Thoughts on Finding the Right Computer Buddy: A Moveable Feast

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The burgeoning supernova of medical information is rapidly overtaking the practicing physician's envelope of comprehension. More physicians by necessity are turning to automated resources as a means of amplifying the information they need to know while, at the same time, reducing the volume of technical pollution. Computers are capable of being a silent partner at your side as you talk with your patient—ready to cut to the quick and retrieve the latest information for the particular clinical problem at hand.

Computers can be considered an extension of the brain. In a sense, they are silicon-based "life" forms. Virtuosity is learned from them as familiarity is gained—the same as becoming acquainted with a human stranger. This article is about one physician's solution to the problem of too much information. It's unabashedly anecdotal but we hope the reader will glean some hints while navigating through the realms of cyberspace.

A Brief Trip into Cyberspace

Many physicians are unfamiliar with computer technology. As in medicine, computer technology has its own jargon. Anatomy cannot be discussed clearly without the vast superstructure of Latin and Greek jargon tagging along. This is reasonable, since new words are needed for new objects.

Computerese, like the computer itself, is very much with us. To become computer-literate, the jargon needs to be mastered as well because everybody who is computer-literate uses this jargon everyday. The English language is a fungating mass of verbal accretions that once were jargon a century ago and now are part of the common tongue.

Physicians need to learn computerese because they need to converse with persons in computer sales and service; physicians need to buy software and hardware intelligently, and they need to avoid being taken advantage of by hucksters who can spot a computer rube. The glossary in Appendix B is a representative sample of jargon commonly encountered and used in this article.

Explaining how a computer works is difficult but physicians must have a good sense of the beast by using a few good metaphors. The computer can be understood in terms of its structure and function: Its structure is similar to that of a post office and its function similar to a symphony orchestra. If you think the latter comparison seems far-fetched, just lean an FM radio against the computer while running a program and listen to the music of cyberspace.

Structure

Imagine the Honolulu post office for a moment with its hundreds of thousands of post-office boxes. Each box has an address and contains information in the form of mail placed in it every day. Behind the boxes are the postal workers.

They pick up incoming information and put it in the boxes, whether locally or farther away. Some people come to the post office, take the letters out of their boxes, and use the information. Other people write letters containing useful information and send them through the mail boxes elsewhere. The postmaster tells all the postalworkers how to run the post office according to a personnel manual written by bureaucrats in Washington and stored somewhere in the post office.

The computer is like the post office. The form and content of the postal boxes represent the addresses and data in this metaphor. These are expressed as binary numbers in a chain as long as 32 bits—equivalent to billions of addresses (2 to the 32nd power).

The mail that goes into the boxes is the data stored in the computer the capacity of which is specified by 16- or 32-bit numbers which code for instructions, numbers, letters, or any other kind of information. Each data and each address bit is carried electronically by a single wire or "trace" on a printed circuit board of the computer, called the mother board. Thus, a 32-bit address, or datum requires 32 parallel wires each. Each group of 32 wires represents a bus.

Contemporary personal computers (PCs) have 32-bit address and 32-bit data buses on their mother boards. Both buses originate in the computer's central processor or microprocessor; this electronic chip is equivalent to our postal workers. The processor sends and receives data to and from other devices on the data bus selected by an address on the address bus; this sort of talking back and forth is called handshaking.

All computer devices except the central processor have an address on the address bus and all devices hang onto the data bus in parallel like fresh laundry on 2 clothes lines. Devices do not conflict with each other because each device's address is exclusively its own and answers its calls.

Now, the postmaster is the program that runs the postal workers in the microprocessor—called the processor's "micro-code"—that resides on the chip. The personnel manual is software called the basic input/output system or BIOS that is located in another chip in read-only memory or ROM—a device that also hangs out with the other devices on the bus.

Our post-office workers are quite nosy; they open all the mail and process the contents before they send it to the next destination. Some of the mail's contents (data) even tell the postal worker where to send the mail next; these pointers are responsible for the power of the computer—its ability to represent addresses as data which can be processed and turned back into addresses again. Advanced addressing instructions in the Motorola 68000 chip made the Macintosh a superior computer.

Sometimes the postal workers are too slow at handling double precision numbers—ones that require twice as many numbers to the right of the decimal point. Therefore, an assistant called a math co-processor, similar to an assistant postmaster, is called in to speed up the mail.

