EDP ANALYZER

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EDP ANALYZER

FEBRUARY, 1983
VOL. 21, NO. 2

Our 20th Anniversary Issue

PLAN NOW FOR WORK STATIONS

A good many organizations, we suspect, are deciding that the personal computer type of work stations are not as cost effective as 'dumb' terminals served by host computers. And $500 for a terminal *does* look attractive, as compared with (say) a $3,000 work station. But be careful; such cost comparisons can be deceptive! Work stations have a number of advantages—some difficult to put a price on—that seem sure to promote their acceptance. We think that work stations will be a fundamental part of information systems a few years hence. (An executive summary will be found on page 16.)

The engineering department of a high technology company recently was faced with the need to provide the engineers with more computing capacity. A few years back, the engineering computing workload had grown to the point where the company installed a super mini-computer, to take this load off the mainframe. Now the super mini had become overloaded. And the question came up—how best to provide this needed extra capacity?

One group of people advocated that each of the engineers be given one of the new 16-bit personal computer work stations suitable for engineering use. This would mean the procurement of several hundred such work stations. With a unit price of about $5,000, the total outlay by the company for these work stations would be well over $1 million.

That price looked steep to company management, as compared with adding one more super mini. A super mini—with adequate disk storage, memory, system software, and printer—would cost under $400,000, plus the cost of any additional terminals that would be needed. Moreover, management knew what performance might be expected if another super mini were added. They *didn't* know what benefits could or would be obtained from the work stations.

So the decision was made to solve the capacity problem by adding another super mini. But it was also decided to test out the advantages of work stations by buying a small number of them, for use by a few of the engineers.

ISSN 0012-7523.

At another company—a leading financial organization—substantial progress has been made toward installing office automation systems. These office systems are being run on departmental mini-computers, to which inexpensive, non-intelligent ('dumb') terminals are attached. This company has postponed, at least for the present, the idea of installing personal computer work stations, due to the volatility of the market place. Their rationale is that dumb terminals can now be purchased for about $500 each, while personal office computers will cost at least five to six times that much—and they do not yet see commensurate advantages of the latter.

These two cases illustrate, we suspect, the approach that many organizations are currently favoring. Today's minis and super minis are rather familiar devices, with a good deal of similarity to yesterday's mainframes. Micro-computers, however, are a new breed of computer and it may not seem reasonable that a micro can provide a user with as much hardware capacity or software power as the shared use of a mini. Also, the cost of the mini approach appears to be less, because dumb terminals are now so inexpensive. So when the decision is finally made on how best to provide the needed additional computing capacity, the mini is often selected.

The point to be made by this report is: *Don't sell personal computer work stations short*! They have numerous advantages over dumb terminals connected to minis or mainframes, which we will discuss. They also have some shortcomings, and we will discuss those, too. Our belief is that personal computer work stations will come to dominate this market area.

There are a number of subjects that are closely related to work stations—for instance, local networks, interfacing with data networks (such as IBM's SNA), and distributed processing. We will not be getting into such subjects in this report but instead will address them in near-future issues. Also, the pros and cons of dumb terminals tied to minis or mainframes are fairly well known, so we will not discuss them much; rather, we will concentrate on the characteristics of work stations.

In this report, we will use the term 'terminal' to mean an inexpensive dumb terminal tied to a mini or mainframe. In addition, we will use the term 'work station' to include both personal office computers and many types of intelligent terminals tied to host computers. It is not clear where the dividing line is between personal computers and intelligent terminals; with at most a few additions, the latter can often be made into the former.

The work station environment

Who are the potential users of office work stations? We see them covering the full gamut of office jobs—executives, managers, secretaries, professionals (accountants, engineers, programmers, etc.), and clerical workers.

It is quite likely that somewhat specialized work stations will appear for these different audiences. Work stations for executives might be either quite small, so as to be put out of sight when not in use, or attractively finished to fit in with an executive's office decor. Also, different forms of input might be provided for these work stations because so many executives resist using a keyboard.

The same thinking would apply to work stations for the other audiences. Some managers will want work stations with color graphics capabilities, for getting reports in color graphical form. Engineers probably would want larger internal memories in their work stations than would be found in other types, plus features such as floating point arithmetic. All users will probably want work stations with human factors design features—detached keyboard, tilt screen, and such.

Then, too, work stations should be able to perform multiple functions, with the functions that are available in a specific work station being relevant to the user's job. These functions can include data processing (transaction entry), word processing, computer message handling, local query and report processing, accessing host computers for queries and reports, accessing network services, performing decision support calculations, and so on. It is quite possible that executives and managers will want most of these capabilities in their work stations.

What is the potential market size for work stations? Today in many organizations, there is

one terminal for every three to four employees. But at a recent conference (Reference 4a), Robert McDowell from United Services Automobile Association in San Antonio, Texas, reported that his company now has over 3,000 terminals installed for their 5,500 employees. In addition, by sometime next year, they expect that essentially *all* of these 5,500 employees will have a terminal. We suspect that many organizations will approach this 1:1 ratio by the end of this decade. In fact, some employees already have more than one computer—such as one at work and one at home.

