader, which loads from the cassette tapes. 2b1b

(c) "To load your IMLAC it will first be neccessary to get a version of ROM 03, the Special TTY Bootstrap loader, into your IMLAC, either by loading it from a ready-made cassette tape (available from IMLAC Corporation), or by keying it in throught the console switches (if you have a programmers console). 2b1b1

"(If you do not have a programmers console, please ask IMLAC for the needed tape of ROM 03.)" 2b1b1a

My paraphrasing would add some commentary such as follows: 2b2

Re. (a): The IMNLS program will reside as a binary file in our PDP-10. We conventionally load IMLAC's with their NLS-interface programs from our 10 -- this is the only way we work with our local IMLAC because we don't have auxiliary tape I/O for it. We write the IMLAC program with NLS, in a special language which is compiled on our 10, then load into the IMLAC for running/debugging. Ken recently visited the Washington ARPA IPT office and got their IMLAC going, so he is familiar with the remote-end problems now, as well as with working with our own IMLAC. We also maintain the IMLAC programs run at RADC in Rome, New York by updating here and loading

them over the Net (then they dump onto local IMLAC tapes.) 2b2a

Re. (b): The special box that we are building, containing A/D converters and some micro-computer chips, will have pre-programmed chips to plug in for matching it with each different kind of display terminal. (Some description in my prior letter -- 18131,3b:gw) 2b2b

I will expect to have such a chip for the box so that the mouse-keyset works for your IMLAC. This is the "line processor" Ken mentions. One version of our IMLAC program is adapted for use with this setup. 2b2b1

In case we can't get the hardware there and working (the line-processor box, with a mouse and keyset), we have another version of the NLS-interface IMLAC program that provides for cursor positioning by means of the IMLAC UP-DOWN-RIGHT-LEFT keys -- this isn't at all as effective, but it can serve to demonstrate many DNLS features as a final resort. 2b2b2

Note that we have made arrangements with the distributors of Delta Data displays for the loan in London during that third week of September of one of their new Model 5200 displays. I will also have a pre-programmed line-processor chip for that equipment: again if the hardware components come together, that will provide full DNLS capability, too. 2b2b3

This particular display costs about $5,000, has upper-lower case, and after considerable search was selected by us as the prototype low-cost display for which we would work out our line-processor box so that it could thus provide full mouse-keyset, DNLS capability over the Network. 2b2b3a

Re. (c): It is necessary but not sufficient for you to avail yourself of the above-described facilities. The actual loading will be done over the Network; to accomplish this you will need simultaneous cooperation from this end from Ken, which action must start with your "linking" to him 2b2c

I sent with my letter (18131,) a draft copy of a

TENEX User Guide describing this process. I suggest that if you try "WHERE (IS USER) VICTOR" in the TENEX Exec and don't find him logged on, that you similarly check for NORTON, IRBY, VANNOUHUYS, WHITE, DORNBUSH, LEHTMAN, or WALLACE, or FERGUSON (Norton is often here early, and the list is ordered by likely arrival time. Wallace and Ferguson are TENEX system people, and may be on at almost any hour.) -- you can arrange with a bit of typing dialogue with one of them for getting in touch with Ken. They may need reminding that you are 8 hours off our schedule; Ken is aware of this, and is ready for any reasonable get-together time with you. 2b2c1

About the NIC/NLS class: 2b3

As soon as we know your TIP's official name, we will establish a directory under that name, so that you can log in, set up files, receive SNDMSG mail or Journal items, etc. 2b3a

We will make heavy use of that file directory during the NIC/NLS class. Each participant will have his special "Initial File" residing there, in which the Journal System will deposit the announcement-citations of his Journal-mail transactions. 2b3a1

We will want to enter for each attendee the approprate personal data for giving him an IDENT entry in the Journal's Identification File. 2b3b

We need each person's First Name, Middle Initial, and Last name in addition to his organizational affiliation and its address and phone number. An example: 2b3b1

Douglas C. Engelbart
Stanford Research Institute
333 Ravenswood Dr.,
Menlo Park, California, USA
(415) 326-6200 ext 2220

