SESSION XII DIGITAL EQUIPMENT CORPORATION USERS' GROUP

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THRIFTNET: An economical software package for interprocessor communications

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THRIFTNET is a collection of programs created in response to the need to share computer resources across computer systems on the campus of the University of Mississippi. Using **THRIFTNET**, files may be transferred between machines so that devices and programs available on only selected systems may be used to process information collected on any machine. File transfer is accomplished in small blocks of 128 data bytes embedded in a modified bisynch protocol that checks for transmission errors. The direction of transfer is dictated by the user, so files on small machines may be sent to large machines and files on large machines may be received by small machines.

Using small computers to collect data is an essential part of most academic communities. Occasionally, needs arise that some small computers cannot fill, such as rapid file listing, paper-tape handling, employment of complex statistical packages, and use of convenient utility programs. In most cases, another computer could fill the need but the lack of an appropriate link between the systems prevents it. Networking, the development of communication among computers, developed out of necessity. Several networking systems, private and commercial, are now available to build intercomputer links.

Many small computer users have attempted to deal with the networking problem. Usually, the resulting programs (1) are specific for given operating systems, (2) can be employed only on the two computers involved, (3) have limited data types (usually only ASCII), and (4) have limited error checking. Various Digital Equipment Computer User's Society (DECUS) programs provide networking, such as "DEC-10 System Controller" (DECUS, 1980d), which allows file transfer between the PDP-10 and the PDP-8. "DECsystem-10 Communication and Utility Package" (DECUS, 1980c) is a set of sub-routines that the user installs in programs requiring transfer between the PDP-8 and the PDP-10. "P8-P11" (DECUS, 1980f) allows transfer from the PDP-11 to the PDP-8 by physically transferring floppy disks between systems. "Telcom: Telecommunication/Teleprocessing Program" (DECUS, 1980e) allows ASCII character

transfer between the PDP-8 and an unspecified machine. "PDP-8/PDP-11 Realtime Data Acquisition System" (DECUS, 1980a) employs a specialized interface that permits the PDP-10 to perform direct memory accesses on a PDP-8. "Asynchronous Communication Package for PDP-10's to PDP-8's" (DECUS, 1980b) allows communication between these two machines.

Most major computer vendors provide some type of commercial networking package, which is usually quite sophisticated. For example, the Digital Equipment Corporation (DEC) DECnet allows multiple users on selected DEC timesharing systems to logically link one system to another by user-transparent network services, such as message routing, file access, user-to-user terminal communications, and remote computer program loading and memory dumping. DECnet accommodates high-baud-rate transfers and has extensive error checking by using "Digital Data Communications Message Protocol" (DDCMP). However, DECnet packages are expensive in terms of hardware (modems, memory, controllers) and software licenses (a separate license is required for each machine). In addition, DECnet cannot be implemented on non-DEC machines. Finally, DECnet requires a network manager who is responsible for reconfiguring basic system software, establishing routing parameters, and adjusting ongoing network performance.

IMPLEMENTATION

THRIFTNET provides an economical solution to the usually expensive commercial networking systems. It

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interconnects a greater number of operating systems than some private packages while retaining accurate, efficient transfer. THRIFTNET sacrifices the elaborate hardware and software services of DECnet in exchange for greater use knowledge of the systems involved. In addition, THRIFTNET is easier to implement on non-DEC machines. THRIFTNET accesses file by invoking the particular operating system's monitor services and then follows an error checking protocol during transfer. Transfers are done asynchronously; therefore, any rate should succeed, but rates in excess of 9,600 baud have not been tested.

A master system, which may be a timesharing system or a single-job system, accepts user commands that specify the direction of information transfer. The target system, which responds to the master's commands, must be a timesharing system. A file transfer is initiated by running THRIFT on the master system, which then acts as a relay to the target operating system. This "relay mode" is similar to running remote (RMT) mode in DECnet. The user of the master system now has access to the resources of the target operating system.