But there is more. USAA has not yet decided whether their employees will have terminals or work stations, said McDowell. They are keeping the work station option open, because with work stations, they feel that their employees' jobs can be enriched perhaps more than is generally true with terminals. Also, the company may want to move some of the data right to the work stations—which is possible with work stations but not with dumb terminals tied to (say) a mainframe.

So the final decision has not yet been made on the question of terminals versus work stations. What are some of the factors that might cause the decision to swing in favor of work stations?

Why work stations?

Here are some of the advantages—and some of the shortcomings—of work stations as compared with terminals.

The psychology of personal computers

For the novice user, there is something less forbidding about a small, personal work station as compared with a terminal tied to a larger computer. In size, some personal work stations are not a great deal larger than typewriters, so that they do not look imposing or mysterious. The user of a terminal, of course, knows that it is tied to a larger machine—a machine "that only programmers understand and can really talk to."

In addition, the user soon finds that the personal work station is 'friendly.' To be successful in the market place, personal computers must have friendly user interfaces—easy to turn on, easy to load programs, availability of menus and other such aids, and if the user makes a mistake, probably the user can correct it without anyone else even knowing about it.

This 'friendliness' should not be dismissed. Today's personal computer work stations are generally friendlier than are most mainframes with their complex operating systems. Then, too, higher reliability, higher availability, and faster response times of the work stations make them even friendlier than mainframes or minis. Multiple-vendor work stations and operating systems give users more options, (generally) lower costs, and access to large amounts of inexpensive software, with practically no software maintenance problems. Fewer downtime and maintenance problems mean users are more comfortable with these systems.

Furthermore, capacity can be expanded in small increments. Engineered redundancy, to provide high reliability, is less expensive than providing duplicate mainframes or minis. And the work stations do not require special air conditioning, professional computer operators, and perhaps no additional floor space (if they fit on employees' desks).

The point here is that work stations seem to be setting the standard for user friendliness—a standard that mainframes and minis will have a hard time matching.

There is still another related factor to consider. As we discussed in the November 1982 issue, tele-commuting is almost sure to spread quite rapidly. Managers and executives will like the option of having work stations at their homes, so that they can do some of their work at home rather than by overtime hours at the office. It will help if their home work stations are similar to, and compatible with, their office work stations. They will feel more comfortable using essentially the same device at both locations. Furthermore, portable computers are selling very well; they might be used both at home and on trips.

Performance

Response time. The computing and processing workload continues to grow, at most computer-using organizations. This condition exists for both batch and on-line applications. One can ex-

pect that the number of terminals and/or work stations—as well as the number of service requests entered on those terminals—will continue to increase within companies.

In addition to this increasing work load, it must be recognized that the work load mix will shift somewhat, toward requests that consume larger amounts of processor cycles. Decision support models, computer graphics, and the use of (say) database management systems all will impose bigger demands on processors.

In such an environment, any type of shared resource will have an increasingly difficult time giving satisfactory response times to users.

Tweedy (Reference 1) reports on a comparative analysis that he performed on four alternative distributed system designs. For this analysis, he used parameter values that he felt were representative of the 1980-90 time frame—such as number of terminals, processor capabilities, prices, and so on. His four designs were: (1) a host computer serving dumb terminals, (2) a host serving intelligent terminals, (3) a host serving an intermediate cluster processor which in turn served dumb terminals, and (4) the host/cluster processor combination serving intelligent terminals. He set up a model by which performance of the four architectures could be estimated, and used (a) three different terminal populations, (b) three different mixes of work load, and (c) three different transaction rates.

One of the main requirements was an average response time for the defined service requests of 3 seconds, which is about twice what the response time is for this particular application running by itself on a host mainframe. A further requirement was that the response time not exceed 6 seconds under heavily-loaded conditions.

What his analysis showed was that alternative (3)—the host/cluster processor combination serving dumb terminals—had the lowest life cycle costs, for most work load conditions. In some cases, alternative (1)—host serving dumb terminals—was the lowest cost. But these two alternatives had by far the poorest response times; neither really was able to meet the 6 second maximum. (Alternative 1 quickly degraded to 25 seconds average response time as the work load increased, in his study, and alternative 3 degraded to this same response not long after.) The two alternatives using intelligent terminals did much better, as far as response time was concerned.

Although Tweedy does not address the point, one suspects that if the 6 second maximum had been imposed as a true maximum, and processor power was added to alternatives 1 and 3 to the point where they could meet this requirement, the life cycle costs of alternatives 1 and 3 would have been much higher than the other two alternatives.

There is still another aspect of performance that is important. A processor can communicate with the screen of its work station at a much higher speed than a host can communicate with a remote terminal, unless the latter communications use coaxial cable. This results in work stations having screen-oriented text editors (not line-oriented editors), on-screen formatting and word-wrap for word processing, etc., that host-type systems generally do not offer. These are definite advantages for users.

Flexibility. Another aspect of performance is the ability to adapt to changing conditions. Here, too, the advantage lies with the work station. For instance, if a person is promoted or shifted to another job, the same work station probably can be used in the new job—and software packages are the key. Available software packages not only cover a wide range of application uses but also can make work stations compatible with SNA private networks or X.25 public networks, at the user's option.

Also, work stations can be programmed to give their users essentially the same friendly interface, whether local or remote processing is being done.

