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Kiewit Computation Center

DTSS -- THE DARTMOUTH TIME-SHARING SYSTEM

Introduction

The Dartmouth Time-Sharing System is a coordinated group of programs which form a complete software system for the Honeywell 600/6000 series computers. The objective of the system is to provide general purpose computing facilities for users having remote access to the computer through teletypes or other functionally similar terminals. The system is designed to handle over 150 users simultaneously and to have a response-time lag of less than five seconds for moderate-size edit-compile-and-go problems. This system is developed to satisfy the expanding requirements of the College for computing in administrative work, as an aid to education, as a tool for research in many fields, and as a medium for research in computer science itself.

The software development project is directed by John S. McGeachie, together with two full-time system programmers. Three additional Dartmouth faculty members devote time to the project. One or two men from outside the College have usually been involved on the project, normally for periods of six months or less. Two graduate students worked on the system for approximately one year. The bulk of the programming effort has been undertaken by Dartmouth undergraduates under the supervision of faculty members involved in the software development effort. These students have worked part-time at the computing center during the academic year and full-time during the summer recess. This programming activity has been entirely extra-curricular; the students have carried a normal undergraduate course load at all times.

Design

The design of the system is based in large part on the successful experiences Dartmouth has had with the GE-235/Datanet-30 coupled computer system developed at the College in 1963 and in operation until 1967. The activities of users on this system were sampled and the new DTSS has been designed to give good response for the most frequent forms of user activity. On the other hand, it was realized that the 235/D-30 system was not general enough to allow easy growth of facilities such as compilers or file systems, so a demand for a more general time-sharing system developed.

It was also recognized that a balance is required between a simple, fast-response, limited utility service, and a system which provides the most general sort of programming facilities. These general capabilities are seldom used and can lead to inefficiencies which are in conflict with the responsibility of the system to provide good service to a large class of users who are using the system for simple edit-compile-and-go problems from remote teletype terminals. There is also a conflict of interest from the user's point of view if he is required to provide exhaustive lists of parameters to a general purpose time-sharing system to perform such a simple operation as edit-compile-and-go. In such a case, the user must understand the general capabilities available just so that he may bypass them or use them trivially. This conflict was resolved in the design of DTSS.

DTSS is based on a very general executive system which provides a simple basis for the easy growth of sophisticated computing services. The user is presented to a monitor -- a job running in the framework of the general executive system; the monitor specifies the parameters, files, etc. to the executive system automatically and communicates with the user. The Simple Monitor (SIMON) is a monitor which provides the simple, successful service that made the 235/D-30 system popular, and is the monitor accessed by most DTSS users.

Monitors have been developed for background and remote batch services, and a simulator has been developed under which the Honeywell GCOS batch processing system can be run. A special-purpose monitor has been developed for use by the operations staff in the day-to-day maintenance of the system. This monitor is called OPMON and actually is identical to Simple Monitor but is run in a very privileged environment. Figure 1 shows the user interface with the various monitors.

