Minicomputer—Characteristics, Economics and Selection for an Integrated Library Management System

Misconceptions about Minicomputers

When the term "minicomputer" initially was coined it denoted a physically small, low-cost computer using available technology and designed to perform a specific function. Usage of these devices was limited mainly to the laboratory, certain process-dependent industrial tasks, and special-purpose computational problems. Today, the minicomputer is no longer limited to such systems. However, not all computing specialists, library systems analysts, and librarians realize that the situation is rapidly changing and will continue to do so. Sometimes the feelings one experiences when discussing minicomputers, particularly as independent processors, may be conveyed by the following verse:

Automation
Is Vexation,
Quarternions are bad;
Analysis Situs
Is only detritus
I wonder: Have I been had?¹

The misconceptions which were based on the qualities of minicomputers until the last few years were:

1. slow instruction execution time and cycle time,
2. small memory with lack of expansion,
3. lack of peripheral equipment,
4. lack of peripheral device interfaces,
5. low reliability and unsatisfactory maintenance services,
6. poor programming instruction sets,
7. lack of vendor-supplied software,
8. greater programming difficulty,
9. lack of character addressability,
10. lack of hardware multiply and divide, and
11. image as front-end processors requiring large host computers for file updating and output processing.

This paper seeks to dispel these misconceptions in the broad sense, although one can see that individual minicomputers have specific strengths and weaknesses dependent upon the end application use. The minicomputers considered here are machines available currently and developed in the last two to three years.

Minicomputer Systems

A minicomputer system is normally composed of a processor, memory, and selected peripheral devices for input, storage and output of data. In other words, the mini may have much the same peripheral equipment as any other computer system. Minicomputers have always employed the technology available at their time of development just as have any other central processors. The technical differences between mini and nonmini systems are that minicomputers usually have shorter word lengths, fewer machine programming instructions, and most of their peripheral devices are designed for use with minicomputers—matched to their speed needs and their prices. A single non-technical difference is that the price of the minicomputer system will be from 10 percent to 30 percent of that of systems judged in the small- to large-scale hardware classes. Let us look in greater detail at the system components.

PROCESSORS

With nearly fifty manufacturers of processors in the United States, there are many to be considered. In choosing the processor and other parts of the system one must define the tasks required to service the envisioned application needs. There are two main minicomputer architectural types to consider—single bus and multiple bus, with the latter the most common. Processors such as Hewlett Packard, Data General's Nova line, and Varian use the multiple bus structure shown in figure 1. The single bus concept is used by DEC in their PDP 11 family. The Bio-Medical Mini-Computer System at the University of Minnesota shown in figure 2 illustrates this architecture.
Fig. 1. Multiple Bus Minicomputer System

Fig. 2. University of Minnesota Bio-Medical Library PDP 11/40 Computer System
The single bus structure gives the user greater flexibility to add or change devices attached to the bus, even mixing memories of differing speeds. Further, the I/O devices may communicate directly with memory without processor involvement. The disadvantage in the single bus structure is its greater design complexity since it must accommodate both high- and low-density bit transmission. Multiple bus systems are simple to design and also provide direct memory access, but usually at extra cost, and usually then require a separate channel for each device.

Word lengths of minicomputers vary from 8 to 32 bits, with 16 bits the most common in current machines, and 24- and 32-bit machines just now coming into the market place at prices very competitive to some 16-bit machines. For library use a multiple of 8 bits is most desirable. The advantage of a larger word size is that more memory may be directly addressed as well as increasing the transfer rate of data. Moreover, the larger word size machines have larger instruction sets. But word length alone cannot determine processor choice; the appropriate instruction set must also be available.

Other processor features such as number of registers, addressing techniques, power fail/automatic restart, real-time clock, and additional processor options must be considered since typically minicomputers have definite strengths and weaknesses when considered for use in a specific application area.

Generally, the processors currently available range from 330 nanoseconds to 1.2 microseconds per word memory cycle time with memory size of 8K-124K words permitted. They will also have from 1 to 5 accumulators, 0 to 24 index registers (or some comparable range of general purpose registers), and interrupt levels ranging from 2 to a variable number. The register arrangement, the number of interrupt levels, and the specific addressing modes permitted is an indicator of programming flexibility and ease.