Security. There is some question of whether or not work stations should have their own hard disk and/or floppy disk units.

On the positive side, one of the nice features of floppy disks is that the diskettes can be removed and stored in secure places. Also, some removable Winchester hard disk drives are now appearing on the market (for under $500 each, in large quantities, would you believe!), so the same advantage would lie with them. In either case, removable disks allow sensitive files to be

taken off the systems and stored in secure places. Until operating systems can provide a much higher degree of access control than is currently the case, this security feature will be found to be very useful by executives, managers, and staff who enter sensitive information in a computer.

On the negative side, removable disks make it easy for someone to take copies of valuable programs and data off-premises.

Cost

How about cost? Don't mini-computers serving dumb terminals have a decided cost advantage over (say) local networks of work stations?

The answer seems to be—not necessarily. We priced out one of today's most popular super minis that is capable of handling (say) about 100 terminals, although response time reportedly can begin to degrade noticeably above 80 terminals with typical time-sharing work loads. The price of the system, including over 200 megabytes of disk storage, 8 megabytes of internal memory, a line printer, operating system, and database manager, is in the order of $350,000. If one adds 80 of the least expensive ($500) terminals, the price tag rises to $390,000; if instead one uses $1000 terminals, the total price is about $430,000. Divide these two totals by the 80 terminals and they come out to $4875 and $5375 respectively per terminal. Wiring costs are significant but will be about the same as for local networks.

On the other hand, if one purchased 80 personal computer work stations at (say) $3000 each, the price is $240,000. To this price, one must add the cost of hard disk storage, a line printer, and perhaps two or more local networks. These prices vary considerably in the market place, but should be below $100,000. For a quantity purchase of 80 systems, $3000 probably would buy a very powerful work station indeed, including some local disk storage and a good amount of software. If the work stations used 8-bit processors with 64k bytes of memory each, total memory would be over 5 megabytes. (The new 16-bit processors could easily double or triple this memory—but at somewhat higher cost.) In all likelihood, 20 more work stations could be added to the networks with little or no effect on user response time, which probably would not be true of the super mini.

This one example does not prove a price differential either way, of course. It only says that the host/terminal combination is not obviously lower in price than networks of work stations; the figures must be worked out for your specific situation. But our guess is that networks of work stations will win the price war much of the time.

Forefront of technology

Work stations allow user organizations to stay closer to the forefront of technology than do minis or mainframes, it seems to us. The reason is, as long as a new work station meets the user company's standards for operating system and communications, the chances are fairly good that it can be attached to a local network within the company without much difficulty; suppliers are seeking to provide this capability. So new technology probably can be added when and where it is most needed, in small increments.

With terminals tied to mainframes or minis, a much larger cost and effort is involved in switching over to new technology—namely, possibly replacing the whole computer and/or operating system.

In addition, the interesting phenomenon of 'dual processors' is occurring with personal computer work stations. Zilog Z80 processor boards can be added to Apple II computers, so that the Apples can run CP/M programs. The Radio Shack TRS-80 Model 16 uses both the Z80 processor and Motorola MC68000 16-bit processor—and the Model II can be upgraded to a Model 16 by the addition of a MC68000 board. Both Cromemco and Altos have announced new computers with both 8-bit and 16-bit processors.

So new 16-bit personal computers are being announced that also have 8-bit processors, for easing migration from the older computers. And new boards are available for upgrading some of the older computers into almost-like-new 16-bit machines.

Then, too, the new 16-bit and 32-bit micros will be offering users very large physical address spaces. The Motorola MC68000, for example, currently has a 1 megabyte address space and before long will increase this to 16 megabytes. Quite

large programs indeed can be run on such machines.

But there is more. Probably the micro-computer portion is the most dynamic part of the computer field at present. In both the hardware and software areas, the entry price for new firms is not great; one has only to attend a major computer conference and see all of the exhibit booths to be convinced of that. While entry is relatively easy, competition is fierce. So there is a tremendous flood of new products incorporating new ideas, mostly involving 'standard' operating systems such as CP/M and MS-DOS.

User companies will find that many of the new developments in decision support systems, graphics, color graphics, computer assisted learning, voice recognition and response, and input methods (such as the Xerox STAR's 'mouse') are occurring in the micro-computer area.

The mainframe and mini suppliers will have a very difficult time keeping apace of the micro part of the market.

Software available for management

Operating systems. As we have mentioned in past issues, several popular operating systems for micros are attracting a great deal of entrepreneurial software effort. These operating systems include Apple's DOS, Radio Shack's TRSDOS, as well as CP/M MS-DOS and UNIX. Other popular operating systems include SofTech Microsystems' p-System and Phase One Systems' OASIS; both run on a number of brands of computers.

These popular operating systems have created a large potential market place for new, good software, some of it (such as financial planning packages) suitable for use by managers. Not all new software is good, of course, but the market place seems to be doing a reasonable job of weeding out the poorer software.

Database management systems. As we mentioned in our October 1982 issue, relational DBMS have now appeared on micros. For instance, Relational Technology is offering INGRES (discussed in last October's issue) on MC68000 systems in the $500 to $1000 price range; this same DBMS is priced in the $30,000 range for minis.