Two programs exist on the target operating system: RECEIV and TRNSMT. To transfer a file from the master system to the target system, the user instructs the target operating system to execute the RECEIV program. Once run, RECEIV triggers THRIFT on the master system to enter its transmitting subsection. At this point, the user is prompted to enter file specifications for both operating systems. Master-to-target file transfer is completed, and THRIFT returns to its relay mode while RECEIV returns control to the target operating system. Executing TRNSMT on the target operating system reverses the direction of transfer by triggering THRIFT to enter its receiving subsection. The transfer of data can be either in ASCII, during which the receiving machine packs the characters according to its own operating system format, or in binary, in which the precision is determined by the word length of the smaller word-sized machine. When transferring binary information from a smaller word machine to a larger word machine, the sign bit is extended to the sign bit of the larger word machine, thus allowing analysis programs on both machines to read the same binary integer. Bits are lost, however, when going from a larger word machine to a smaller word machine, in which case only the least significant bits are transferred.

THRIFTNET's asynchronous protocol insures adaptability to different transmission speeds between operating systems and permits changes in an operating system's performance without affecting THRIFTNET's reliability. THRIFTNET employs a modified Bisynch protocol (IBM Systems' Reference Library, 1970; McNamara, 1978) that provides an efficient error-checking method with low overhead. The actual transfer of data occurs in relatively small blocks composed of 128 data bytes; this prevents overflowing inaccessible operating system buffers and allows for a short recovery time when errors force retransmission. Figure 1 shows

- 1—Start of Text (ASCII 2)
- 2—End of Text (ASCII 3)
- 3—Longitudinal Redundancy Check Character

Figure 1. THRIFTNET data transmission protocol.

the format of a THRIFTNET transmission block consisting of STX (start of text, ASCII 2), 128 data bytes, ETX (end of text, ASCII 3), and longitudinal redundancy check character (LRCC) that is the exclusive OR of all other bytes in the block. The EOT (end of transmission, ASCII 4) is sent following the successful transmission of the last block. During information transfer, the transmitting machine sends a THRIFTNET transmission block, to which the receiving machine responds with ACK (acknowledge, ASCII 6) and 0 after successfully receiving the block. If the receiving machine has not received ETX after 128 data bytes, a byte count error has occurred and NAK [negative acknowledge, ASCII 27(8)] followed by 1 is sent to the transmitting machine, initiating block retransmission. If the receiving machine's LRCC does not match the transmitted LRCC, an LRCC error has occurred and NAK followed by 0 is sent to the transmitting machine; this also initiates retransmission. Five successive retransmissions are allowed before returning to relay mode. Additionally, to preclude the possibility of both machines waiting for the other to respond, a time-out error condition is established. When file specifications are being exchanged, a time-out error results in a return to relay mode. During file transfer, a time-out is considered a byte count error, which leads to block retransmission.

UTILIZATION

To invoke THRIFTNET, the user first physically connects an extra serial port from the master machine to a serial port on the target machine via a null modem (i.e., receive and transmit wires are switched) (McNamara, 1978). Matching baud rates will insure the accurate

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OS/8
.R THRIFT
THRIFTNET-VERSION 2
RELAY mode - You are now connected to the target operating system
LOGIN 1260.714
JOB 43 U OF MISS 603A.N TTY117
Password:
2059 03-Jul-80 Thu

.R RECEIV

Entering TRNSMT mode

Enter OS/8 file specs "DEV:FILE.EX"
LTA1:DATA.TX

Enter "a" or "b" followed by target cpu file specs
A LPT040:
++1++++00++
File transmitted

RELAY mode

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Figure 2. A typical THRIFTNET session (user responses are underlined).

transmission and receipt of all characters. Parity must be nonexistent, and the number of stop bits must match to preclude an infrequent, subtle error that occurs when one character quickly follows another. THRIFTNET requires that the number of bits per character be 8 and that RS-232/current-loop conflicts be resolved.