MEMORY

Minicomputer memories are usually magnetic core construction, but semiconductor memories also are available on some processors. The MOS (metal-oxide semiconductor) and bipolar memories are very fast—from 300-450 nanoseconds but, of course, currently at greater cost than core memories in the 600-900 nanosecond range. The memory speed and size is available to support any library data processing task in an on-line integrated data management system. Even without increasing memory speed, which can many times be added from another manufacturer later, today’s minisystems offer more throughput than past and some presently used conventional systems. Current memory technology is bringing memory cost down rapidly so
that memory cost for an application is not restrictive. Most processors can accommodate up to 64K bytes equivalent memory and a reasonable number beyond this. Memory protection, if offered, is normally an extra cost option associated with the larger memory configurations.

PERIPHERAL EQUIPMENT

Today, it is possible to interface virtually any current peripheral device to a minicomputer. This interface is independent of the brand of processor, but obviously the larger manufacturer's machines will tend to have ready-made interfaces for larger numbers of peripheral devices. The leading mini manufacturers offer many peripheral devices. More than 100 manufacturers are currently in the mini peripheral equipment marketplace. If ready-made interfaces are not available there are custom system houses which will interface virtually any device to any processor. One can choose peripherals from among the following categories:

1. Fixed head disks for program swapping use with capacities to 250,000 bytes.
2. Floppy disks, as a cheaper, usually slower alternative to the above with similar capacities.
3. Moving head disks with capacities from 1.2K bytes to 86K bytes per cartridge or pack, with up to 8 drives controllable per controller, at costs from $9,000 to $300 per million bytes or approximately $7.50 to $.25 per MARC catalog entry.
4. Tape drives, industry compatible or units such as dual density DEC tape, usually with 45 ips speed—slow but adequate.
5. Impact and nonimpact printers which range from $4,000 to $20,000 and give slow to medium print speeds. Many have upper/lower case and some offer character-set extensions such as those with point plotting capability or chain cartridges such as the Data Products Charaband Printer.
6. Cassette tape units for software package and diagnostic support, replacing paper tape units at equivalent prices.
7. Visual and hard copy keyboard terminals with both hard wired and private or dial-access telephone communications arrangements.
8. Special purpose peripherals such as plotters, graphic line drawing displays, digitizers, Rand tablet devices, and a variety of sensors of various types.

There is a slight advantage to minimizing the number of manufacturers involved with the computer system from a maintenance and administrative
viewpoint, although this depends upon the geographic area and the size of the system. One can see from this overview that properly chosen minicomputer systems have many hardware features that make them attractive for file- and message-oriented processing.

**INSTRUCTION SET AND SUPPLIED SOFTWARE**

When considering the foregoing factors about hardware, one must consider the instruction set of the machine and relate this to the hardware features to determine if the processor will be suited to the application. Library systems require byte and bit manipulation instructions. Some of the more powerful systems have hardware features found on large-scale computers which ease programming and enhance throughput, such as hardware stacks, and extended instruction sets with hardware byte features to match, such as hardware byte manipulation.

Many, if not most, minicomputers are weak in data test type instructions as they have no Compare instruction, and thus require a complicated sequence of instructions to effect arithmetic comparison. Some machines also do not have direct bit testing capability—a must for library applications. Shift/rotate instructions normally are not of the multiple shift type, i.e., one instruction must be executed for each bit position that the word is to be shifted. Instructions such as Translate also are not found on minicomputers, but such functions can be carried out through use of macros in the programming.

Although various compilers are available for minicomputers, they are not desirable for use in an on-line data management system due to the excessive overhead required. Assemblers, primarily of the two-pass type, and some macro assemblers are the most common programming languages. Macro assemblers such as used with the DEC’s PDP 11/40 are quite powerful and well suited to on-line data management system development.