In addition to INGRES, four other relational systems for micros were discussed at the Mini/Micro 82 conference and exhibition held last September. These include Relational Software's ORACLE, Pacific Software's SEQUITER, Logical Software's LOGIX, and Relational Database System's INFORMIX.

These five systems were discussed in a session titled "The new wave of database systems." It followed another session titled "Microcomputer software grows up." These two sessions gave a most impressive picture of the status of microcomputer software; see Reference 5c and 5d.

In our July 1981 issue, we discussed the USER-11 data management system, which runs on the larger DEC PDP-11 models. It, too, is now available, as USER-BASE, on micros that use the OASIS operating system. The price an Integrated Business Computer's Middi-CADET hardware/software combination, involving 256k bytes of memory, 1 megabyte of floppy disk storage, 20 megabytes of Winchester hard disk, 10 asynchronous ports (for terminals, printers, communications), OASIS and USER-BASE, is under $10,500. A larger model, with 80 megabytes of hard disk and the same software, costs about $17,500. The power of these 8-bit systems in running USER-BASE is amazing, approaching PDP-11 performance—and a 16-bit version for the MC68000 is imminent.

Software systems such as these bring to managers (and others) the ability to query data files, request reports, and even set up their own special applications, if desired.

Financial planning packages. The most popular type of today's financial planning packages is the electronic spreadsheet. VisiCalc was the first of these. Originally designed to run on Apple computers, it by itself is reported to have accounted for the sale of hundreds of thousands of Apples. VisiCalc is also available on Radio Shack, IBM, and Hewlett-Packard personal business computers. For CP/M computers, SuperCalc is perhaps the most popular. But there are now many such packages on the market for micros, covering a wide range of prices (from $50 to over $1,000) and capabilities.

In addition, many other types of financial decision support packages are now available, and more are continually arriving in the market

place. Some help on investment decisions for stocks and bonds; others are aimed at real estate. Still others are more general purpose, such as for performing sales forecasting, production forecasting, and budgeting.

References 2 and 3 are catalogs of available packages designed to run under the CP/M operating system. Reference 2 lists almost 1,700 such packages, from over 500 suppliers and divided into 87 categories. Reference 3 lists about 1,800 packages from almost 400 suppliers, some international, and divided into 38 categories. While there is a lot of overlap between these two listings, each has a good number of packages listed that are not found in the other. Many of these packages will be of interest to managers with CP/M-compatible work stations. Similar lists exist for Apple and Radio Shack computers. Lists like this surely will develop for computers employing the MS-DOS, OASIS, p-System, or UNIX operating systems.

Other types of software. We could go on and on about the types of relatively inexpensive software that are now available for micros. These types include data communication packages, terminal emulation packages (for making a work station operate like, say, an IBM 3270 terminal), utilities, graphics packages, and more.

There is just no way in which a supplier of a proprietary line of computers (no, not even IBM) can offer the variety of software packages that today's market place offers for micros. Selections for proprietary computers will be much more limited and prices generally much higher. Personal computer work stations that use a common operating system such as CP/M and MS-DOS, on the other hand, provide a direct, convenient way of letting (say) managers select and use the packages that they feel are of value to them.

Other management uses

In the latest edition of our book, *So You Are Thinking About a Small Business Computer* (Reference 4), we describe a number of other ways in which managers, executives, owners, etc. can and are using micro computers. Here is a brief overview of some of the points made in the book in this regard.

Management uses of word processing. Many people think of word processing as something to be used by secretaries, typists, and clerical workers. While these people can make good use of word processing, somewhat surprisingly the same is true for managers, executives, and professionals.

Word processing in marketing. Sales people can use word processing to send computer letters to prospects—based on (say) names from a directory—to be followed a few days later by phone calls. The letters alert the recipients and tell what the sales person will be calling about. The phone call determines whether the prospect is interested and whether a visit to the prospect's place of business is justified.

Other firms are using word processing to develop profile data about their customers. After anyone in the company has a contact with a customer, the high points are entered (using word processing) in the customer profile—who was contacted, by whom, when, relevant comments, and so on. Managers can review such information and insert their suggestions on how the next contact should be made.

Automating your calendar. If a special 'calendar' program is not being used, for listing future appointments, etc., the word processing package on the work station can be used. A special calendar program would be preferred if the manager has many appointments and/or frequent changes. But for the manager with relatively few appointments, where it is desired to store detailed information about each one, word processing can be used to advantage.

It is relatively easy to add new dates for the future; each week probably would have a different file name (such as the date of the first day of that week, like FEB14). If appointments are moved from one day to another, it is easy to move the information.

One case example described in the book involved a calendar for the workers in an office. In this instance, the boss required that each employee list the tasks that he/she planned to do *for the next work day.* These lists were entered into the computer, using word processing, then printed out and given back to the employees the next day. The employees checked off the tasks

from their lists during the day, as those tasks were done. Near the end of the day, the tasks for the next day were hand-written on the list. The secretary then prepared the new lists for the next day, including any from 'today' that had not been checked off. Not only did this help to organize the work days, but it also provided essential information if one of the employees was sick and did not come to work. Someone else could tell quickly which tasks were urgent and which ones could be delayed.

If each person has a work station, each could maintain his/her own calendar, for an application of this type.