2b3b1a

These data can be transmitted via the Network, or by mail if you know the facts suitably ahead of time. (Marcia Keeney (MLK), our NIC Station Agent, --sndmsg address: KEENEY@SRI-ARC-- will take care of it for you, as part of our NIC services). 2b3c

For teaching effectively, we find that we need at least one online typewriter per pair of students--and have found a noticeable increase in value if each student has one. Do what you can. 2b3d

We haven't discussed class size. One instructor has trouble handling more than about eight or ten students, for intensive learning. 2b3d1

We could support ten or more terminals until 1pm your time, but perhaps more like 6 after (at 5am our time, East Coast users begin to enter their peak period and they are on in large number by 7:30 our time.) 2b3d2

Sincerely,

Douglas C. Engelbart
Augmentation Research Center

DCE/jcn

18652 Distribution 1

James C. Norton, Richard W. Watson, Charles H. Irby, Kenneth E. (Ken) Victor, Marcia Lynn Keeney, 1a

September Visit to England: NIC/NLS Course Matters

(J18652) 24-AUG-73 15:39; Title: Author(s): Douglas C. Engelbart/DCE; Distribution: /JCN RWW CHI KEV MLK; Sub-Collections: SRI-ARC; Clerk: JCN;
Origin: <ENGELBART>LKIRSTEIN.NLS;3, 24-AUG-73 15:36 DCE ;

September Visit to England: NIC/NLS Course Matters

Augmentation Research Center
Stanford Research Institute
Menlo Park, California 94025

Peter T. Kirstein
University of London
Institute of Computer Science
44 Gordon Square
London, WCIH OPD
ENGLAND

Dear Peter:

Your 31 July letter answered all of the points in my 31 July letter (18131,). 1

Regarding your borrowed IMLAC: 2

I will appreciate whatever use of it that works out down at Brighton, and I am very pleased that it will be at Gordon Square during the NIC/NLS course. 2a

I don't assume that the course will have its use for all three days -- being able to give several demonstrations to the group will be very useful, if you have other uses to put the IMLAC during those three days. But, if it were to be available during more of that period, I could be giving various people some supervised DNLS experience that perhaps would be helpful. We can discuss this further at short range sometime before that week. 2a1

I am asking Ken Victor to deal with you directly regarding getting NLS to work in your IMLAC. Ken's IDENT, for using NLS Journal communications, is KEV; and for SNDMSG he is addressed by VICTOR@SRI-ARC. (Incidentally, my IDENT is DCE; SNDMSG address, ENGELBART@SRI-ARC) 2b

Following is a passage contributed for you by Ken: 2b1

"Our plans for the IMLAC are as follows: 2b1a

(a) "We will be generating an IMLAC program, called IMNLS, for your IMLAC configuration. 2b1a1

"After IMNLS has been generated, it will be

neccessary to load it into your IMLAC (see below) and then dump it out onto a cassette tape for future uses. 2b1a2

"We do not have the facilities for making cassette tapes locally, thus it will be necessary to use your IMLAC to make the tape. 2b1a2a

"(Also, we have been told that tapes made on one cassette recorder are not always readable by another recorder!) 2b1a2a1

(b) "We will be placing a line processor (an MCS4 computer), with a mouse and keyset, between the TIP and your IMLAC using standard TTY connectors. 2b1a3

"Concerning loading your IMLAC, you indicate that you have a cassette and that you have TTY ROM loader 01. I assume that you also have ROM 04, the Serial Bit Bootstrap loader, which loads from the cassette tapes. 2b1b

(c) "To load your IMLAC it will first be neccessary to get a version of ROM 03, the Special TTY Bootstrap loader, into your IMLAC, either by loading it from a ready-made cassette tape (available from IMLAC Corporation), or by keying it in throught the console switches (if you have a programmers console). 2b1b1

"(If you do not have a programmers console, please ask IMLAC for the needed tape of ROM 03.)" 2b1b1a