Micro-code is beyond the scope of this paper but it is essential to know that the BIOS chip is crucial to operating the computer. BIOS firmware tells the microprocessor how to get access to the devices on the bus—from disk storage, to ports, to displays. It interprets the instructions from the operating system—the personality of the computer—in terms of hardware. The BIOS version needs to be kept up-to-date in order to run the latest operating system.

Most devices need more than one postal box to work; in fact,

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if one postal box represents one bit of information, then the video display, for example, needs as many postal boxes as there are dots or pixels on the screen—more than a million for today's high resolution color displays. Each pixel has an address to which the processor has access according to the BIOS instructions. In the graphics mode, a processor analyses each individual pixel so that very sophisticated color presentations can be made. Sometimes the postmaster needs an assistant because the pixel calculations can't be handled fast enough and a video co-processor is given the task. In text mode, BIOS uses a look-up table to tell it how to display a character for the display; this is generally a limited way to display data.

External devices, such as printers, need data spigots called ports; these spigots need as many as 16 addresses in order to operate. BIOS requires thousands of addresses in a large block of memory in order to function. Random-access memory, or RAM, also needs as many addresses as there are bits of data. Disk devices need addresses as large as input and output ports—these are called channels. Remember that all postal boxes are capable of carrying 32 bits of information in billions and billions of combinations because all devices are connected in parallel to the same data bus. A 32-bit address bus allows the computer to access billions and billions of postal box addresses. Remember the address bus is separate from the data bus and each device is attached in parallel to each other.

Function

We have described the computer's structure in space but not in time. To explain the computer's function, imagine a symphony orchestra. The orchestra consists of the various devices on the address and data buses. Each musician has a place or address in the orchestra and each musician has a score or data in front of him or her. The conductor is the central processor. The score is the program to be run—primarily the operating system within which other programs run as sub-routines.

The instructions for how to interpret the score are in the mind of each musician. The conductor has a micro-code and the musicians have their BIOS and firmware to tell them how to interpret the score into the music that comes out of their instruments or devices.

In the background a metronome ticks setting the rhythm of the score. This is the computer's clock. With every tick, an instruction is loaded into memory, instructions and addresses are decoded, data is processed, data is stored in devices, and new instructions are fetched from other devices. The notes of the musical score are read, interpreted and played. Music is made.

Computer clocks run at millions of cycles a second or megahertz (MHz). On modern computers, each command takes less than a millionth of a second to execute and hence computer power is measured in millions of instructions a second, or MIPS. The latest microcomputers are pushing over 50 MIPS, or what a small Cray super-computer in the early 1980s could process.

In summary, the computer is a kind of post office that acts like an orchestra. In other words, a bunch of musicians who hang out together on a bus waiting for a letter from Satchmo in their postal box telling them how to play a riff.

With an apology for mixing metaphors, let us proceed to selecting a computer-buddy. Once again, please refer to the glossary for review of unfamiliar terms. By the time the reader finishes this article, he or she will be talking computerese with the best of us and turning that knowledge into informed purchasing decisions.

Selection criteria

Criterion One

Our definition of the ideal computer is one that isn't there yet. Computers should allow a seamless, transparent area of contact with the information coming in or going out. After all, we're after information, not Tinkertoys; these devices are tools, not fetishes. Computers now are portable enough to offer minimal hassle to the user's life-style. Hence, transparency is the first criterion for selecting a computer.

Criterion Two

The kind of information to be processed should be considered. Define the kind of data to be searched for. Is it on-line services, data bases, simulation, instruction, and so on? Next, find the software to fit the desired information—pick the software to reflect the data—and then always select the hardware to fit the software, in that order.

Next, fit the software to your brain. How do you think? Are you an intuitive thinker or one who is more linear? Some people love graphic displays, while others prefer text-mode and staring at the DOS prompt. What kind of cognitive operations will you be doing with the information the software dishes out? Will you be doing much searching, sorting, listing, reporting or will you be crunching numbers, creating art work, creating ideas or objects that require massaging of the data? Generally, software that is not easy to use also is not very useful. That is why graphical interface software, like Microsoft's Windows is preferred.

Criterion Three

An intuitive thinker would find it important to get a computer good at "disk-intensive operations." A computer with a fast seek-time is appropriate for locating information quickly on a storage medium; a fast hard-disk, for example, would be something needed in a computer more than a fast processor.

