THE

DARTMOUTH TIME-SHARING SYSTEM

A
BRIEF
DESCRIPTION

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Introduction

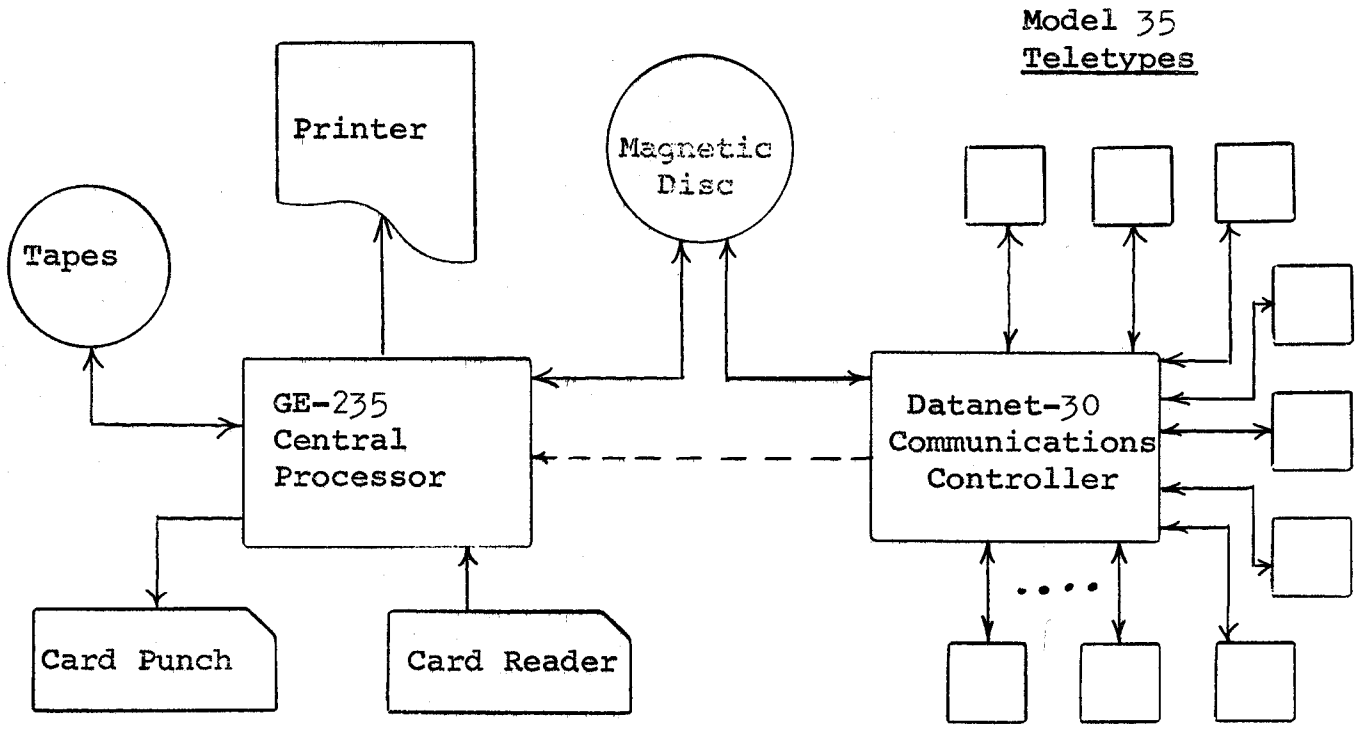
The Dartmouth College Computation Center operates a Time-Sharing computer system that can simultaneously service a large number of remote consoles. This system is used both for teaching large numbers of undergraduate students, and for faculty research purposes. It was designed and the software constructed in a relatively short time by a small group of faculty members ably assisted by a highly qualified and enthusiastic group of undergraduates. The Dartmouth Time Sharing experience shows two facts: First, Time-Sharing should be considered not only for major research and teaching Centers but also for smaller and more conventional installations. Second, the nature of the programming and systems problems connected with Time-Sharing are now fairly well understood and present less difficulty than was previously anticipated.

External Description

The Dartmouth Time-Sharing hardware complex contains two computers. One is the General Electric Datanet-30, which is used both as the remote console controller and also as the site of the master executive program. It can control, through interrupts, the other computer, a General Electric GE-235, whose main function is to perform floating point arithmetic. There is a direct line connecting these computers, which is used for control purposes. However the main path of the data and information transfer in both directions is through a disk storage unit which can be accessed by either computer. In addition to its role in handling information flow between the two computers, the disk provides a storage for both active and saved programs.

The multiple remote consoles are model 35 teletype machines. However, the equipment can handle almost any type of remote device employing standard codes transmitted at relatively slow rates.

The computer complex also includes conventional tape drives, card reader, card punch, and high-speed printer. However, these devices play only an ancillary role in the Time-Sharing System.



Schematic Diagram of System Hardware

Users Description

The user introduces himself to the system by typing the word HELLO. This initiates a short series of questions and answers which serve to further identify the user and his problem. Specifically, the user supplies his user number, the name of the system with which he intends to operate, specifies whether the problem he is about to name is new or old, and gives the problem name. If it is an old problem this system retrieves it from the saved program storage area on the disc. The user may then add to the program or modify it in any way. If it is a new problem, the user is presented with a clean slate, and he composes his program from scratch.

The statements of the program start with a line number, which distinguishes them from the commands to the system. Having the user type his own line numbers permits him to correct lines in the program simply by retyping them, to insert new lines in the program, or to delete unneeded lines. When he has finished composing his program, he then types RUN without a line number. This command causes the system

to deliver his source program to a translator, after which it is run. The answer will then be typed out on the teletype machine.

