THE BURROUGHS B8500

thin films and monolithic i. c.

by JOHN T. LYNCH

Functional, as well as physical, modularity have been distinguishing characteristics of Burroughs Corp.'s edp line, the B5500 and its military counterpart, the D825, being outstanding examples. The latest addition to the line, the B8500, exploits this modular system design concept. In the 8500, as many as 16 computer and input/output modules and 16 memory modules—each containing 16,384 (52-bit) words stored in magnetic thin film—can be combined with modular disc files, tape units, communications networks, and other peripheral devices to form a system. To ease expansion, processor, memory, and I/O modules can be added and operation begun immediately without interruption to the system. All software is written to utilize the equipment available at a given moment in any system configuration.

hardware characteristics

The B8500 makes extensive use of monolothic integrated circuits—integrated versions of the discrete circuits used in Burroughs' 30mc systems as early as '59. The storage medium consists of magnetic thin film.

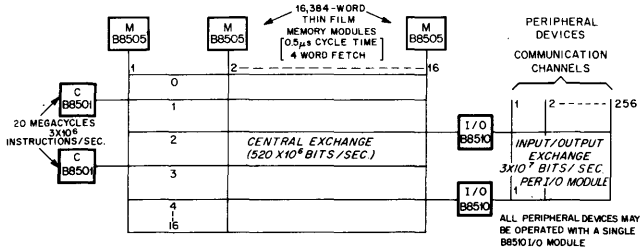
The B8501 computer module incorporates a 20mc clock and employs multi-processing and look-ahead techniques to increase processing speeds. The computer module includes an arithmetic stack for automatic call-up of operands, a variable syllable instruction format and a 48-bit operand, as well as a local scratch pad memory. Associative indexing permits any memory word to be used as an index word rapidly and automatically. Stack extension permits the arithmetic stack to be pushed down in local memory to a depth of 16 words without recourse to main memory storage.

Up to 512 simplex peripheral channels may be buffered and controlled by a single B8510 input/output module, handling peripheral devices such as card readers, magnetic tape units, Teletype equipment, display devices, etc. Additional devices can be handled if the I/O channels are multiplexed. The I/O module contains an independent processing capability, minimizing computer monitoring. One of the primary functions of the I/O module is to automatically enter into disc files the low-speed data coming from external peripheral devices. The central processor thus services peripheral devices from the disc file, increasing the efficiency of the system. I/O module functions include:

- Independent and interlacing channel operations,
- Storing or fetching to or from main memory,
- Accumulating a word in a variety of byte sizes,
- Testing for word count and character coding,
- Modifying the main memory address field,
- Sequencing descriptors for extended I/O operations.

The combination of descriptor word flexibility and a rapid channel servicing cycle have made the I/O a significant element of the system. It is important for the descriptors to control the flow of data into and out of the system, minimizing the amount of computer monitoring. In this respect, the I/O is semi-autonomous. Thus, data is neither slowed down for lack of I/O response nor is the computer hampered by a continuing need to supervise every detail of each of the many I/O transactions.

B8500 Modular Data Processor



External requests for service are specially encoded for fast recognition by the I/O module. I/O service programs communicate directly with peripheral equipment and begin the necessary response to the request. If the request requires processing in the computer module, an interrupt is passed on to the computer for the proper scheduling of the request for service. The external requests are treated to minimize computer module attention.

The B8500 system utilizes a hierarchy of memories ranging from 0.1-microsecond cycle thin film memory in each computer module through the 0.5-microsecond cycle thin film main memory to the disc file system and tape storage. Throughput is maintained at a high level by balancing the flow of information among these various memories. The B8500 executive program manages this information flow so that data is available in the 0.5-microsecond main memory storage when required for the programs to be executed.

Look-ahead logic transfers data and instructions from 0.5-microsecond memory to 0.1-microsecond memory for execution. The former memory communicates with the next level in the hierarchy, namely the disc system, which has an average transfer time of 5 microseconds per word. In general, the executive routine collects programs and data in the disc file before initiating their execution. As much data as is needed at any one time is then brought into the 0.5-microsecond memory by the executive program.

The B8505 memory module is a 16,384-word thin film

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memory, 52 bits per word, with a full cycle time of 0.5 microseconds. Words can be stored or fetched in four-word groups so that the maximum data rate possible for a single memory module is 416 x 10^6 bits/second. In addition to the speed, a selection of logic operations have been installed in the memory module. The B8500 system permits expansion to up to 16 of these modules for a total of 262,144 words, each of which is randomly and directly addressable.

