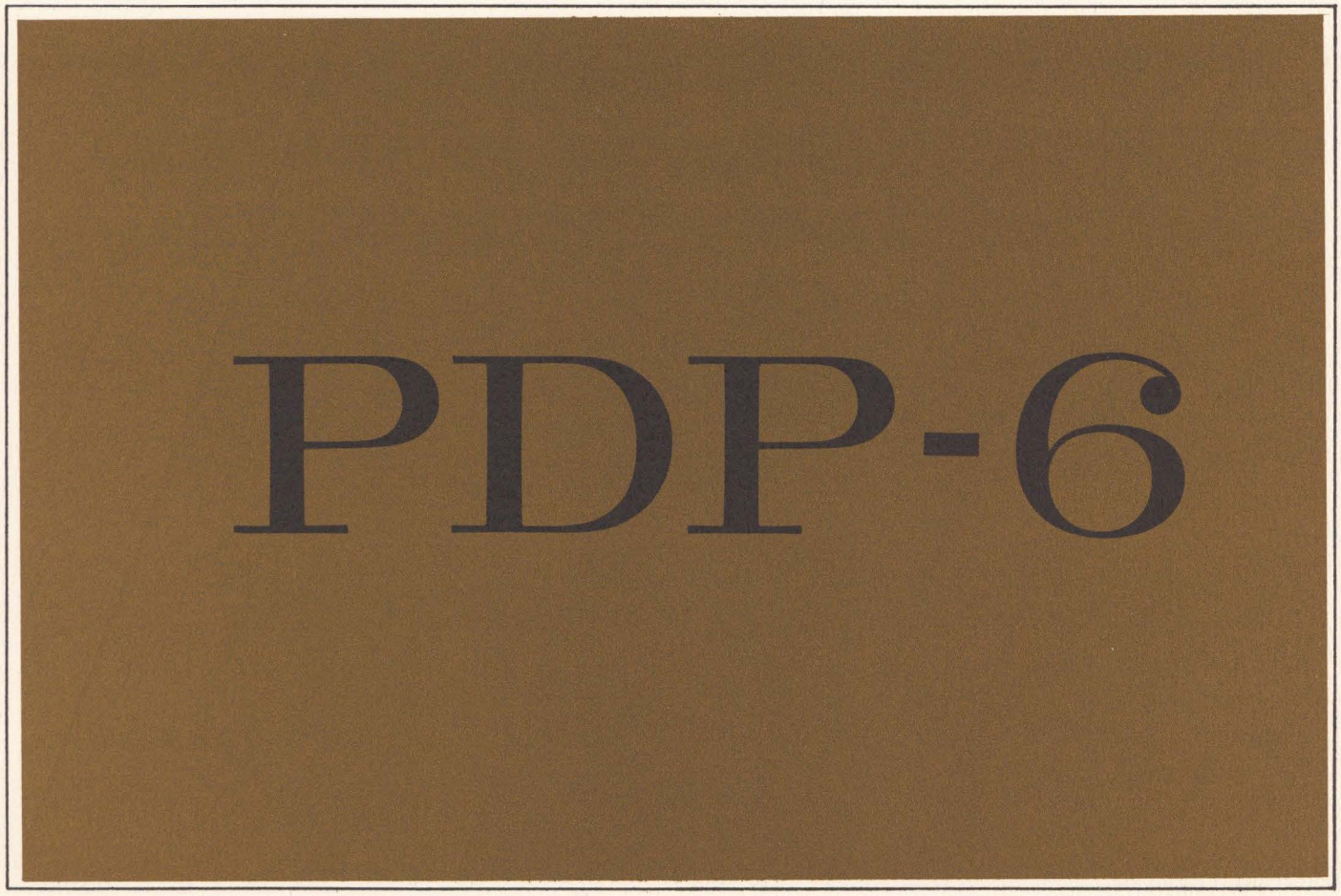
TIME SHARING SYSTEM



DIGITAL EQUIPMENT CORPORATION • MAYNARD, MASSACHUSETTS

PDP-6 TIME SHARING SYSTEM

Programmed Data Processor-6 Time Sharing System provides integrated hardware and software for time sharing. This means that user and machine can interact (debug, edit, translate, etc.) on line with consequent savings in time and programming costs. It also means that PDP-6 can perform all of the operations usually associated with a computer center and do them more efficiently than the conventional computer-and-satellite installation.

The PDP-6 Time Sharing System eliminates two major problems typically found in present day data processing centers. First, the user of conventional data processing centers cannot interact with his program while it is running. The response time of the user to his program run is measured in the hours it takes to get a print out of the results. Turn around includes slow and costly manual program modification plus the waiting for processing time.

Second, because input-output operations such as conversion make inefficient use of computer time, a smaller peripheral conversion system has traditionally been used to perform these operations. The extra data processor required for the satellite system has three disadvantages: It adds to the cost of the center, it requires a second programming language, and it presents another delay to the system user.