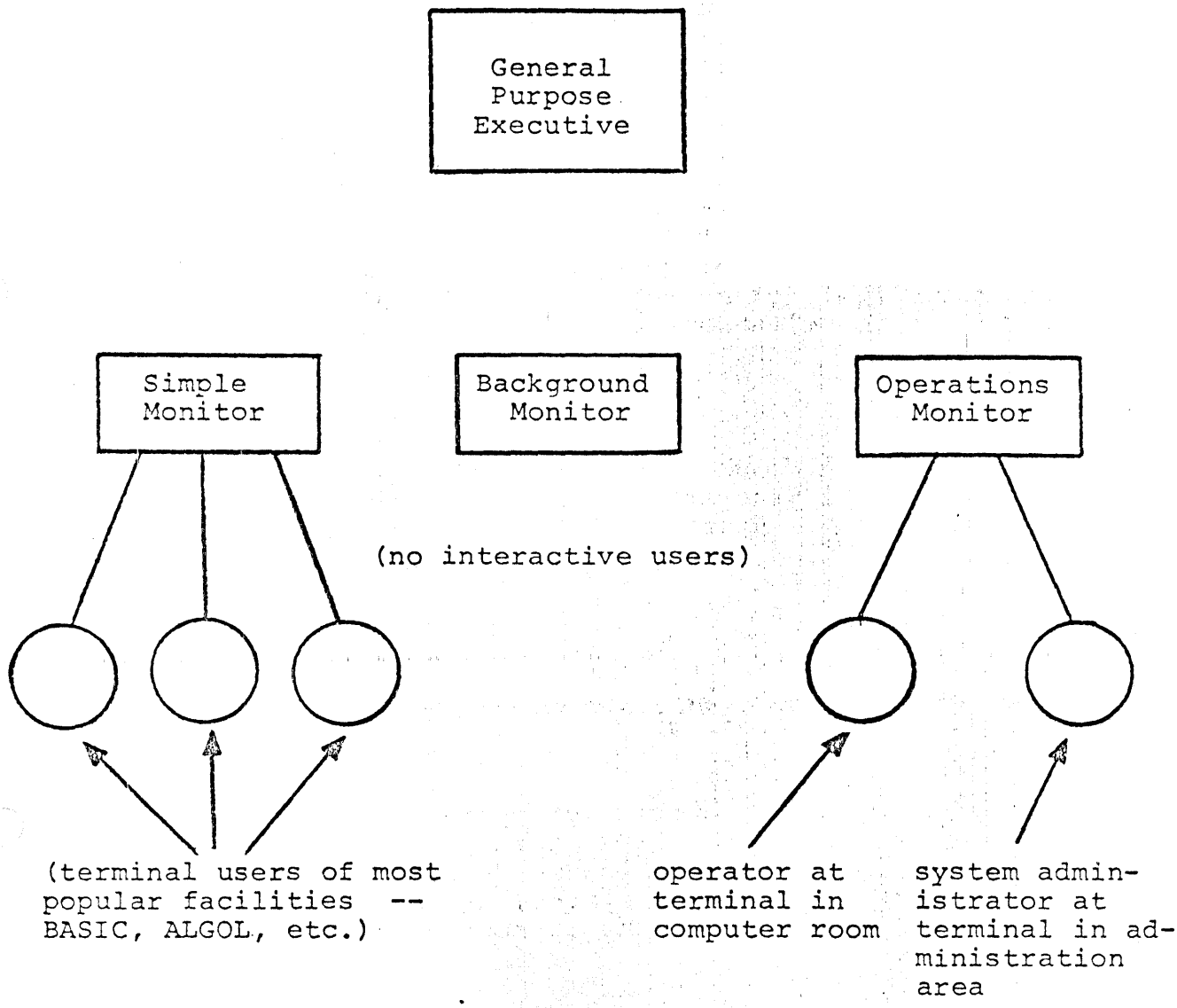

General Purpose Executive
Simple Monitor
Background Monitor
Operations Monitor
(no interactive users)
(terminal users of most popular facilities -- BASIC, ALGOL, etc.)
operator at terminal in computer room
system administrator at terminal in administration area