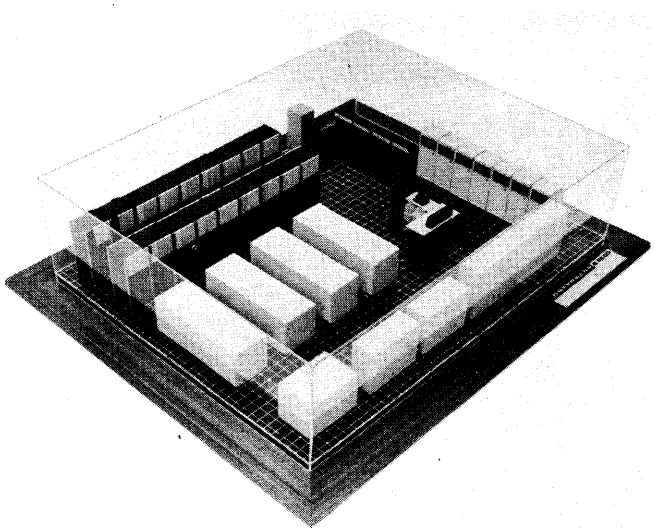
The disc file storage modules are mechanically identical to the unit used in the B5500 and B200/B300 series computers. Up to 50 storage modules may be included with each B8500 system for a total of 60 million (52-bit) words.

The average access time is 20 milliseconds. The transfer rate is 10.4 million bits per second. Two important design features of the disc file system have made such speeds possible. The head-per-track organization eliminates the need for mechanically positioned head assemblies, and permits paralleled read/write operation which accesses eight tracks simultaneously.

software

In the B8500, the concept of modularity is applied to the software too. The operating system has two major sections. The central section is the Executive and Scheduling Program (ESP). ESP performs those functions normally associated with an operating system such as I/O control, interrupt control, timing, etc. Surrounding the ESP is a collection of service and system programs. A service program is defined as a program written much like a user program in compiler language, but possessing direct contact with portions of the system normally reserved for the ESP. An example would be a program

A model of the B8500 System



allowed to communicate directly with Teletype channels, as opposed to making a call on ESP to perform the communication. A systems program is defined as a user program permanently available for all users, e.g., compilers, assemblers, I/O procedures and filing routines.

Modularity is achieved by requiring all program segments to conform to a standard structure. The compilers, the programs they compile, and most of the operating system utilize the standard structure. The ESP is a small set of routines which forms the heart of the operating system and does not conform to the standard structure.

The total software package is composed of a collection of small segments or modules. At any given time in the execution of the program, only the active segments need to be in memory; large contiguous areas are not required. Therefore, programs can be run with varying amounts of memory.

Program segments operate independently of their location in memory so that during the course of a job, program segments may be executed from several different places in memory. This movement of program segments in memory requires no modification of the segments.

The Executive Scheduling Program (ESP) is written to handle the maximum B8500 system configuration (16 memory modules and 16 processor or input/output modules). This approach permits automatic self-regulation as configurations change and provides the basis for automatic scheduling around any malfunctioning module. The executive program supervises the compilation of all programs to generate data and program objects in a format that permits most efficient handling. Memory bounds and dynamic storage protection permit programs to be debugged while production programs are being executed.

The principal function of the ESP is to dynamically allocate equipment modules, such as processors, memory, and I/O channels, to a constantly changing set of jobs. Sharing equipment modules among many programs is generally called multiprogramming. The ESP goes a step further by multiprogramming a set of jobs that consist of both user requests and operating sytem functions.

The interrupt system for the B8500 is responsive to interrupts generated within the computer module and those received from sources external to it. Every interrupt received by a computer module is an indication to the ESP of some set of functions which have to be performed, are being performed, or have been performed. The function of interrupt processing is to evaluate and pre-process each interrupt prior to passing it on to the major portion of the ESP for final disposition.

A judgment must be made on each interrupt condition to determine if it is to be passed on to the ESP or handled completely by the interrupt processor. Interrupts which are passed on to ESP are mapped into a consistent form to allow convenient and economical handling by the appropriate ESP routine.

All of the operating system, including the compilers, are written in Extended ALGOL. Memory protection and an extensive file system are also included in the operating system. This filing system provides reference to files and file items by name rather than absolute location or storage medium.

The B8500 Extended ALGOL compiler uses the compiling technique known as recursive descent syntactic analysis. This technique, used in the B5500 ALGOL compiler, compiles quickly, makes modifications easier and produces good object code. B8500 Extended ALGOL implements virtually all of ALGOL 60, and provides extensions for I/O operations, partial word operations, string manipulation, and diagnostics.

The B8500 FORTRAN IV compiler implements the A.S.A. FORTRAN IV language. The compiling is done in one pass using conventional precedence scan techniques. Library programs written in Extended ALGOL can be called in FORTRAN, making it unnecessary to include any assembly language coding.

The B8500 COBOL compiler implements D.O.D. COBOL 61, Extended. All the additional features in B5500 COBOL are also included in B8500 COBOL. In addition, data segmentation and the ability to compile program segments independently are also included. The character operations in the B8500 are well suited for working with character fields as required in COBOL. ■