The PDP-6 Time Sharing System combines modular hardware with modular software to solve these problems. The system provides:

1. Time shared access to the PDP-6 facilities through user-consoles, that is, local or remote teleprinters. The user may directly request system programs for text editing, program translating, loading, or other functions. Also, the user may request to have his program put on a queue to be run. The time-shared access makes possible both a fast turn around time and on-line debugging.

2. Efficient use of input-output equipment. First, by use of the priority interrupt system and resident system programs, peripheral processing can be done while a program is running. Thus the need for a peripheral processor and a second programming language is eliminated. Second, a program will schedule the use of I/O facilities as they are needed by programs in memory. There are no system delays due to input-output operations, since the program waiting for a device to be free is interrupted and another one run.

3. Program modifications and the inclusion of functions and/or equipment at a later time, because the software system is modular.

4. Conventional stacked job processing, with jobs run in the same manner as though they were user-console initiated. One control language thus provides for on-line operation or job stacking.

HARDWARE FOR TIME SHARING

The PDP-6 computer system is designed to be completely modular and flexible. These are significant advantages in time-sharing applications. In addition, there are several specific features of the hardware that make PDP-6 uniquely qualified for time-sharing.

Executive Mode Hardware - When un-debugged programs share memory with other programs, protection must be provided against illegal references to other areas of memory. To provide this protection, programs prepared and run by the user are run in the Executive Mode. They are placed in memory, and relocated, by the Relocation Register. Memory references outside the area assigned to the user are detected by the Memory Protection Register and the illegal instruction flag is set. Any time an illegal instruction is given, a supervisory program is called to check for the cause of the alarm. In addition to a memory reference outside of the program bounds, the alarm could be generated by an attempt to stop the machine or directly control an I/O device.

Large Storage - Since time sharing software systems are large, and since a number of users are to occupy memory at once, a time sharing system must have a large core memory and/or the ability for a fast interchange between core memory and auxiliary file stores.

A processor in a PDP-6 system may directly address up to 262,144 36-bit words of core storage in memory modules of varying size and speed. The powerful instruction set also provides for addressing the same storage as characters, providing a store of up to 1.6 million characters. Magnetic drums or Micro Tape can be connected for auxiliary file storage. Both have similar structure to allow the switch over from a Micro Tape backed secondary storage to a fast access, 6 million-character drum system with only minor modifications to the supervisory control program.

Uniform Representation of Data - To avoid unnecessary conversion programs all data in the PDP-6 is represented by the American Standards Association Information Interchange (ASCII) code. Line printer and teleprinter codes are ASCII, and other codes are converted to ASCII as they enter and leave the system.

Minimum Time Sharing System

The minimum equipment necessary to operate the PDP-6 Time Sharing System is:

Type 166 Arithmetic Processor
Type 163C Memory Module (16,384 words)
Micro Tape System
    Type 136 Data Control
    Type 551 Micro Tape Control
    Type 555 Dual Micro Tape Transports (2)
Type 626 Teleprinter

The system can be easily expanded with standard options such as the following:

Paper Tape Reader and Paper Tape Punch
Card Reader and Card Punch
Line Printer
Extra Memory Modules (including Fast Memory)
Drum and Input-Output Processor
Data Communication System for additional Teleprinters

SOFTWARE FOR TIME SHARING

All programs must operate within the framework provided by the PDP-6 Operating System. The Operating System consists of a supervisory control program, system programs, and system subroutines.

The Supervisory Control Program

This is the name given to a collection of programs remaining permanently in memory to provide overall coordination and control of the total operating system. The segments of the program are:

Command Control Program, which handles all commands addressed to the system from the User-Consoles. These commands would include requests to log in or out, a request to use the edit program, requests to have a program placed on the run queue, requests to load a program, etc. In short, requests to use whatever functions are provided by the system programs go to the Command Control Program.

Program Scheduler, which is called at regular intervals to decide which program in memory is to be run. A running program is temporarily terminated each time its allotted time has run out, or when it requires input-output operations with a device that is busy. A program may be terminated temporarily by user intervention to the scheduler, or it may suspend its own operation. Temporary termination does not remove the program from memory. A program may be dumped on backing storage and permanently discontinued by calling the scheduler and allocator.

Facilities Allocator, which is called any time an I/O device or memory space is required. It may be called from a User-Console or by a running program. Under this program one User-Console is designated the operator console. As such it has special facilities available which are not available to other consoles, such as line printer assignments. Storage is permanently assigned for all resident programs, that is, those programs that are in memory at all times. Finally, "logical" tape assignments are made . Two Micro Tape units are designated the system library and the system scratch tape. Two other tapes may be assigned as Peripheral Input Tape - used to prepare jobs to be stacked from cards or paper tape, and System Input Tape - used to input a full tape. (Each user-console may require a Micro Tape unless programs requiring files are to be run.)