On the other hand, working with ideas or pictures requires much number crunching. In that case, a computer that is good at "processor-intensive" tasks such as the latest chip with the fastest clock and bus speed is desirable. A math co-processor will speed up spreadsheets and graphics as much as 700%. To go on-line, then, the fastest modem available is needed: Nothing slower than 9600 baud. Distinguish between "processor-intensive" and "disk-intensive" computers—the third criterion.

Criterion Four

A word of advice is offered concerning selection of hardware and software. Criterion Four is a corollary to Criterion Three: Never use a software utility to fix a hardware problem or deficiency. For example, many people are buying disk-compression software as a cheap alternative to increasing the storage capacity of their hard-disks. The failure rate for such software is much higher than competitive compression-code residing in "firmware." Disk-compression software on a magnetic disk is subject to data corruption and is not robust enough to recover from disk crashes. The result is a disk that one day simply doesn't respond and only a low-level format will recover its use. If the data isn't backed up, the consequences could be disastrous to a business.

Microsoft's MS-DOS 6.0 contains a "disk-doubler" but it is only marginally more reliable than other compression software that has been incorporated into the operating system. When suffering with "RAM-cram," either a larger physical storage medium (more RAM, more replaceable media, or more hard-disks), or a disk-compression board with its software in firmware should be considered. It is very unlikely that firmware will accidentally flip a bit, as do the software versions. In any event, always back up the data.

An exception to the above corollary might be the memory manager utility. It provides Microsoft's MS-DOS operating system with upper, expanded and extended memory. This is only an apparent exception to the rule; it is really a Band-Aid. Memory managers are the tribute the buyers of IBM equipment pay for Microsoft's Jurassic DOS operating system design.

At the time IBM designed its very first PC in the early 1980s, in its great wisdom, this computer giant thought that no personal computer would ever need more than 64 kilobytes of conventional

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memory to run programs—equivalent to about 30, single-spaced, typed pages. Microsoft and others convinced IBM to increase this limit to 640 kilobytes, which is the present DOS standard. As current sumo-sized programs now weigh in at several megabytes each, this memory limit has become a straitjacket.

Software engineers have reclaimed unused upper memory with various memory management tricks such as paging (Lotus-Intel-Microsoft—LIM 5.0 specification-expanded memory) and an extended-memory bus addressing Microsoft's XMS standard specification. Microsoft is trying with Windows NT and Windows/32 to simply rewrite DOS the way Apple did it 10 years ago.

At that time, Apple had design control over the entire architecture of its Macintosh computers from the beginning. They chose the Motorola 68000 series microprocessor—with more powerful addressing instructions than Intel. IBM has always used Intel's 80n86 (where n=2,3,4,5,...) series microprocessors. Apple's programmers wrote an intuitive operating system for the Mac employing essentially open memory mapping for running programs. Fortunately for Apple customers, of course, Macintosh has never had RAM-cram; its "open" memory map was designed to be limited only by the physical memory available—not by the software.

IBM Microsoft's mistake in design was paid for by all of its customers. They essentially subsidized the industry's re-engineering of the PC to the point where today's IBM looks like a Mac, talks like a Mac, walks like a Mac. Along the way, IBM has been drawing customers away from Apple with the promise of super microprocessor chips and "WYSIYG" (What you see is what you get) interfaces. Apple sales are taking a downturn as a consequence.

Criterion Five

The converse to the above criterion is not necessarily true, however. Hardware frequently can fix a software deficiency or problem. Criterion Five states: Whenever possible, put as much software onto the hardware as possible. An example is slow video-graphics speed. Software publishers still peddle utilities to speed up, compress and generally bolix the video-display devices. Many manufacturers are moving to local buses for video-processing chores. Local buses are akin to distributed or parallel processing. A co-processor, similar to a math co-processor together with its own RAM on the video board, does all the computations required to produce a graphics image on the screen. This little computer in itself is faster because the local bus can run at data-speeds far greater than the speed of the main processor's data bus.

