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What is the most cost-effective approach to data processing? Many business managers find there is no clear-cut answer to this question. The variety of equipment available to match their data processing and communications needs, and its continually improving price/performance ratios, have made the options available to them almost infinite.

As a result, some basic management questions about computers are back on the drawing board. Should we have a large computer or several small computers? Should we have centralized computers or decentralized computers?

The most recent and aggressive sales barrage has come from minicomputer advocates, who assert that their systems will:

- Offer twice the capacity at prices significantly less than those of large systems;
- Provide the level of service needed by a smaller user, when the data processing department is too busy with its big systems;
- Offer on-site services to user departments who must meet tight work schedules;
- Do the job at half the price charged by the corporate service bureau;
- Increase efficiency by distributing the processing throughout the data communications network.

What Is a Minicomputer?

The typical minicomputer is defined technically as a digital processor with integrated semiconductor circuits, a 16-bit word length, 4,096 to 32,768 words of magnetic core or semiconductor storage, and fast memory cycle times of 0.8 to 1.5 microseconds; other word lengths, sizes, and speeds also are available. The minicomputer is small in size and usually weighs less than 50 lbs. It utilizes standard 115 volt power, and reportedly needs no special environment.

While it is difficult to get precise agreement on the definition of a minicomputer, it is generally agreed that it is a computer whose processor, or "main frame," is available at a purchase price ranging from $10,000 to $30,000, and that it provides index registers, multi-level indirect addressing, and flexible input/output capabilities which may be enhanced by one or more direct memory access channels. Perhaps of greatest significance is its modularity, which allows its assembly in an infinite variety of configurations.

A good deal of the debate over defining a minicomputer is prompted by the overlapping characteristics of minicomputers, microcomputers, and midicomputers. (The accompanying table shows some characteristics of the processors of these three types of computers—see page 15.)

The major weaknesses of minicomputers occur in the areas of (1) hardware limitations, (2) software difficulties, and (3) lack of vendor support. Most of the hardware limitations can be resolved with such extra cost options as: additional main storage, parity checking, storage protection, hardware multiply/divide instruction, a real-time clock, power-failure protection, and direct memory access channels.

The software difficulties relate to a lack of sophisticated, generalized routines (from disk file access modules to utilities to programming aids), the additional programming required due to the minicomputers' short word lengths, their sometimes limited storage capacity, and the single-purpose orientation of their operating systems. This may result in a relatively high cost for program development.

Underlying the lack of vendor support is the fact that the cost of providing the type of support associated with larger systems may be more today than the cost of the computer hardware itself. Minicomputer manufacturers therefore have directed their primary sales efforts toward original equipment customers, including programming firms and contract systems houses, treating them essentially as wholesalers or branch offices.

The History of the Minicomputer

The minicomputer industry, which is just over 15 years old, has grown rapidly since the mid 1960s. Total computer sales currently exceed $14 billion annually, and the U.S. Department of Commerce estimates that sales by the 70 minicomputer manufacturers are approximately 10 percent of this market.

Behind the growth in the minicomputer industry are a number of fundamental factors:

—Technological innovations in LSI (large-scale integrated) circuits, which have resulted in dramatic price/performance improvements;
—Specialized software products, which are uniquely suited to minicomputer applications;
—Very competitive pricing among minicomputer vendors;
—An increasing emphasis on distributed processing, a subject discussed below.

Minicomputer manufacturers deal with three major markets. The first is original equipment manufacturers. A high proportion of minicomputers' sales are being made for incorporation into OEM products, such as machine tools, process control units, or data entry devices. This is an extremely competitive market where the specifications call for acceptable performance at minimum cost. It also is a very volatile market and was responsible for most of the minicomputer growth during the industry's first decade.

The second market, which has emerged in the 1970s, is comprised of sophisticated end-users of minicomputers.

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This market includes multinational corporations with far-flung business operations, large agencies of the federal government, and banks, savings and loans, and other financial institutions—plus such special applications as retail credit authorization and message switching over data communications networks.