My paraphrasing would add some commentary such as follows: 2b2

Re. (a): The IMNLS program will reside as a binary file in our PDP-10. We conventionally load IMLAC's with their NLS-interface programs from our 10 -- this is the only way we work with our local IMLAC because we don't have auxiliary tape I/O for it. We write the IMLAC program with NLS, in a special language which is compiled on our 10, then load into the IMLAC for running/debugging. Ken recently visited the Washington ARPA IPT office and got their IMLAC going, so he is familiar with the remote-end problems now, as ell as with working with our own IMLAC. We also maintain the IMLAC programs run at RADC in Rome, New York by updating here and loading

them over the Net (then they dump onto local IMLAC tapes.) 2b2a

Re. (b): The special box that we are building, containing A/D converters and some micro-computer chips, will have pre-programmed chips to plug in for matching it with each differnt kind of display terminal. (Some description in my prior letter -- 18131,3b:gw) 2b2b

I will expect to have such a chip for the box so that the mouse-keyset works for your IMLAC. This is the "line processor" Ken mentions. One version of our IMLAC program is adapted for use with this setup. 2b2b1

In case we can't get the hardware there and working (the line-processor box, with a mouse and keyset), we have another version of the NLS-interface IMLAC program that provides for cursor positioning by means of the IMLAC UP-DOWN-RIGHT-LEFT keys -- this isn't at all as effective, but it can serve to demonstrate many DNLS features as a final resort. 2b2b2

Note that we have made arrangements with the distributors of Delta Data displays for the loan in London during that third week of September of one of their new Model 5200 displays. I will also have a pre-programmed line-processor chip for that equipment: again if the hardware components come together, that will provide full DNLS capability, too. 2b2b3

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Sincerely,

Douglas C. Engelbart
Augmentation Research Center

DCE/jcn

September Visit to England: NIC/NLS Course Matters

(J18653) 24-AUG-73 15:33; Title: Author(s): Douglas C. Engelbart/DCE; Sub-Collections: SRI-ARC; Clerk: DCE; Origin: <ENGELBART>LKIRSTEIN.NLS;3, 24-AUG-73 15:13 DCE ;

BBN/BPO MEETING

DEAR DAVE
I HAVE RECEIVED A LETTER FROM MR ROBERT FOSTER OF THE BRITISH POST OFFICE REGARDING HIS SURVEY OF DATA NETWORK DEVELOPMENT IN THE USA.
I BELIEVE THAT HE WILL BE VISITING YOU AT BBN SOMETIME IN LATE SEPTEMBER 1973. WE SUGGEST,IF YOU ARE IN AGREEMENT, THAT WE VISIT YOU ON THE SAME DAY AS THIS WILL MINIMISE THE TIME YOU SPEND AWAY FROM YOUR WORK.
WOULD YOU PLEASE LET ME HAVE THE DATE AND TIME OF THE MEETING.
MY MAJOR INTEREST IS IN THE PROGRESS AND SOFTWARE OF THE HSIMP.
THANKS
KEITH.
PS: YOU CAN CONTACT ME AT THE NIC MY USER ID. IS KNS

1

18654 Distribution
David C. Walden,

1
1a

BBN/BPO MEETING

(J18654) 24-AUG-73 15:39; Title: Author(s): Keith N. Sandum/KNS;
Distribution: /DCW3; Sub-Collections: NIC; Clerk: KNS;

DVN 24-AUG-73 15:47 18655

When Secondary Distribution Fails

<Ijournal,1428,> migt interst you. Some obscure bugs mkes it impossible to distribute it, by the way. 1

18655 Distribution 1

Harvey G. Lehtman, 1a

When Secondary Distribution Fails

(J18655) 24-AUG-73 15:47; Title: Author(s): Dirk H. Van Nouhuys/DVN; Distribution: /HGL; Sub-Collections: SRI-ARC; Clerk: DVN;

KNS 24-AUG-73 16:20 18656

MIT/BPO MEETING

DEAR DR. BHUSHAN
I HAVE RECENTLY RECEIVED A LETTER FROM MR ROBERT FOSTER OF THE BRITISH POST OFFICE REGARDING HIS SURVEY OF DATA NETWORK DEVELOPMENT IN THE USA.
I HAVE BEEN STUDYING THE A.R.P.A. NET. AT U.C.L.A. OVER THE PAST YEAR AND WOULD LIKE TO MEET YOU BEFORE I RETURN TO ENGLAND IN OCTOBER.
IF IT IS AGREEABLE TO YOU MR FOSTER AND I SUGGEST THAT WE COMBINE OUR VISITS,THIS WILL NODOUBT SAVE YOU TIME.
PLEASE WOULD YOU LET ME HAVE THE DATE AND TIME OF THE MEETING,MY NIC. USER ID. IS KNS.
MANY THANKS
KEITH SANDUM.