Criterion Six

In general, virtual processor speed can be traded off for virtual memory. The word "virtual" is used here to describe the number of resources apparently available to the user. The total amount of resources is the user resources plus the internal resources required for the computer's housekeeping. For example, disk-compression recognizes redundant information and eliminates it. After compression, the disk looks larger than it really is; the "fat" has simply been eliminated. To accomplish this trick, the processor spends extra amounts of time coding and decoding files every time the disk is accessed. This slows down the processor-intensive tasks available to the user. Hence, virtual memory goes up as virtual speed goes down. The same applies to speeding up disk-intensive tasks. Here a disk-cache, RAM disk, or extended/expanded memory-enhancement provides access to data at electronic speeds. The principle behind this is that the next disk access will most likely be near the last access on the disk. Hence the computer will load an entire block of the disk into electronic memory in order to by-pass the very much longer seek-time of the disk. Processor speed is improved a thousandfold but at the cost of more electronic memory being taken from running programs. In other words, as the virtual processor speed goes up the virtual memory decreases. Therefore, for any given system with a fixed amount of resources, the product of available user-memory and available user-processing speed is a constant. In other words, Criterion Six states: Disk-intensive and processor-intensive tasks are mutually exclusive and must be traded off one against the other.

Criterion Seven

Of course, technology marches on and the performance values used here certainly will be obsolete by the time this goes to press. The seventh criterion is, therefore: The most advanced computer needed is the one that will do the job given the information that is needed. The computer wanted is the computer that will be used. This also applies to software; the most useful software is the one that is easily used.

An old IBM personal computer is still very useful for peripheral tasks like an office telecommunications system or as a laboratory instrument-control processor. We recycled our 2 used IBM-XT clone-computers to store recipes and diet information in the kitchen and to run our voice-mail system in the office. Both jobs required only good disk-intensive ability. Unless the user plans to design nuclear weapons in his or her spare time, the new Alpha, RISC, or Pentium super-microprocessor chips are pure overkill for the average physician in private practice. A group practice with a local area network might consider the advantages of a 32-bit operating system such as Windows NT, but processor-intensive tasks should be located in the workstations that handshake with the LAN file-server's disk-intensive operations.

Criterion Eight

Never get locked into a system that uses exclusive vendors for hardware or software. Even though a new whiz-bang computer is technically superior, if it is not on the open market, widely used and supported by thousands of vendors, the consumer will be paying many times what the technology is worth.

Consumers should buy software and hardware that the majority of customers are buying, even though they may have features that are inferior to the dream model. Mass marketing causes other software designers to incorporate the most-used software "hooks" into their product at affordable prices.

For example, there are many other manufacturers of multimedia soundboards, but Creative Labs' SoundBlaster sold the most products and its code became an industry standard.

In software, MS-DOS was a pretty poor operating system, but the prestige of IBM made it a standard. The other operating systems designed for the Intel chips are now pushing up daisies. Macs were a vastly superior machine to IBM but again prestige pushed the IBM PC into a majority market position. It became the standard.

When manufacturers market a new product, they design it for mass appeal. This pressure to conform is not innovative, but it is the way the market works. Criterion Eight: Stick with the tried and true—even though the product is not so hot, it's supported. A corollary to this Criterion is to pay a little bit more for a product that is backed up by customer support service.

Criterion Nine

The Ninth Criterion concerns the question about what "platform" to select. A platform is the operating-system environment that the computer uses to handle housekeeping and coordination of the hundreds of devices used for input and output. Here the