The third market, rapidly emerging today, includes a broad spectrum of unsophisticated, first-time computer users. These users frequently have one-of-a-kind requirements, which can be best met by custom developed "turnkey" systems. To meet their needs, a number of minicomputer manufacturers have distribution or marketing agreements with local programming or software companies. These companies sell the customers complete systems to meet their individual requirements. They configure the equipment, write the programs, provide software services, sometimes provide training and conversion services, and assume technical responsibility for providing an operational or turnkey system.

The early prominent manufacturers of minicomputer equipment included: Digital Equipment (with an estimated 35 percent of today's market), Hewlett-Packard and Data General, plus Burroughs, Control Data, Honeywell, IBM, NCR, and Univac. More recently, additional manufacturers have become well-known, including: Basic Four, Computer Automation, Datapoint, Digital Computer Controls, Four Phase, General Automation, Interdata, Microdata, Modular Computer Systems, Prime, Quantel, Varian, and Wang. In addition to these, there are more than 50 other lesser-known manufacturers.

A recent survey by the publishers of *Datapro*, well-known for their technical reports on computers, indicates that more than 56 percent of all minicomputers are acquired by outright purchase. Another 36 percent are acquired through long-term lease/purchase agreements. Unlike the market for large-scale computers, which has shown a high preference for third-party leases, the minicomputer industry achieves only about eight percent of its sales through such leases. This lack of interest in the third-party leasing may be attributed to the fact that the typical minicomputer system is assembled for a specific application, and there is little likelihood of its being leased again to a different user when the original contract expires. Most third-party minicomputer leases follow traditional full payout capital equipment type leases, which are primarily used for off-the-balance-sheet financing.

Given the special purpose nature of most minicomputer systems, they obviously require highly customized programming, which can be done in-house or purchased. The external sources for such programming are almost equally

divided among vendors, custom contract software houses, proprietary software packagers, and contract programmers.

How the Minicomputer Is Used

A rundown of the uses to which minicomputers are put in industry includes a variety of control, research, and engineering applications.

The industrial control applications cover process control, numerical control of machine tools, direct control of machines and production lines, automated testing and inspection, and telemetry. Research and engineering applications include data acquisition and logging, control and analysis of laboratory experiments, analysis and interpretation of medical tests, traffic control, shipboard navigation control, computer-aided design, typesetting and photocomposition, computer-assisted instruction, engineering and scientific computations, and time-sharing computational services.

Another major use for minicomputers is in data communication. This use is about equal in volume to those previously mentioned. Examples include message switching, communication control for large computers, communications line concentrators, programmable communications terminals, peripheral controllers for larger computers, control of multistation key-to-tape or disk systems, and display control.

Business data processing, the other major use of minicomputers, is expected soon to equal all the previous uses combined. Typical applications for a minicomputer in manufacturing, for example, include order entry, bill of materials processing, shop floor reporting, inventory control, work-in-process control, job costing, customer billings, accounts receivable, payroll processing, labor distribution, personnel data files, accounts payable, and general ledger. In effect, few basic applications now processed on large computers cannot also be adapted to the mini.

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The combination of two of these uses—data communications and business data processing—has resulted in what is referred to as distributed processing. In practice, it occurs whenever a single user has employed more than one computer site, and particularly when the computers have communicated with each other in any way—by punched card, tape, diskette, or communications line. However, the unique characteristics of the minicomputer have encouraged the proper amount of processing power to be placed where it is most needed, as opposed to the older practice of moving all input and output data to and from a central site.

What is the correct distribution of processing capability? Generally, there are three methods: by function or application, by data, and by resource.

Distribution by function is probably best known. An example is data entry and recording at one or more locations (frequently remote) and master file updating at another. Or it could be a communications processor "front ending" a large main system. Distribution by data might entail identical systems, each serving a particular warehouse and controlling its stock, but interconnected to service local out-of-stock conditions. The distributed resource system calls for a closely connected series of processors each capable of providing a variety of services. Under such a system the problem or work is moved with its data to the nearest available processor. Some have labelled this latter approach "relocatable processing."

There still are many questions to be answered about distributed processing. These include questions about control and security over information, procedures and standards, and whether estimated money savings actually will occur. In summary, distributed processing is the ability to locate the computer processing power on a cost-effective basis wherever it is needed within an organization.