Manufacturer-supplied software usually consists of very minimal operating systems, an assembler, an editor and a linker. The editor enables program code to be altered via keyboard. The linker attaches assembled code to other programs. Operating systems for the most part are single-user systems which support either tape or disk and enable running the assembler, the text editor and the linker. Some other utility functions are usually provided, such as tape-to-disk copying. Some batch operating systems are offered and a few multiuser timesharing systems are available but these provide only single-language support (either BASIC or FORTRAN). Some real time executives also are offered which are usable primarily in an industrial control or analog/digital laboratory data acquisition and monitoring system.
Therefore, the library user will have to use what is provided in a development mode and create his own software, including any operating system functions which are required. There is an advantage to this in that the single dedicated system does not need an operating system of the overhead and complexity featured on typical large systems. Lourey speaks to this point in his discussion of the design of the University of Minnesota Bio-Medical Library Mini-Computer system elsewhere in this volume.

One of the benefits of projects such as the University of Minnesota Bio-Medical Mini-Computer System is to develop data management software amenable to use in many libraries, thereby enabling common software maintenance, lower software costs, and careful testing of system enhancements for use throughout the various libraries. Now let us see how all of the above relates to the on-line library management system.

**On-line Library Management System Needs**

Most libraries of significant size either are in the process of deciding to develop new or first systems, are enhancing present systems, or are installing completely reworked systems using different hardware and software. The traditional library applications of ordering, accounting, in-process control, cataloging, serials management, and circulation comprise a complex data base dependent system. Data entered and used in one process may carry over to other processes, with or without change.

Multiple entry point retrieval is required for many functions. Moreover, the size of the data base and the transaction load may be very large. For these reasons, an integrated data base system functions best when hosted on a dedicated computer system. However, because of the inherent cost of large computers, and the fact that library data processing systems are I/O bound, we try to share the computer, ideally with jobs requiring more processor service than I/O service. To do this, however, we must have a complex resource management system, consuming a large portion of machine resources, to oversee such multiple use.

A good way for the library to determine if it should use a shared system or acquire a minicomputer system is to answer the following questions:

1. Does the proposed shared system have on-line capabilities and sufficient disk storage?
2. Are those capabilities expandable to fit the library’s needs for the next five years or for the expected life of the hardware?
3. What will be the library’s portion of hardware and storage costs for the shared system?
4. Does our application require control over the hardware system configuration to avoid inconvenient or costly program alterations?
5. Is our priority and use high in the computer center?
6. Does the library have its own programming staff or is it able to acquire its own programmer?
7. Is the purchase of a minicomputer system equal to or less than the estimated computer center charges for three years?

These questions will help to isolate the capabilities and costs of the shared system as opposed to the dedicated minicomputer system. If the library is intending to proceed toward a completely on-line system for its data base needs and is sizable enough to acquire its own programming staff, the choice of a dedicated minicomputer system should be made, as the system development costs will be amortized through lower operations costs accompanied by a higher quality system at the user level. Moreover, the library can control the system, enhancing or changing equipment or software as its processing needs change. This will further improve the long-term system economics.

To summarize, there are three points to be considered in coming to a decision on a minicomputer system versus the shared large system: (1) the economics of the system, (2) the performance of the system, and (3) the control over the system.

System economics and performance are discussed in detail by Lourey elsewhere in this volume. Control over the system relates to being able to determine the future of the system as well as assure its current operational status. The library administrator will find both program maintenance and enhancement to be far easier if the programming staff are part of the library rather than having prime responsibility to a data processing center management. An alternate arrangement for control is to use contract services to develop and support a system. However, this really requires that the library have someone with a technical background able to develop the system specifications in considerable detail and then work with the contractor to refine them, code the programs, debug them, test and install the system. With good management, the least costly approach is in-house development of the system. Brudvig discusses this control and library view of the system in detail elsewhere in this volume.

Choosing a Minicomputer System

After a decision has been made to acquire a dedicated minicomputer system, the specific features of processors and their instruction sets must be
evaluated. In addition, decisions on peripheral equipment will have to be made. All of these decisions will be made in light of the applicability of the equipment to perform the tasks required, the ability of the vendor or vendors to keep the equipment operating, and the purchase/maintenance costs of the system.