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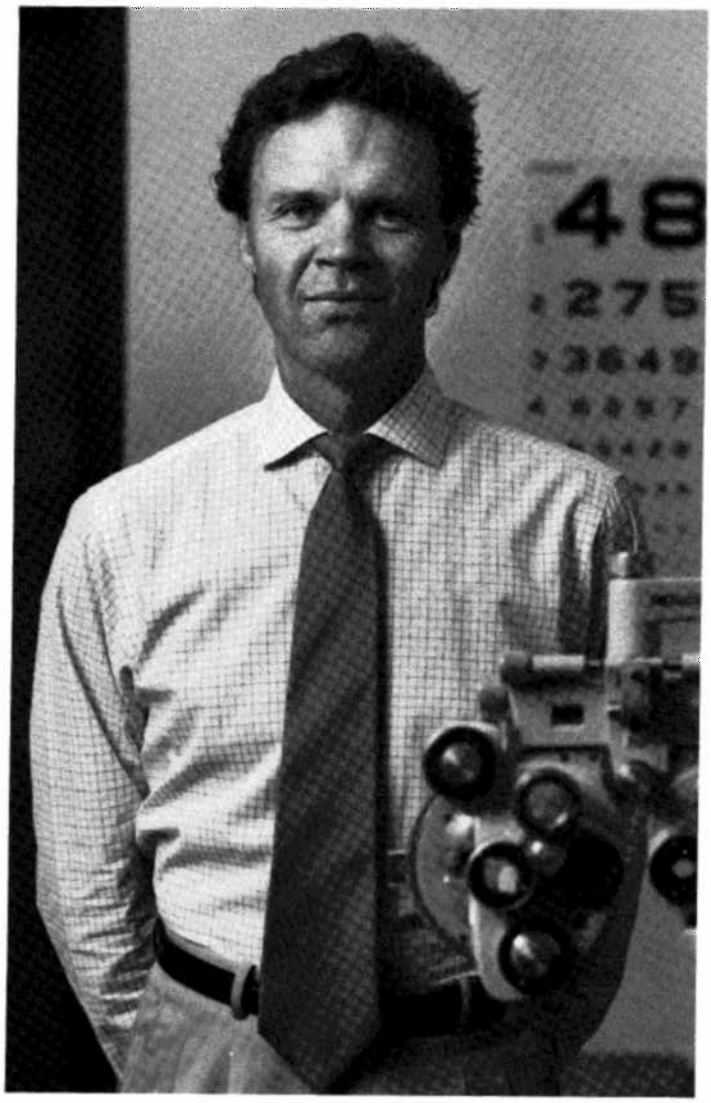
When Dr. Clason speaks, we listen.

Steve Clason, M.D.
Ophthalmology



When physician Steve Clason speaks, we listen. And he's not the only one we talk with about upgrades to our accounting, billing and claims product called **Medical ABC.**

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software and the hardware together determine the computer's personality. Pick a platform that satisfies all previous eight criteria.

Are you a Mac person? Do you like Pen computing? Do you like the IBM man's suit? Is NeXT in your future? This all depends on how much you are willing to pay for a computer-buddy.

Open memory-mapping with open hardware architecture is recommended. Open memory means the user uses all of the computer's physical memory to run programs—unlike the early PCs but like the Macintosh.

Open hardware means the user can have expansion capability (slots and sockets) to use second-source vendors to upgrade or customize the system economically—unlike early Macintosh systems but like the early IBM PCs.

Also recommended are true 32-bit data and addressing in the operating system such as OS/2 and Windows/32. This simply means the user is using the current chips at the capacity they were designed to handle.

NeXT is a very expensive and impressive Unix-like workstation whose cost-effectiveness for the physician makes no sense. Macintosh is a friendly, easy-to-use computer but it costs twice as much as a comparable IBM-clone product and is generally slower. Nowadays, with the new graphical displays available, such as Windows, OS/2 Version 2.1, Norton Desktop, or Hewlett-Packard's New Wave, there is very little difference except the price between the Macintosh/Quadra and the IBM clones. Market pressure is forcing Apple to discount its line steeply.

IBM has a higher profile in the business and nerd worlds. Intel microprocessors currently are the fastest, so IBM computers generally are faster than Macs. Macs attract graphic artists, educators, and other people who are more concerned about Criterion One. In the future, the distinctions in hardware will continue to blur across platforms until all platforms eventually will be interchangeable. IBM and Macintosh platforms already are able to run each others' operating systems. Computers are essentially a commodity.

A System to Consider

Given these 9 criteria, here is a system that we like a lot. We chose the IBM ThinkPad 700C (and the later models 720C and 750C) mainly because it is half as expensive as a comparable Apple computer; a comparable color Macintosh Notebook doesn't exist at the time of this writing). It has the largest color VGA screen (10.5 inches) in its class (Do not pooh-pooh a color display; modern software uses color to convey information rather than just to look pretty—it is an added dimension of information.)

The ThinkPad uses a 486SLC processor at 25 Mhz. The SLC series is a low-power consumption Intel 486SX made for notebooks. The 25 Mhz chip is upgradable to a clock-doubling 486SLC at 50 Mhz. With an additional 38SLC co-processor chip, the numbers will crunch, crunch, crunch.