How to Manage a Minicomputer

Minicomputer systems, like any other systems, must be managed. This should cover planning, development, and implementation.

Planning should start with an analysis of the current operations. If this suggests that improvement can be achieved by using minicomputers, a preliminary study should be made to establish the feasibility. The user's needs should be documented in terms of the processing functions, data files, work flow, forms, personnel, time constraints, controls, and appropriate management reports. This preliminary study is necessary to determine if the use of minicomputers in the system can be cost-effective. Like any feasibility study, it should identify the costs involved and the projected benefits.

In addition to hardware costs, there will be other vendor charges, such as software costs, shipping costs, installation fees, and maintenance cost. Communication costs also must be considered, as well as personnel costs, including the cost for management, operators, other support personnel, and the associated fringe benefits. While minicomput-

A Comparison of Minicomputer Processors

Processor Size	Storage Capability	Memory Technique	Strategy	Price Range	Software
—MINI	4-32K Words	Semiconductor Memory w/LSI Circuitry	Special Application, User Oriented	$ 5-20K	Basic, Fortran, RPG, Cobol, Utilities
—MICRO	1-4K Words	Single LSI Chip or Set of Chips	Large-Scale OEM Users	$ 2-10K	Basic, APL
—MIDI	16-100K	Fast Semi-Conductor Memories	Medium Computer Replacement	$20-50K	Same as Mini Plus File Management, Multiprogramming and Operating Systems

er manufacturers advertise that minicomputers need no special environment, introducing one into any operation may prompt still further costs, since remodeling may be required to improve the work flow, reduce dust and dirt, or contain the noise of the printer.

The benefits being considered should be both tangible dollar benefits, from reduced costs, and such intangible benefits as improved customer service. Finally the cost, personnel time, and schedule requirements for implementing the system should be consolidated. The result will be a complete package for management approval.

The development steps for any system are fairly standard. In the sequence, the steps are: the detail definition of user requirements; system specifications*; technical specifications*; implementation planning; programming*; user procedures and training; and system test.

It is important to note that only three of the generally accepted development steps—marked by an asterisk—can be replaced by a software package or other custom development contract. It is generally agreed that when management fails to complete the other steps, the system will probably fail to meet the requirements of the business.

After completing the detailed definition of user requirements, the request for proposals should be prepared. This should specify the current and future data processing requirements, outlining the general systems design from the user's point of view.

The proposal request should describe each major function in as much detail as possible, following computer industry documentation standards. The vendors should be requested to provide detailed technical specifications, including proposed system configurations, hardware components, and software products. In addition, the vendors should be required to list the support services they will offer and their related costs; this should include the types of hardware and software maintenance, the number and experience of support personnel (with individual time commitments), and conversion and installation assistance.

The evaluation of proposals should include the following: functions, features and limitations of hardware and software; available programming languages; available application packages; system expansion potential; quantity, quality, and price of such system support as conversion assistance, management training, technical training, and hardware/software maintenance; location and availability of backup equipment; and tradeoffs regarding lease versus purchase contract offerings. After the evaluation, the buyer should be prepared during negotiations to insist on benchmark tests, demonstration operation specifications and system acceptance criteria.

Implementation should include conversion and establishing the ongoing operation. Following implementation, the system should be evaluated along with the operation it is supporting, in order to determine if the benefits forecast in the planning phase have been achieved.

Miracle or Myth?

Today's minicomputer technology allows each organization to choose its own approach to data processing. Business needs, not just hardware and communications costs, should dictate the mix of computer equipment, whether it be large or small, centralized or remote. The miracle of the minicomputer is its relatively low price and high performance. This allows companies practical alternatives to large centralized data centers, or can make special purpose application cost-effective. Minicomputers can also be cost-effective when supporting general business applications for small and medium-sized companies. The myth is that the minicomputer can do everything done by a large computer at a lower cost and with less management attention. Reality is that a mixture of large scale computers and minicomputers, uniquely configured for each situation, will provide the most cost-effective data processing.

But should *you* have a minicomputer? You must weigh your needs against the content of this article. △