Other commands are available to the user. By typing SAVE the user can store away for future reference his program as it exists at that moment and under the problem name he is currently using. Such saved programs can be later retrieved by typing OLD. If the user is finished with his saved program, he should type UNSAVE, which makes available that particular storage space for some other program. At any point he may type LIST, which will list his entire active program, or LIST--XXXX, which will list his program starting with line number XXXX. At any time in the procedings the user may type STOP. Even if the system is printing out answers or listing a program, it will immediately stop and wait further commands. The combined use of the selective LIST and the STOP commands, permits the user to easily list single lines in the middle of his program.

At any time the user may specify a new system. The effect is to move into the last half of the HELLO sequence where he selects NEW or OLD and then gives the problem name. He may also at any time specify NEW or OLD, and then give the new or old program name. The command RENAME, which simply replaces the old problem name with a new name, allows the user to generate easily two almost identical versions of the same program. He would retrieve the first, rename it, make slight modifications, and then save the modified version under the new name. SCRATCH permits the user to erase all the lines in his program and start out with a clean slate. RENAME plus SCRATCH, in either order, is equivalent to NEW.

A user may obtain a complete listing of all programs saved under his user number by typing CATALOGUE. Such a listing is useful not only for users having a large library of saved programs, but also for users who might forget the spelling of their problem names.

Currently under development are two new commnads RENUMBER and MERGE. MERGE will permit a user to retrieve two or more saved programs to create a larger composite program. RENUMBER will permit the user to renumber the lines in any program to permit later merging with programs having similar line numbers.

Internal Description

The system may be divided logically into three parts. The Datanet-30 computer acts as a remote console controller but more importantly contains the master executive program. The GE-235 performs

all transactions and executions, and certain bookkeeping operations as well. The disc storage unit acts as the buffer area for currently active programs, the buffer area for information being outputted from the GE-235, and as a storage unit for saved programs. It also serves as the storage unit for the various systems used in the 235.

Inside the Datanet-30 are input-output buffer areas associated with each teletype station. These are operated in a flip-flop fashion so that input or output typing may continue in one part of the buffer while the other is "connected" to the disc unit. The program in the Datanet-30 is divided into two parts, a real-time part and a spare-time part. The real-time part is entered via clock controlled interrupt 110 times per second in order to scan the teletype lines. As characters are completed, the real-time part collects them into messages and, when a "return" character is encountered, interprets the message. If it is a line in the program, nothing is done. If the message is a command, a spare-time task to start carrying out the command is set up and inserted in the spare-time task list. If there is not enough time to complete his setting up, the real-time part will complete the set-up during the next real-time period.

The spare-time portion carries out the spare-time tasks, which include mainly disc operations and certain teletype operations. Communication to the GE-235 is carried out in real-time according to instructions generated in spare-time.

In the 235 there is a resident compiler system that acts as a translator, and a resident executive routine to manage the disc input-output operations and to perform other functions. The executive system permits simultaneous use of the card equipment, the tape drives, and the high-speed printer during Time-Sharing through interrupt processing.

The disc unit is divided into three areas. First is the current working area containing the program which the user is either composing or has retrieved. It is this program that is delivered to the 235 when a RUN request is made. The second area in the disc includes the storage area for saved programs. Depending on the size of the program, somewhere between 2,000 and 7,000 programs may be saved. The third area is a catalogue for saved programs. The catalogue is divided into 100 equivalence classes according to the third and second digits of the user number. Each time a request for a SAVE, OLD, or UNSAVE is made, the catalogue is scanned by the Datanet-30 for either the desired entry or a space into which a catalogue entry for the program may be placed.

Because the rate of information flow between the two computers is disc-bound, the maximum utilization of the 235 cannot exceed approximately 80 percent. Future plans call for a reallocation of the areas on the disc to minimize the average arm movement time, and to possibly cut down the disc overhead time by about 25 percent.

Comparisons

The Time-Sharing system is not compatible with the monitor-controlled system as operated at other times during the day. In Time-Sharing, the user has a block of only about 6,000 words at his disposal. During monitor operations he has a considerably larger area at his disposal. However, it is planned to permit a user to compose and debug a program during Time-Sharing, and then to create an equivalent form for production running during monitor operation.

This system can be accurately described as a small job processing system. At the present time, Dartmouth Time-Sharing does not have the capability for running large complex programs under Time-Sharing. Furthermore, the design of the system as a job processor does not permit it to be designated as a truly real-time system. There can be fairly long waits of from 5 to 10 seconds as the spare time tasks and run requests become stacked up. These stack ups and delays are almost entirely a result of the central role played by the relatively slow disc as an extension of memory. Future systems with large memories need not be so encumbered. Furthermore, relatively simple changes in the master executive program will permit almost any sort of communication with external devices, including the instantaneous sort of response required by laboratory experiment equipment being controlled by the computer.

The Dartmouth Time-Sharing system is, however, extremely effective as a small job processor. The minumum amount of red tape required by the user, and the simplicity of the BASIC language provide an accessibility equivalent to that offered by a desk calculator. In fact, it is often easier to run a trivial calculation through the Time-Sharing system that it is to use a desk calculator, and it may also be easier to use the Time-Sharing system to calculate some tabled quantity than to look up that quantity in the handbook. While such usage may not be an effective use of the teletype consoles, it costs virtually nothingin terms of the machine time used; such an equivalent table lookup can be made for less than one penny.