Figure 1: Complete computer office set-up. (Front view)

Generally our tasks are disk- and modem-intensive, so we don't need the processor speed. The ThinkPad has a fast, removable, 120-megabyte hard-disk that allows the user to upgrade to a larger capacity, or interchange disks between offices or for security reasons. We like the computer's notebook portability; it will run on a rechargeable battery for about 2 hours on a long plane flight.

Our entire system works on rechargeable batteries and there is even a manufacturer of solar panels made to run the entire system if the user is out in the Australian bush doing medical relief work.

The ThinkPad was a "best buy" in a recent survey of notebook computers in *PC Magazine*.

We're more intuitive and graphically oriented so we run Norton Desktop with Windows 3.1—not ideal, but it will do until Windows/32 comes out. We have access to medical data bases using a battery-operable NEC Intersect CD-ROM reader that feeds into the ThinkPad's parallel port through a SCSI adapter that doubles as a printer port attached to the back of the printer. We chose the battery-operable Kodak/Diconix 701 ink-jet printer, a best buy according to *PC Magazine*. It gives us laser quality WYSIWYG printing without the laser.

The software for our compact disc (CD-ROM) includes the *PDR Merck Manual, Family Practice Medicine, Family Physician Magazine, STAT!-Ref,* Little Brown's *Maximum Access to Diagnosis and Therapy (MaXX), Scientific American Medicine, Clinical Dermatology Illustrated* and the *Family Doctor*. We use them daily in our office practice. The latter CD, along with *Bodyworks*, are excellent patient-education programs. Recently an even better program called *A.D.A.M.* became available; it dissects the human body. We run drug-interaction reports using Medical Letter's *Drug Interaction Program* and a special facility inside the *PDR* program. As an adjunct to CME, we run Scientific American's *DiscoTest* patient-simulator program for credit. *Clinical Dermatology Illustrated* comes with a 20-CEU test. If we have a tough internal medicine problem, we run the patient data through the *Iliad* Expert System for ideas. The program also doubles as a patient-simulator. Anything we can put on the screen can be printed out for patients to take home.

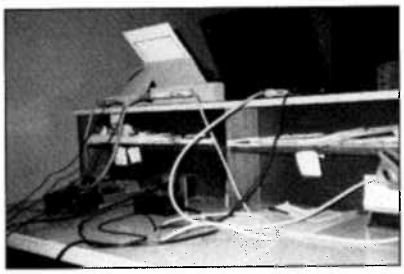

Figure 2: Note the connector on back of printer is parallel to SCSI ("scuzzy") adapter. Black boxes on counter are power cubes for line operation.

We are always looking for good practice-management software, but alas, we have not found a single one that we like. Most are MS-DOS text-mode programs limited to conventional memory-usage and interfacing. Many still require an experienced encoder which is the lion's share of the work of billing. Also, few practice management programs seamlessly integrate all office functions including clinical records.

Doctors need to get together with programmers experienced in object-oriented C++ programming in order to design a transparently cost-effective Windows program for clinical notes, and for billing and coding that takes advantage of the new operating system's full capabilities for multi-tasking and for multiple access. Remember, software that is not easy to use is also not useful.

We send and receive faxes using the Lotus *Ami-Pro 3.0* word-processor through a fax/modem and software. We created our own ICD-9 and CPT-code reference data bases, using *Microsoft Access*, an easy-to-use data base program. Office and personal accounts are kept on *Quicken for Windows* and update our credit-card expenses and pay our bills on-line through CompuServe.

Installed inside our notebook is a 14,000 baud modem. If we can't find an answer in the local system, we have regular access to *CompuServe* through the modem as a gateway to *Dialog,*

Knowledge Index, BRS Colleague, Index Medicus, and a hundred other data bases, forums and services. On-line services work as fast as our own system at 9600 baud or above, such that they meld seamlessly and transparently with our own system. We use *Prodigy* occasionally for the fun of it, but it is not an on-line service for the office. The powerful InterNet system is worth looking into but we were not impressed by its primitive user interface. However, through InterNet, computers at major private and government research institutions worldwide can be interrogated.

Figure 3: Entire office computer system with CD-ROM software packs into a Targus carry-on bag that fits easily under air line seats. Extra roomy for clothes or cosmetics case.

Our entire system, including software described above, packs into a leather Targus briefcase that fits under an airline seat (Figure 3). Since we do much *locum tenens* work, the system is a valuable sidekick that has already paid for itself.