Many types of lists. In many offices, certain types of information are scattered throughout the paper files. When a need arises for that information, there is generally a hectic search for it.

Insurance information is one such type. Word processing provides an easy way to develop an insurance inventory, with the key points about each policy in force. The information does not change rapidly, so updating is no great problem. But when a need arises for information on a policy, chances are the answer can be found in the list.

This same principle can be used for a list of fixed assets, a list of suppliers, a list of investments, and so on. While secretaries might create such lists initially, using word processing, managers often will want to update, modify, or expand the lists themselves.

A word processing package on a work station means that all such uses are at the fingertips of the managers and others. Further, any strictly local files will not clutter up a company's centralized disk storage space and file directories.

Network services. Another area addressed in Reference 4 is that of network services that can be accessed from a personal computer. These include The Source and CompuServe, two information services that provide a variety of types of information on a very reasonable cost basis. Types of information include airline schedules (both domestic and foreign), hotel and motel reservations, UPI news stories, stock prices, and many more. (The Source provides *over 1,200* such services, and users' monthly bills average about $20, we were told.)

There are many other network services—Dow Jones, Western Union Mailgrams, Lockheed and SDC search services, New York Times Data Bank, to name a few. American Express has indicated that it will be expanding its network services in a variety of ways.

Why use a work station for accessing such services; why not just use a terminal? Because a work station can do *all* of the things we are discussing, not just one or a few. It is the combination of a powerful processor and lots of effective, inexpensive software that makes the work station so attractive. As long as you have a work station for performing all of these activities, use it also for accessing network services.

Reference 4 covers still more possible uses by managers—using decision support packages, learning to do some BASIC programming so as to create your own decision support program, and using computer graphics to help make decisions.

Furthermore, as mentioned earlier in this report, some organizations see work stations as perhaps supporting job enrichment better than can be done with terminals tied to hosts. In theory, a clerical worker who today is doing essentially just one function does not need a multifunction work station; a terminal could be sufficient. But the importance of 'quality of work life' is becoming more and more recognized. Work stations probably will allow for a more varied, richer work day than do terminals—if and when jobs are re-designed to make use of those functions. (We discussed some of these ideas in our April 1981 and May 1982 issues, and will return to job re-design month after next.)

Personal computer work stations is where the main action is, in the computer field. We believe that users will find that work stations offer more friendliness, flexibility, and functionality than do terminals tied to hosts.

Some shortcomings

But personal computer work stations are not without their shortcomings and problems. Here are some.

Higher incremental cost. The cost of adding one more terminal to a network of terminals

usually will be less than the cost of adding one more work station to a network of work stations.

Of course, as a company continues to add terminals to an existing mainframe or mini, the service to all users suffers as response time increases.

Substantial total cost. The point being made here is best described by the example at the beginning of this report—the engineering department that needed additional computing capacity. Additional capacity to meet near-future needs could be obtained by adding one super minicomputer, at a cost of about $400,000. But converting to work stations would require a complete changeover, at a cost of over $1 million.

However, several hundred personal computer work stations would provide *much* more capacity than would one super mini. Furthermore, the response time for each user would be largely unaffected as more work stations were added, unless there is heavy contention for hard disk access. But the out-of-pocket cost of switching completely to the work station environment would be higher than just adding one more super mini.

Possible maintenance problems. Personal computer work stations involve many more components than do terminals, so there is more that can go wrong. Thus the maintenance of work stations might be more costly than the maintenance of terminals (but perhaps less than the maintenance of terminals *plus* the computers to which they are attached).

Fortunately, most of today's micro computers are indeed reliable; many operate for thousands of hours with little or no need for maintenance. Even so, the maintenance problem cannot be ignored.

Response times. Since the work stations have their own processors, large quantities of CPU cycles can be supplied rapidly, so processing response times generally will be good. But if many work stations share the same hard disk, access response times can deteriorate. The response time problem should be easier to solve with work stations on a local network than with host/terminal systems, since there are fewer shared resources.

Work stations don't meet all needs. A research study conducted by Christine Bullen of M.I.T. at the IBM San Jose Laboratories (Reference 6) uncovered the fact that secretaries chose to use their typewriters for some functions instead of their computer terminals. They preferred typewriters when filling in forms, when entering information on small pieces of paper (postcards, labels, etc.), and when the information being typed was sensitive.

So it is quite possible that a (say) $3,000 work station will not meet all of the needs of employees. They may still need to use typewriters, calculators, and perhaps even specialized terminals.

The privacy problem. We have pointed out that work stations with removable media (such as floppy disks) can provide a fairly high degree of data security. At the same time, they do open the door for violations of privacy policies.

The point here is that both government-mandated and company-voluntary rules have been and are being established concerning the storage and processing of information about people. Only information that is legitimately needed by an organization should be collected, and it should be used only for the purposes for which it was collected.

Work stations with local storage raise the possibility that managers will create and maintain their own records about employees working under them, in violation of the rules. This possibility seems quite a bit more likely with work stations than it does with dumb terminals tied to mainframes or minis—because the managers might well feel that they can hide this information better with their own work stations.

Assuming that the above-listed 'pros' outweigh the 'cons,' what should one look for in work stations? Here are some thoughts on the matter.