1

18656 Distribution
Abhay K. Bhushan,

1
1a

MIT/BPO MEETING

(J18656) 24-AUG-73 16:20; Title: Author(s): Keith N. Sandum/KNS;
Distribution: /AKB; Sub-Collections: NIC; Clerk: KNS;

KNS 24-AUG-73 16:32 18657

PCI/BPO MEETING.

DEAR DR. ALTER
I HAVE RECENTLY RECEIVED A LETTER FROM MR ROBERT FOSTER OF THE BRITISH POST OFFICE REGARDING HIS SURVEY OF THE DATA NETWORK DEVELOPMENT
IN THE USA.
I HAVE BEEN STUDYING THE ARPA. NET. AT UCLA. OVER THE PAST YEAR AND WOULD LIKE TO MEET YOU BEFORE I RETURN TO ENGLAND IN OCTOBER.
IF IT IS AGREABLE TO YOU MR FOSTER AND I SUGGEST YHAT WE COMBINE OUR VISITS,THIS WILL NO DOUBT SAVE YOU TIME.
PLEASE WOULD YOU LET ME HAVE THE DATE AND TIME OF THE MEETING,MY NIC. USER ID. IS KNS.
MANY THANKS
KEITH SANDUM.

1

18657 Distribution
Ralph Alter,

1
1a

KNS 24-AUG-73 16:32 18657

PCI/BPO MEETING.

(J18657) 24-AUG-73 16:32; Title: Author(s): Keith N. Sandum/KNS;
Distribution: /RA2; Sub-Collections: NIC; Clerk: KNS;

IMP vs. TIP Reliability

The following material regarding IMP vs. TIP reliability is a result of communications with Alex McKenzie on 3-AUG-73 (journal message) and on 23-AUG-73 (phone conversation). 1

General concusion: 1a

BBN's experience indicates there is little to choose between the 316 IMP and 316 TIP (without mag tape) with regard to reliability of the host servicing function. 1a1

Causes of Failure: 1b

The main causes of failures to the 316 IMP section seem to be 1b1

Hardware: 1b1a

some marginal components/design causing problems in the power supplies and elsewhere. 1b1a1

Software: 1b1b

bugs invoked by network complexity and high volumes of traffic. 1b1b1

These factors have roughly the same effect on the 316 IMP and 316 TIP. 1b2

Tip section of the 316: 1c

While it doesn't happen often, the TIP section can fail and not affect the IMP section. 1c1

A power supply failure affecting the TIP portion of memory can leave the IMP section running. BBN's special terminal handling logic can fail without affecting the rest of the machine. 1c1a

The terminal handling section of the TIP, while not trivial, is relativly straightforward in construction and debugging. There have been no diagnosed cases of the TIP code smashing the IMP section. 1c2

Reliability statistics from BBN: 1d

The Mean-Time-Between-Failures statistics are with respect to "hardware-software failures", i.e. any time the IMP section goes down excepting PM periods, environmental failures (power failure at site, etc.), down times for changing physical location... 1d1

IMP vs. TIP Reliability

The MTBF data presented below is averaged over the time period June 72 - June 73 (inclusive) and is measured in hours. 1d1a

516 IMP	566	1d1a1
316 IMP	309	1d1a2
316 TIP (without mag tape)	307	1d1a3
316 TIP (with mag tape)	159	1d1a4

Two points to note: 1) the mag tape TIP problems are probably mostly cleaned up by now, 2) sometimes the "terminal handling" portion of a TIP can be down without that fact showing up in the statistics cited above. 1d1b