So, we hope we have convinced the reader that computing is truly becoming a *moveable feast.* This article was composed, written and faxed to the *Journal* on the above system.

Appendix A

Hardware

IBM ThinkPad Series notebook computers with 10.5 inch SVGA flat color screen, 120 MB or 240 MB removable HD, 14400 FAX/modem and nickel hydride battery. Two-year warranty on parts and labor supported by 24 hour 800-line.
NEC Intersect CD-ROM Reader with NiCad battery and SCSI to parallel converter and printer port.
Kodak 701 Diconix Printer with NiCad battery.
Targus leather computer briefcase.

Software on CD-ROM

Scientific American Medicine and ***DiscoTest***
Medline, Family Practice Subset, Macmillan Multimedia
MaXX, Maximum Access to Diagnosis and Therapy, Little Brown Publishers.
Family Physician, Creative Multimedia.
STAT!-Ref, Teton Data Systems.
Family Doctor, CMC Research.
PDR On CD-ROM including Merck Manual.
Clinical Dermatology Illustrated, CMEA.

Software on Floppy Disk

Iliad, Internal Medicine Expert System, AI Systems.
Bodyworks, Software Marketing.
Medical Letter's ***Drug Interaction Program.***

Sources

CME Associates, CD-ROM Software, 1-800-227-CMEA, 4015 Hancock Street, Suite 120, San Diego, CA 92110.
Penguin Portables, Notebook Computers and Accessories, 1-800-241-1096, 119 Witmer Road, Horsham, PA 19044.
The Medical Letter, 1000 Main Street, New Rochelle, New York 10801-7537.
Computer Discount Warehouse, 1-800-578-4CDW, 2840 Maria Avenue, Northbrook IL 60062.
Micro Warehouse, 1-800-367-7080, 1720 Oak Street, POB 3014, Lakewood, NJ 08701-3014.
Applied Informatics, makers of ***Iliad***, 1-800-584-3060, 295 Chipeta Way, Salt Lake City, Utah 84108
Keyword Publishers, distributors of A.D.A.M., 1-800-945-4551, 482 Norristown Road, Suite 111, Blue Bell, PA 19422.

Magazines

PC Magazine, PC World, Mac User, Mac World, Computer Shopper, Windows User.

On-line services

CompuServe, oldest on-line service with fairly good interface and good medical information, 1-800-848-8990.
America On-Line, CompuServe look-alike with excellent user interface but very little medically oriented information, 1-800-87-6364.
Delphi, InterNet Gateway, 1-800-695-4005, clumsy interface but best access to medical information.
Prodigy, a frivolous service for home use. Hundreds of bulletin board services (BBS) exist for medical information and are too numerous to mention here. Check the file finder on CompuServe for files containing lists of BBS.

Appendix B

Glossary

Artificial intelligence. Software emulation of the human thought process—a virtual mind—with broad ability to make inferences in random contexts and situations.

ASCII. A table of 25 hexadecimal codes for numbers, letters, graphics symbols, control codes, and foreign language characters established by the American Society of Computer Manufacturers. Text mode computers use ASCII codes in tables to tell their displays how to create a character on the screen without having to calculate each pixel. Use in less powerful computer systems.

Back-up. Copying information in a hard-disk onto a more reliable storage medium. One must have a regimen to back up important data to protect against the inevitable disk crash.

Baud rate. The number of characters per second that are sent over an asynchronous communication system like telephone modems. Each baud consists of an ASCII character code plus extra bits responsible for handshaking and error correction. The baud rate is generally slower than an equivalent synchronous data transmission due to the added bit overhead.

Boot. The act of giving the boot, from bootstrapping or lifting oneself up by one's bootstraps. Booting starts up the computer either by resetting the system clock (cold boot) or from software (warm boot). Either way, booting provides pointers to addresses in BIOS of start up routines.

Boot sector. An area on the storage disk used by the operating system to start the computer from disk. It contains the addresses for BIOS commands as well as tables.

Byte. A 4-bit binary number. A byte can code as many as 2 to the 4th or 16 possible states. Two bytes code for the ASCII set of 256 characters. A double precision 4-byte code could allow for 35,536 characters.

Clock. The master chronometer of the computer which synchronizes all activity on the buses (see synchronous communication).