Work station features

Some of the following features are available now on many of today's personal computer work stations. Other features, while it is likely that they will prove popular, are still in the development stage.

Near term features

Multi-function capability. Most of today's personal computer work stations can perform data processing functions, using their own programs or acting like dumb terminals to access programs on host computers. They can also perform word processing, and there are many word processing packages on the market. These work stations also can perform data communications (often asynchronous, 300 baud) and can act as terminals for electronic mail systems. Higher speed synchronous transmission also is available.

Alsup, in Reference 5a, gives an overview of the functions that are performed in an office and how these can be supported by electronic systems.

What to look for: Computer capability with at least 48k bytes (for 8-bit machines) or 128k bytes (for 16-bit machines) of internal memory, for performing the multiple functions.

Storage. If you choose to provide storage at work stations, two floppy disk drives are preferred; having just one drive is annoying, due to constant swapping of diskettes. Small hard disk units, that fit into the same space as floppy disk units, increase the storage capacity by factors of 5 to 20 or so. As has been mentioned, there are even some small (5-1/4 inch, 13 cm) *removable* Winchester-type hard disk units now on the market.

What to look for: Two floppy disk drives, with a total storage capacity of at least 300,000 bytes (and preferably twice that or more), or one floppy and one Winchester hard disk with a total capacity of over 5 megabytes.

Display. The most common display today has 24 lines of 80 characters each on a 10-inch (25 cm) wide screen, for a total of 1,920 character display positions. An 8-1/2 by 11 inch (21 by 28 cm) typing sheet, with one inch margins, has over 3,500 character display positions. So today's typical display shows the equivalent of just over one-half a page of typing.

There are some displays on the market that show the equivalent of a full page of typing. And some, too, can be tilted so that the long side is either vertical or horizontal.

Most displays show white characters on a dark background. Human factors research has indicated that light green characters, or amber characters, on a dark background are less tiring on the eyes—so these color combinations are appearing in the market place.

Color has begun its widespread appearance. There is a color alphanumeric display on the market for under $1,000. Color graphics displays (which require fairly large internal memories for good resolution) have had only moderate acceptance so far, but they are available.

What to look for: At least 24 lines of 80 characters on a 10-inch (25 cm) wide screen, for alphanumeric displays—preferably with light green or amber characters. If graphics are desired, seek a display/computer combination that has at least 200,000 points on the screen (say, 500 by 400 points); 140,000 points is 'low resolution' and may be only marginally acceptable for your intended uses. The use of a color display is optional and color graphs might better be created on plotters.

Input options. Most of today's personal computer work stations provide only keyboard input. Some have additional function keys that are either 'hard' (with function names engraved on them) or 'soft' (with the function names shown on the screen immediately above them). However, the most popular personal computers provide only a typewriter-like keyboard and the user must remember which combination of keys must be depressed to perform desired functions.

One important feature is the detached keyboard with a long, flexible cable—at least 3 feet (1 meter) in length, so that the user can move the keyboard to a comfortable operating position.

What to look for: Detached keyboard, as just described. Hard and/or soft function keys would be desirable but are not often offered as yet. Also, check the layout of the keyboard. Some have very poor layouts, such as very small shift and 'enter' keys surrounded by function keys, making it all too easy to depress the wrong key by mistake. The IBM Selectric typewriter keyboard is the standard against which to measure.

Printed output. Will some of your work stations have their own local printers, or will they share the use of printers? Secretaries probably will have correspondence-quality printers at

their work stations, for printing letters and short documents. Long documents might be printed on shared-use line printers.

We suspect that many users will want to have inexpensive ($500 to $700) dot matrix printers attached to their work stations. These can produce print that is almost of correspondence quality, suitable for reports and some letters. Also, they can have graphics options added.

No general guidelines can be given here, as to whether to have printers attached to work stations and what types of printers to have. These decisions depend on the specific situations and the preferences of management and the employees.

Data communications. The work stations should certainly have both hardware and software for data communications. At the very least, the work stations should provide for asynchronous transmission, 300 baud (1,200 baud very desirable), full or half duplex, with selectable parity (generally, parity is off). The software should allow the work stations to communicate with each other and/or with host computers, for file transfers (both sending and receiving) and dumb terminal type of operation. These features will allow work stations to communicate with each other and with many network services.

For private networks, such as SNA networks, hardware and software will be needed for making work stations emulate (say) IBM terminals or mini computers. There is no reason why work stations cannot operate in both public and private network environments, at the user's option.

If, as is likely, work stations are connected to local networks, then the hardware and software will have to be compatible with the local network. The gateway between the local network and any outside networks will have to provide the necessary interface functions.

Again, no additional general guidelines can be given because so much depends upon the specific situation.

Future features

Some of the following features are already being offered with certain personal computer work stations. However, the choices today are so limited that we have chosen to call them 'future features.' You may be able to get some of these to meet specific needs.

Additional functions. While today's personal computer work stations can perform a wide range of functions, tomorrow's work stations will do more. They will have a calculator mode that can be initiated at any time; the user can branch from (say) entering text and perform a calculation. They will have a typewriter mode that (hopefully) almost duplicates the use of a typewriter, for filling in forms, preparing labels, and so on. In all likelihood, the telephone will be integrated with future work stations, so that the work station can look up a telephone number, do the dialing, and then let the user take over for a voice conversation, if that is what the user desires.