A typical THRIFTNET session is shown in Figure 2. The user on the master system (e.g., a PDP-12 running the OS/8 operating system) connects to a larger time-sharing target machine (e.g., a DECsystem-10 running the TOPS-10 operating system). The user decides to transfer an ASCII LINCtape file, LTA1:DATA.TX, to the target's remote station line printer (e.g., LPT040:). The user is prompted to enter the file specifications for the master and target machines. An "A" is specified in the target file specification to indicate that ASCII

characters will be transferred. With each successful block transmission, a plus is printed on the master's terminal. The number 1 is printed in the event of a byte count error and the number 0 is printed to indicate an LRCC error. In either case, the block is retransmitted. The user is returned to the relay mode following successful transmission of the entire file, a time-out error during file specification, or five successive block transmission failures.

Once returned to relay mode, the user can send another file, receive a file, use the target's utility programs, return to the master system, or "log off" the target and return to the master. It should be noted that unless the user logs off the target, the connection still exists; the user may return to the master operating system, again run THRIFT, and still be "logged" into the target operating system. THRIFT's escape character is CAN [cancel, ASCII 30(8)], which when used during relay mode takes the user back to the master operating system and when used during file specification returns the user to relay mode.

During entry of file specifications for the master or target system, four basic errors can occur: syntax, open, look-up, and enter errors. Syntax errors are caused by an improper delimiter, absences of an "A" or "B" in the target file specifications, or an illegal character. An open error occurs if the device or its handler does not exist. If the user tries to send a nonexistent file or is denied access to the file, a look-up error occurs. If the file already exists, the user is not allowed to overwrite it. Finally, if an enter error occurs, the receiving CPU cannot create the file due to insufficient user privileges or device unavailability.

Figure 3. THRIFTNET at Ole Miss.

Special timesharing system problems may exist. Characters arriving at the proper baud rate will be lost if the terminal line scanner has a slow response to character interrupts or an infrequent clock rate. To avoid this, THRIFTNET can be optionally configured to wait for the target's acknowledgment of each character. This conditional assembly also prevents terminal concentrators that monitor line activity from breaking the link between the two systems and circumvents the time lag introduced by remote job entry protocols.

AVAILABILITY

THRIFTNET is now running on most of the systems on the University of Mississippi campus (Figure 3): the DECsystem-10 (TOPS-10), PDP-12(OS/8), PDP-11/03 (RT-11), PDP-11/34 (UNIX), LSI-11 (RTS), and PDP-9 (ADSS). Information on program listings and machine-readable media may be obtained by writing the Department of Computer Science, University of Mississippi, University, Mississippi 38677.

REFERENCES

- DIGITAL EQUIPMENT COMPUTER USER'S SOCIETY. *DECsystem-10/20 software catalog* (DECUS 10-29). Maynard, Mass: Digital Equipment Corporation, 1980. (a)
- DIGITAL EQUIPMENT COMPUTER USER'S SOCIETY. *DECsystem-10/20 software catalog* (DECUS 10-156). Maynard, Mass: Digital Equipment Corporation, 1980. (b)
- DIGITAL EQUIPMENT COMPUTER USER'S SOCIETY. *PDP-8 software catalog* (DECUS 8-893). Maynard, Mass: Digital Equipment Corporation, 1980. (c)
- DIGITAL EQUIPMENT COMPUTER USER'S SOCIETY. *PDP-8 software catalog* (DECUS 8-905). Maynard, Mass: Digital Equipment Corporation, 1980. (d)
- DIGITAL EQUIPMENT COMPUTER USER'S SOCIETY. *PDP-8 software catalog* (DECUS 8-908). Maynard, Mass: Digital Equipment Corporation, 1980. (e)
- DIGITAL EQUIPMENT COMPUTER USER'S SOCIETY. *PDP-11/VAX software catalog* (DECUS 11-364). Maynard, Mass: Digital Equipment Corporation, 1980. (f)
- IBM SYSTEMS' REFERENCE LIBRARY. *General information—Binary synchronous communications*. Research Triangle Park, N.C: IBM Systems Development Division, Publications Center, 1970.
- McNAMARA, J. E. *Technical aspects of data communication*. Bedford, Mass: Digital Press, 1978.