Figure 1

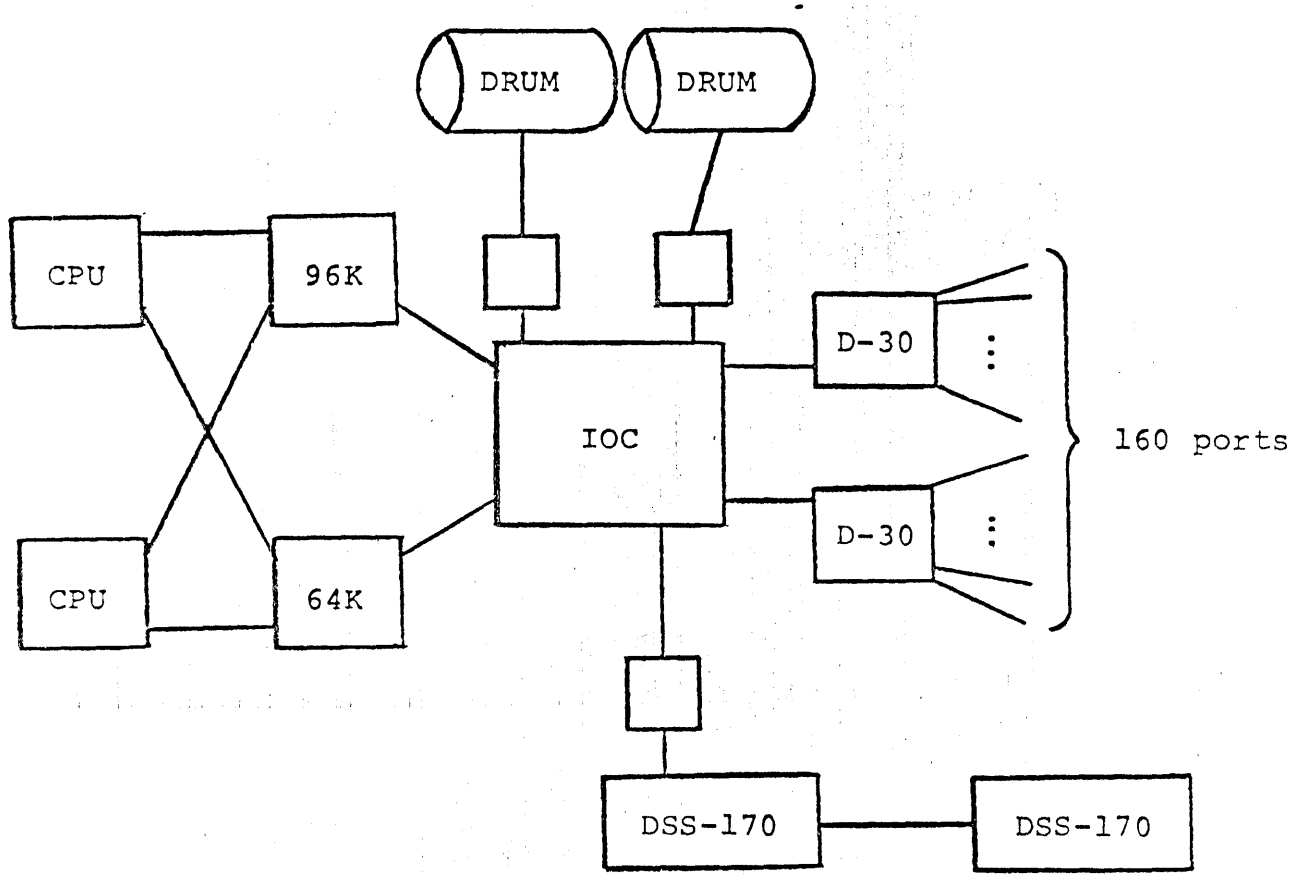
File System

The fundamental rock upon which DTSS is constructed is the file system. DTSS files and the catalog tree reside on permanently mounted disc and drum storage. A file in DTSS is simply a contiguous list of words. File storage is automatically allocated by DTSS when the file is written into; all files may be addressed randomly. Even to the assembly-language programmer, the file system is device independent and record-length independent. The security of the file system is effected by password protection at each level of the catalog tree and by trap programs. The integrity of the file system is assured by programs and procedures for dumping the logical or physical file structures onto reels of magnetic tape. The complete file system is accessible from all subsystems of DTSS.

Hardware

The hardware on which DTSS operates is a Honeywell 600/6000 series computer. DTSS operates with machines providing from 64K to 256K words of core storage, and the software is designed to support from one to eight central processing units. DTSS supports from one to four Datanet-30 communications controllers, disc systems such as the DSS170 or DSS180, and drum-like devices such as the MDU200 or DSU270. Seven- and nine-track magnetic tape units may be used in addition to the standard unit-record peripherals such as the line printer, card reader, and card punch. A large 6050 configuration for 160 simultaneous users would rent for approximately $50,000 per month.

DTSS at Dartmouth currently operates on a dual-processor Honeywell 635 system with 160K words of core. Two DSS-170 storage devices provide 72 million words of disc storage. There are 160 ports available on the system, at speeds ranging from 110 to 2000 bps. Figure 2 shows the current hardware configuration.