In order to solicit bids on the equipment and inform the prospective equipment suppliers of its needs, the library should prepare a set of hardware/system specifications. This document should provide basic system requirements and conditions of procurement. For a full system, with processor and peripheral equipment, the document should contain:

1. a brief technical description of the proposed system's functions and data base content,
2. any specific system details known to be required by the application,
3. processor hardware and instruction set features required or desired,
4. peripheral equipment devices required,
5. details of system acquisition if several stages of equipment additions are planned beyond the initial order,
6. maintenance service provisions desired from the vendor,
7. software supplied and prices of specific software such as assemblers, editors, operating systems, if not included in hardware costs,
8. delivery schedules and method of shipment vendor provides, and
9. evaluation criteria on which the vendor's bid will be judged.

To illustrate some of the above points the University of Minnesota Bio-Medical Library Mini-Computer system vendor document contained the following requirements for the processor:

1. CPU must be 8-bit byte oriented, with main memory addressable by byte location and preferred word size a multiple of 8 bits,
2. either explicit character manipulation instructions or some reasonable method of effecting these within the available instruction set,
3. multilevel indirect addressing and indexing or their functional equivalents are required,
4. multilevel indexing is desirable but not required,
5. main memory must be incrementable to at least 64K bytes,
6. direct memory access required,
7. real time clock required,
8. hardware multiply/divide required,
9. power fail/automatic restart required,
10. memory protection required, and
11. operator console keyboard/printer with 30 cps speed required.

The bidders on this system were judged on their:

1. capability to support both hardware and software to be used during development,
2. capability to supply all of the required equipment exclusive of terminals and telecommunications interfaces,
3. delivery schedule,
4. equipment being suitable to character manipulation and library data management system applications, and
5. equipment costs and continued maintenance costs.

To illustrate the outcome of this process let us look at the result of the bidding. We received seven bids on the system. All were very similar in price, except for one, if each vendor had bid identical peripheral equipment according to the specifications. However, vendors did not bid the specified peripherals in most cases. One vendor bid a special purpose minicomputer completely outside the processor specifications. Another vendor bid one minicomputer instead of another one newly added to his equipment family which did fit the specifications quite closely. There are many ways to judge such bids. Several articles have been written which use a formula to show price/performance. However, price/performance alone cannot determine if the system will be well suited to the library problem. The library programming staff must make the final judgment as they have the responsibility to deliver the functioning system and keep it running.

Vendor Relations

Vendors have different pricing policies for equipment. Most offer educational or governmental discounts up to 10 percent, although some specific equipment which they may procure from other manufacturers may not be discounted. Also, after initial system installation there are additional charges for field installation of system additions. What the initial equipment order should contain should be carefully considered.

Service arrangements also vary among vendors. The safest arrangement is an 8-hour service contract which can be purchased for one year on all or part of the system. On-call maintenance or a combination of on-call with the above is the next most common arrangement. On service contracts there usually is a
discount of up to 8 percent for prepayment for the year. Moreover, additional discounts may be available depending upon the number of systems the vendor sells that year or has sold in the past year to the parent institution. These arrangements should be investigated carefully as worthwhile amounts of money can be reallocated to other use.

Another important point is to have the physical space for the system ready when it is delivered. The vendor will be able to help determine the right number and capacity of electric circuits, receptacles, and grounding requirements. Also, be sure the room temperature can be maintained under 75°F in the area of the equipment as tapes and disks, as well as programmers, are subject to temperature and humidity excesses. The processors can withstand rather high operating temperatures, but it is best to provide good ventilation and climate control even to the point of installing a window air conditioning unit.

There will be problems with the first installation. Reconcile yourself to contending with late equipment deliveries and some malfunctions, particularly in disks and their controllers. Keep after the vendor. This is a normal condition in the data processing equipment field, so plan accordingly.

Hopefully, some minicomputer misconceptions have been cleared away by looking into their general characteristics and the decision-making process which may result in their specification for a system. Guidelines for developing that specification as well as suggestions on how to evaluate the resultant vendor proposals should enable librarians to seriously consider the dedicated mini for the library. As an additional aid to those investigating this field a bibliography of current literature is included in this paper.

Earlier, I quoted a verse applicable to the minicomputer’s initial entry in libraries. I will close with another applicable verse:

Geniac, Geniac,
Digital miracle,
Giving an answer that’s
Truly empirical,
Learned men, lost in a
Drawjopping daze,
Watch six-year-old Seniors, all
Grabbing off As!
REFERENCES


ADDITIONAL REFERENCES