Downtime percentages (these are heavily influenced by BBN's not having access to machine on nights and weekends) 1d2

516 IMP (15 machines) 1d2a

%down	number of machines	
3	1	1d2a2
1	1	1d2a3
<1	13	1d2a4

Median: .4% 1d2a5

316 IMP (6 machines, in service from 4 to 15 months) 1d2b

%down	number of machines	
>1.14, <2.8	6	1d2b2

Median: 1.8% 1d2b3

316 TIP (12 machines) 1d2c

%down	number of machines	
.1	1 (Hawaii, not used for much)	1d2c2
>.1, <1	2	1d2c3
>1, <2	4	1d2c4

>2, <3	2	1d2c5
>3, <4	1	1d2c6
>4, <5	1	1d2c7
5.6	1 (new site, locked nights and weekends)	1d2c8

Median: about 1.5% 1d2c9

Conclusion: 1e

The reliability statistics and the descriptions of the main causes of failure indicate that factors unrelated to the terminal handling portion of the machine overshadow any effects this portion may be having on the computer as a whole. 1e1

We may hope that BBN's and Honeywell's efforts to correct the design shortcomings will bring the 316's reliability close that of the 516 in the near future. 1e2

If the 316 proves to be a major source of Utility down time, we might try to get a 516. 1e3

Since the machine costs twice as much as the 316 and the delivery time would probably be a minimum of six months, we might have to persuade someone on the net to give up an existing one. 1e3a

18658 Distribution 1

James C. Norton, Donald C. (Smokey) Wallace, Michael L. Marrah, 1a

IMP vs. TIP Reliability

(J18658) 24-AUG-73 17:07; Title: Author(s): J. D. Hopper/JDH;
Distribution: /JCN DCW MLM; Sub-Collections: SRI-ARC; Clerk: JDH;
Origin: <HOPPER>IMPTIP.NLS;2, 23-AUG-73 17:28 JDH ;

My Contribution to the Log of Mario Grignetti's Visit

It is in <vanNouhuys,mario,>

18659 Distribution
Douglas C. Engelbart,

1
1a

My Contribution to the Log of Mario Grignetti's Visit

(J18659) 24-AUG-73 17:16; Title: Author(s): Dirk H. Van Nouhuys/DVN; Distribution: /DCE; Sub-Collections: SRI-ARC; Clerk: DVN;

VGC 24-AUG-73 18:56 18660

INWG/X3S37 Liaison

Ira: Thanks for your note. I am pleased to hear that you will serve as liaison for X3S37 packetswitching and INWG. Sorry you won't be able to make Sussex, but documentation will be sent to you. INWG will want to contribute to the interface standards part of X3S37 as well as packet switching protocols;will you handle this, also? Could I count on you in Hawaii for a report on XsS37 progress? Cheers. Vint 1

18660 Distribution 1

Ira W. Cotton, Robert E. Kahn, Keith W. Uncapher, 1a

INWG/X3S37 Liaison

(J18660) 24-AUG-73 18:56; Title: Author(s): Vinton G. Cerf/VGC;
Distribution: /IWC REK2 KWU; Sub-Collections: NIC; Clerk: VGC;

SDC Network Access

Mort: SDC has shown very little interest in networking according to the statistics I have seen lately. McKenzie's traffic reports how virtually no traffic in or out of your site, and DMCG shows an availability statistic of about 8% or less. It would be very enlightening to hear why this is so. Actually, I was hoping to have access to Charlie Kellogg's CONVERSE system over the net, but it appears unlikely, I guess. Could Jeff make use of other SUR group's work via the net (e.g. the stuff at CMU)? As a friendly bit of advice, I suspect that ARPA may be looking at little used sites with an eye to relocating IMPs to other sites. Vint 1

18661 Distribution

Morton I. Bernstein, Vinton G. Cerf, Robert E. Kahn, Steve D. Crocker,

SDC Network Access

(J18661) 27-AUG-73 04:54; Title: Author(s): Vinton G. Cerf/VGC;
Distribution: /MIB VGC REK2 SDC2; Sub-Collections: NIC; Clerk: VGC;