Dartmouth Time-Sharing System
Honeywell 635 Hardware Configuration

Figure 2

DTSS--CAPACITY

Daily Throughput

DTSS processes more jobs in a single day than most computer centers process in an entire month. As many as 20,000 jobs have been processed by DTSS in a single 17-hour period. Note that 1% of these are long running jobs requiring several minutes of processor time. At Dartmouth 1000 different users log in for 3000 sessions each day. In an active month 5000 different persons use DTSS.

Wide User Base

There are 25,000 valid user numbers on the version of DTSS at Dartmouth. These users include 50 colleges and high schools distributed throughout seven eastern states and the Province of Quebec in Canada. DTSS also services a small number of commercial firms in the northern New Hampshire and Vermont areas. The system provides useful services to a wide spectrum of users. More than 90% of the 3000 undergraduates at Dartmouth use DTSS in the academic year.

Simultaneous Users

DTSS supports more simultaneous users than any other time-sharing system. Averaged over all the hours of system operation, the average number of simultaneous users is 50. Hardly a day goes by in which the peak number of simultaneous users is not greater than 100. The system has in fact on occasion handled as many as 137 users with response times to most commands remaining under ten seconds. The hardware installed at Dartmouth will allow up to 160 users if the demand requires this. DTSS software will allow about 250 users.

Resource Usage

On a typical day 1000 hours are logged by users of DTSS at terminals. Eight hours of processor time are used and billed. Nearly a half-million accesses to the disc storage systems are completed in the same period.

Cost Effectiveness

The cost effectiveness of DTSS is due largely to the capacity of the operating system to allocate the minimum number

of resources necessary to perform a given task. The software system was designed to provide service to 200 users; at each step of the design the question was asked -- "What would be the effect of 200 users on the system?"

DTSS--AVAILABLE LANGUAGES

BASIC

BASIC was developed at Dartmouth in 1964. Although it was originally designed with emphasis on ease of learning, it has continually been expanded to become DTSS BASIC -- a language including such features as

- data packing and unpacking
- direct access file support
- independent subprograms
- string handling
- interactive symbolic program debugging.

FORTRAN IV

FORTRAN IV on DTSS is second only to BASIC in popularity. DTSS FORTRAN IV contains several additional features which allow file access in a manner compatible with BASIC. A new FORTRAN language processing system is under development; it contains the full ANSI standard as a subset.

COBOL

A COBOL system has been developed which will allow rapid construction and debugging of COBOL programs from remote terminals. DTSS COBOL is full ANSI COBOL 68 with the exception of the segmenting feature. The COBOL compiler and run-time package have been verified using the Navy-prepared audit programs.

ALGOL 60

ALGOL 60 is also available on DTSS. The version available on DTSS follows "The Revised Report on the Algorithmic Language ALGOL 60" (Communications of the ACM, January 1963) with some commonly accepted exclusions. In addition DTSS ALGOL 60 contains

- double precision capability
- string handling facilities
- input/output for terminals and files
- chaining to successive ALGOL 60 programs.

ALGOL 68

ALGOL 68 is an extensible language of the ALGOL type, having features for the manipulation of structured data, strings of characters, bits, etc. Unlike PL/1, it is a safe language which insures at compile-time that an incorrect program cannot destroy data or sequencing information. ALGOL 68 is under development although some limited experimental use is possible.

DTRAC

DTRAC is the DTSS version of a published language for Text Reckoning and Compiling. It is essentially a character-handling language with a macro facility.

LISP 1.5

LISP 1.5 is an interpretive language for the manipulation of list structures. The DTSS LISP 1.5 interpreter most closely resembles that implemented at one time by the MIT Project MAC artificial intelligence group.

MIX

The MIX language system implements the ficticious computer used to illustrate computer operation by Donald Knuth in his series of books The Art of Computer Programming. A machine language interpreter, a debugger, and a symbolic assembler exist.