Command Decoder preprocesses commands from the User-Console. This program is used to convert parameters, etc., before the command is sent to the program for which the command is intended.

I/O Control is called whenever an I/O device is to be used. This program assigns equipment, controls the I/O devices, controls data transfers between memory and the I/O device, and controls the buffering of data for the device. (Users provide the necessary buffering for devices which require file buffering.) All program I/O instructions are trapped, and the actual control of the I/O operation then passes to the I/O Control Program.

System Programs

These are the programs designed to implement system functions which may be requested from the User-Console. This is in contrast to system subroutines which may be called by system programs or other programs. System programs are normally provided by Digital, but they may be provided by each installation for its users. The programs contain a mode by which they may be terminated to return the communication link to the system. Some of the system programs are described below.

Editor Program, which provides a means for manipulating the text of a named file on a Micro Tape or in the user area of the drum (corresponding to Micro Tape). This file may be used for the creation of text or for later use as data or as a program to be translated by the FORTRAN compiler, etc. The commands provided for the editor allow text to be created, deleted, or moved about.

Peripheral Conversion Program, which handles all those jobs normally done by a separate peripheral processor. The priority interrupt system and multiple memory accumulators in the PDP-6 eliminate virtually all loss in running time. Such processing is done through the arithmetic processor.

Inter-Console Message Program, which switches message traffic between the various User Consoles. This program provides a means by which the user may request manual operations by the operator and receive acknowledgment. (Such an operation would be the mounting/dismounting of user tapes.)

Linking Loader Program accepts programs in a form produced by the translators, and produces an area of core memory loaded with the program. Upon request, it may also produce a storage map of the loaded programs along with symbol tables. Several programs may be linked together in loading. The loader requests special library tapes to be loaded, and verifies that the program has been completely loaded.

Translator Dispatcher is called to load the FORTRAN, MACRO-6, or other translators. The translators are rather large programs that do not reside in memory, but are stored on the System Library tape until they are called into memory by the translator.

FORTRAN II Compiler accepts FORTRAN II input statements and produces relocatable binary output coding for later loading by the Linking Loader. Compiling is done in one pass. PDP-6 FORTRAN II is an extension of the conventional FORTRAN II language to give the user more facilities and to take advantage of PDP-6 hardware. The ASCII character set is used. Subscripts may consist of statements (fixed or floating). Any number of dimensions may be used to specify an array. Signed integers have 36-bit values, but when used as subscripts are truncated to 18 bits.

MACRO-6 Assembly Program translates MACRO-6 input language to a relocatable binary output for the Linking Loader. MACRO-6 is a two-pass assembly program and the language provides for MACRO instruction definitions and usage. Literal assignments are made by brackets [] . Numbers may be expressed as binary, octal, decimal, and floating point. Text may be placed in a binary program by the occurrence of the "text" data generating statement, and "byte" will cause a string of bytes to be assigned and packed into a word. The "repeat" control statement causes the statements following the control to be repeated "n" times.

The system subroutines include:

1. I/O Format Control which provides for the various format statements used in the FORTRAN II language. These subroutines are also available to other programs and may be called from the systems library tape.

2. Arithmetic Subroutines which include all the arithmetic subroutines required for FORTRAN II, such as, sine, cosine, $\log_e$, $\log_{10}$, exponent, tangent, arctangent, and square root.

Debugging Program (DDT) is loaded with a program and allows all assembly language programs to be debugged. The program may be started or stopped, words in the program may be modified, and DDT may search the program looking for particular words. DDT may also be used in a "trace" or break point mode, and the program is run until a particular location (a break point) is encountered.

SYSTEM USE

The operating system implicitly defines two classes of users: primary users and secondary users. The primary user is the one whose program is currently being run by the processor. A secondary user is any other user who has been logged in at a User-Console and is not currently being run, although his program may be in core and on the queue waiting to be run. While he is active, a user is liable to switch back and forth between primary and secondary use several times.

In a typical sequence, the user logs in on a User-Console, and his first job is to get his program into file storage, either Micro Tape or Drum. To do this, he may request an operator to load his cards or paper tape and/or mount a Micro Tape reel; or he may type in his program directly from the User-Console. Finally, he would call the peripheral processing program to get the program into file storage.

The second major step is to get the program translated. To do this, the user would request the proper translator and then wait his turn on the schedule queue for primary use of the processor. If the translator did not show any significant number of errors, the user might then request that his program be loaded along with library routines and DDT. He would then go back on the queue to await a debugging run. After debugging his program, the user can request a read out on Micro Tape or put the program under control of the system for stacked job processing.

digital
EQUIPMENT
CORPORATION
MAYNARD, MASSACHUSETTS

Los Angeles • Palo Alto • Park Ridge, Ill. • Washington, D.C. • Parsippany, N.J. • Monroeville, Pa. • Ottawa, Canada • Munich, Germany • Sydney, Australia

3576

PRINTED IN U. S. A.

25-4/64