Input options. A great deal of progress is being made in this area. For instance, the 'mouse,' used with the Xerox Star work station, is a device that is rolled around on the table top to move the cursor; also, it has buttons for activating functions. It appears to be much faster and easier to use for these functions than the standard keyboard.

Touch sensitive screens are being used today, such as with the Control Data PLATO terminals. One use of these screens is for allowing users to make selections from menus.

Voice recognition and voice response are closer to practical use (for specific applications) than many people realize. Voice recognition is still pretty much confined to a rather limited vocabulary of discrete words (speaker pauses after each word). Even so, some impressive uses are being made of this feature. A good summary of the state of the art in this area will be found in Reference 5b.

Display and output options. With much larger internal memories for work stations in the near future (in the megabyte range), we would expect to see bit-mapped displays become dominant. A fairly high resolution screen might have about 1 million points, we think; a really high resolution might have 16 million points on the screen. For two-color displays (black and white, or any other two colors), this 1 million points would require 1 million bits (say, 125,000 bytes) of storage. Multiple or full color displays will require 3 to

24 times as much storage. But memory is becoming relatively cheap, so these numbers are not as impractical as might first appear.

Why bit-mapped displays? The answer is: So that what you see is what you get. Text can be shown on display screens just the way it will be printed—by font type and size, with underlining shown, and so on. Graphics will be high quality, with little or none of the 'staircasing' that is seen on curves and slanted lines in most of today's graphics systems. Bit-mapped displays will become economically feasible, and will probably drive the poorer quality displays off the market.

And then there is the feature of multiple windows on the displays. Multiple windows are available with some systems today, such as VisiCorp's new VisiOn, but this is not yet a common feature. Managers and executives, in particular, will welcome multiple windows, we think, because they are often looking at and evaluating several types of information concurrently.

These, then, are some of the features that are available today in a large number of work stations, as well as some that are still emerging.

What to do about work stations?

As we said at the beginning of this report, it is likely that many organizations today are choosing to expand computer capacity for on-line users by adding dumb terminals tied to mainframes or minis, in preference to adding local networks of work stations.

The message that we have sought to give in this report is that work stations offer a lot of advantages. We believe that they will gradually take over much of the work that today is performed on minis and mainframes, plus additional new work that is not being done today.

So our recommendation is—plan on personal computer work stations becoming a fundamental part of your future information systems. Get started in using local networks of personal computer work stations, to get experience with them. And build them into your intermediate and longer range information system plans.

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One of the main problems facing many information system executives is: What to do about old, hard-to-maintain application systems? They consume all too much programmer and computer resources, and make it difficult to move to new technology. Next month, we will discuss what some innovative users are doing about "replacing old applications."

COMMENTARY

SOME NEW PRODUCTS AND THEIR SUPPLIERS

In both this and last month's issues, we have mentioned a number of recent hardware and software offerings in the micro-computer arena that have caught our interest. In our Commentary last month, too, we described briefly the rather overwhelming nature of the COMDEX Fall '82 exhibition, with its 1000+ exhibits.

Here are the name and addresses of suppliers for *some* of the products that impressed us.

Single-user computers. At COMDEX, there was about 150 exhibitors of micros, covering both single- and multi-user systems. Here is a sampling. In the 8-bit systems, we were impressed with the Eagle (Eagle Computer, Inc., 983 University Avenue, Los Gatos, Calif. 95030; 408-395-5005) with its relatively low price and high performance characteristics. And the Micro Decision (Morrow Designs, 600 McCormick Street, San Leandro, Calif. 94577; 415-430-1970) was an interesting CP/M-type system in the $2,000 range.

As we mentioned in last month's Commentary, the 16-bit machines were much in evidence. The Victor 9000 (Victor Technologies, Inc., 380 El Pueblo Road, Scotts Valley, Calif. 95066; 408-438-6680) is much like the IBM Personal Computer but with superior characteristics; the Ford Motor Company reportedly has selected it as the company's standard general purpose single-user work station. And the Olivetti M20 (Docutel/Olivetti Corp., 155 White Plains Road, Tarrytown, N.Y. 10591; 914-631-8100) uses the Zilog Z8001 processor and works with CP/M-80, CP/M-86 and MS-DOS.

Multi-user micros. There were *many* of these on exhibit, serving (generally) five to fifteen users at terminals. The question is often raised: If micros are so cheap, why have multi-user ones? Why not give everyone his/her own micro? The answer is—economics. Small groups of users are served at very low costs.

The 8-bit offerings of IBC (IBC/Integrated Business Computers, 21592 Marilla St., Chatsworth, Calif. 91311; 213-882-9007) were very powerful indeed; we mentioned them in this issue in connection with USER-BASE. And they are ready with a 16-bit system, using the MC68000 processor and serving up to 32 users, just as soon as the OASIS operating system for this machine is released.

TeleVideo (TeleVideo Systems, Inc., 1170 Morse Avenue, Sunnyvale, Calif. 94086; 408-745-7760) has touched all bases. It offers 8- and 16-bit single user CP/M systems with Z80A and Intel 8088 processors, multi-user CP/M systems via their own local network (up to 16 user stations), and a 16-bit multi-user system that employs the Motorola MC68000 processor and UNIX.