GMAP

GMAP is the assembly language for the Honeywell 635 which is the host computer for DTSS. This is a high-speed, two-pass macro assembler with excellent cross-reference features. Assemblers are also available for Honeywell's Datanet-30 Communications Computer (DMAP), Digital Equipment Corporation's PDP-9 (9MAP), Data General's NOVA (NMAP) and IMLAC Corporation's IMLAC (IMAP).

DDT

DDT is a system for debugging machine language programs produced by the GMAP assembler. DDT is highly developed, with selective breakpointing, symbolic patching, and file processing abilities. This technique was used to debug the entire DTSS software system.

Editors

A variety of editing systems are available to users of DTSS. One is oriented to process files of ASCII characters arranged in the line number order which most users prefer. Another editor operates on context, and a third allows the flexibility of regular string expressions and programs of edit commands.

DTSS--TIME-SHARING BATCH-PROCESSING CONTINUUM

Time-Sharing

DTSS is most widely known for its time-sharing capability. Indeed the first goal of DTSS was to minimize the effort required for a user at a terminal to compose and execute computer programs. Such interactive usage has expanded through the development of sophisticated data analysis packages, file-system maintenance procedures, and hardware maintenance aids.

Background

The background mode of operation is available for jobs which require long running times or other resources not normally available to interactive users. These resources would include the magnetic tape drives, the high-speed printer, etc. The user may write and debug a program in the interactive mode and then submit a background job description to schedule the job to be executed at the discretion of the Background System Monitor. The job specification statements are checked immediately upon submission of a job, so that simple job control statement errors are immediately brought to the attention of the user. Status reports are appended to the job description file as the work progresses so that a user at a terminal may determine, for example, if he should go to the computing center to pick up his output. This illustrates how the best features of foreground and background operation are made available to the DTSS user.

GCOS

The traditional operating system for the 600/6000 line is GCOS. Users of DTSS who also desire GCOS III services may obtain them through the GCOS III Subsystem Simulator which operates under the Background Monitor. The expanded error messages presented under this mode of operation are only one of the advantages of operating GCOS under DTSS.

Users may submit decks of cards in the traditional manner, or they may indicate a file which contains the GCOS III job. This mode of operation enables all of the capabilities of DTSS to be brought to bear on the problem of constructing and updating this job submission file. An important advantage is that most control-card errors are detected at the time of submission of a GCOS job. Another benefit is that reports may be appended incrementally to a file as job steps are completed, thus allowing

a user at a terminal to follow the progress of a GCOS III job through the system. A side benefit is the reduction in card handling by the operator; DTSS operates with only one operator.

Terminal Support

DTSS supports all popular time-sharing terminals. Software has been developed over a period of five years for the Datanet-30 communications controller which makes economical, reliable support possible for the following terminals:

Teletype 33/35	110 bps
Teletype 37	150 bps
IBM 2741 (EBCDIC)	134.5 bps
IBM 2741 (Corrsp)	134.5 bps
Terminet-300	300 bps
Memorex 1250	600 bps
Teletype Inktronic	1200 bps
Remote Batch Terminal	2000 bps

DTSS can operate with as many as 250 terminals; it has been tested successfully with 160 ports operational.

Applications

The prolific development of system services has been exceeded only by the development of applications services by the thousands of students, faculty, administrators, and others who number among the 25,000 active users of DTSS. The development of advanced applications programs has placed demands for expanded system services upon the DTSS development staff at Dartmouth. This peculiar symbiosis between applications development and DTSS development has resulted in a balanced, cost-effective resource available to the Dartmouth community.

For example, although most files on DTSS are ASCII, special packing and unpacking facilities were made available in BASIC to enable a survey summary system to be developed using random-access files. The IMPRESS (Interdisciplinary Machine Processing for Research and Education in the Social Sciences) application has won national acclaim for the facile manner in which hypotheses of social interaction may be tested against real data.

The easy use of foreground and background processing for data base management has encouraged the development of traditional data processing applications in the flexible environment of DTSS. Project management has been implemented on DTSS, and several management information systems have been put into use with good results.

Libraries of hundreds of applications programs are currently available on DTSS, and are constantly being expanded and augmented. In addition to programs, supporting curriculum materials for undergraduate education are prepared under the auspices of several projects underway at Dartmouth.