Also, systems that employ the National Semiconductor NS16032 32-bit processor are beginning to appear.

Local networks. There were over two dozen exhibitors of network systems, mostly local networks. One that impressed us was PLAN 4000 (Nestar Systems, Inc., 2585 East Bayshore Road, Palo Alto, Calif. 94303; 415-493-2223), a new generation of local network that currently serves IBM Personal Computers plus Apple II and III.

Application development, reports, queries. There were many data management, application generator, and program generator packages on display. As we have mentioned in numerous issues, these help in setting up new applications very quickly. They also allow users to do their own querying and report preparation.

USER-BASE (UserWare International, 2235 Meyers Avenue, Escondido, Calif. 92025; 619-741-8825) is an impressive data management system that runs on IBC 8-bit micros under OASIS and will be available on the MC68000 as soon as OASIS for that system is released. It is related to USER-11 that runs on larger DEC PDP-11s; we have been using USER-11 for several years and like it.

Micro-INGRES (Relational Technology, Inc., 2855 Telegraph Avenue, Berkeley, Calif. 94705; 415-845-1700) is a full relational DBMS that runs on some MC68000 systems under UNIX, such as the Dual Systems 83 (Dual Systems, 2530 San Pablo Avenue, Berkeley, Calif. 94702; 415-549-3854).

There were numerous other packages in this category that we wish we had space to discuss. These include COGEN (Bytek, 1714 Solano Avenue, Berkeley, Calif. 94707; 415-527-1157), ORACLE (Relational Software, Inc., 3000 Sand Hill Road, Menlo Park, Calif. 94205; 415-854-7350), and SEQUITUR (Pacific Software Company, Tenth and Parker, Berkeley, Calif. 94710; 415-486-2070).

Spreadsheets. In our Commentary last month, we mentioned VisiCorp's new VisiOn (VisiCorp, 2895 Zanker Road, San Jose, Calif. 95134) that integrates a spreadsheet, word processing and graphics on the IBM P.C. Another integrated approach to these same three functions is offered by Lotus's 1-2-3 system (Lotus Development Corp., 55 Wheeler Street, Cambridge, Mass. 02138; 617-492-7171). Sorcim (Sorcim Corp., 2310 Lundy Avenue, San Jose, Calif. 95131; 408-942-1727) offers graphics and other functions tied in with their SuperCalc, but not yet integrated to the same extent as the other two suppliers mentioned.

Printers. While we could go on and on, we'll close this discussion with printers. The big gains have been in dot matrix printers, with prices in the $800 to $2,500 range. In general, they print draft-quality characters (at speeds ranging from 80 to 600 characters per second), correspondence-quality (at 1/3 to 1/6 draft speed), compressed type, different fonts, graphics, and more. Suppliers include Datasouth Computer Corp., (P.O. Box 240297, Charlotte, N.C. 28224; 704-523-8500), Facit Data Products (66 Field Point Road, Greenwich, Conn. 06830; 203-622-9150), Florida Data Corp. (600D John Rodes Blvd., Melbourne, Fla. 32935; 305-259-4700), Infoscribe Inc. (2720 South Croddy Way, Santa Ana, Calif. 92704; 714-641-8595), and Qantex Division (60 Plant Avenue, Hauppauge, N.Y. 11787; 516-582-6500).

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EXECUTIVE SUMMARY

Inexpensive, non-intelligent ('dumb') terminals served by mainframes or minis may seem to be cost-effective when compared with personal computer work stations. But the message of this report is: *Don't sell personal computer work stations short*! They have numerous advantages over dumb terminals, some of which are difficult to put a price on.

For instance, these advantages include human factors, such as a rather small, not-scary appearance, 'friendly' user interfaces, and very high reliability and availability.

Other advantages are found in the area of performance. Response times typically are better than most mainframes or minis can deliver, particularly when loads get heavy. Work stations are flexible (via programs) and can provide common user interfaces for a variety of uses. Sensitive data can be kept off-line, on removable media, when not in use.

Perhaps surprisingly, the cost of a local network of work stations can compare very favorably to the cost of a super mini-computer serving many terminals. Further, micro-based work stations allow users to install new technology when and where it is most needed, rather than having to replace whole computers or operating systems. And there are *many* useful software packages now available for micros, at relatively low prices. A good number of these packages are suitable for use by managers and executives.

Personal computer work stations have some shortcomings, too. The incremental cost of adding one more work station usually is higher than the cost of adding one more terminal. Taking out a mainframe or mini and replacing it with a local network of work stations, in order to increase capacity, can involve substantial out-of-pocket costs. Although most work stations are very reliable, maintenance costs cannot be ignored. And any shared resources, such as hard disk storage on a local network of work stations, can increase response times when usage peaks.

All in all, though, the shortcomings seem to be outweighed by the advantages.

With the rapid change in work station technology, wouldn't it be wise to delay getting them? Our view is that many of the features that are expected to be commonplace a few years hence are already available on some work stations—and we list some of these in the report.

1983 looks like a good time for setting up strategic plans. We suggest that you include personal computer work stations in those plans.