Controller. A smaller scale processor with an even more restricted capability than a co-processor. This chip controls the channels to the disk storage units. Controllers take a request from the bus and translate it into an exact disk function necessary to find the data, read or write it on disk, and put the data on the bus.

Conventional memory. Core memory where the programs reside so that the processor always knows where to look for them.

Co-processor. A microprocessor in its own right, designed to perform a specialized housekeeping function and occupies a device address on the bus.

Cyberspace. A lyrical description of the virtual world inside computers. Coined by William Gibson in the novel *Neuromancer.*

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Data base. An accumulation of data organized in a special way that allows easy access and manipulation. The data base program takes records in files and generates forms, reports and tables based on inquiries.

Data Compression. A technique of compacting data into a smaller memory space by taking advantage of the redundancy inherent in certain kinds of data. For example, English text is over determined by unnecessary characters such as spaces which do not add any extra meaning to the text. Algorithms exist that reduce the text without changing the data. For example if the spaces were removed from between words: the reader wouldbestillabletoreadthissentence.

Disk cache. A method of speeding up disk access by creating a block of RAM—a cache—where large amounts of data from disk can be squirreled away. The next disk access is usually from the same area of the disk that the last disk access was drawn. Therefore, the data around the last disk access is loaded into cache and accessed from RAM at electronic speed. A disk cache speeds up the effective seek-time for disk access by a factor of several hundreds. A large cache can service up to 80% of disk requests and approaches 100% as the cache size approaches the disk's size.

Disk crash. A corruption of data on the hard disk such that the disk cannot be accessed or will not work correctly. Usually disk crashes originate by flipping a bit in the file allocation table or boot sector of the disk. Crashes are caused by viruses, failures in the media or just plain quantum uncertainty.

Disk-intensive. An operating system task that occupies the majority of the central processor's time in servicing accesses to mass storage. Data bases are paradigmatic.

DOS. Disk Operating System refers to any operating system that stores its programs on a disk storage medium. The most advanced operating systems are System 7, OS2, and Windows NT which are true 32-bit addressing programs utilizing the full capability of current microprocessors. MS-DOS is simply Microsoft's version.

E-Mail. Electronic Mail. Mail between workstations on a LAN or over an on-line service.

Expert system. An evolution of artificial intelligence consisting of a data base of IF...THEN inferences garnered from experts in a specialized field of learning such as internal medicine and a program (inference engine) which interprets inquiries by sorting through the inferences based on likelihoods.

Expanded memory. A technique of addressing memory that increases the memory available to the system. A block of unused upper memory is set aside as a window called a "page" into an expanded memory device. The computer relies on the device's controller and a special software utility to access this memory. The memory cannot be accessed unless programs have this special software (LIM Version 4.0).

Extended memory. Memory available to the computer beyond the addressing capability of the processor, bus or operating system. Special software in the operating system is used to extend addressing. The computer accesses this memory as if it were really an extension of the address bus. Sometimes called virtual memory (Microsoft's XMS specification).

FAT-File allocation table. An area on the storage disk that keeps track of where to find the files stored on the disk. If the FAT is corrupted, there is no way to find the files and they are lost. Some software utilities save a copy of the FAT so that the disk can recover from a crash.

File Server. A LAN computer not assigned as a workstation. The file server is similar to a librarian who gets the book wanted. A LAN computer which contains the majority of the mass storage of programs and data in the net and runs the network in some LANs. Workstations get their files and programs from this computer.

Firmware. Software coded into computer ROM chips so that they are indestructible. Firmware is immune to viruses and other causes of disk crash.

Format. Either a verb or noun. To format a disk means to divide the disk up into electronic sectors and create a FAT and boot sector on the disk. After this is done, the disk is called a formatted disk. The disk is bootable or not depending on whether the operating system is copied onto the disk in the boot sector. In this way the disk controller and operating system have pointers to any files given to the disk or read from the disk. It also can contain enough of the operating system to boot the computer.

Gateway. An on-line service providing access to other on-line services and networks. Some on-line services contain gateways themselves; example, InterNet, a world telecommunications network between computers in the major research and governmental institutions of the world including the old Soviet Union.

Handshake. The protocol required in order for 2 devices to talk or exchange data with one another. Modems handshake other modems; printers handshake with computers; computers handshake with other computers—hey, its a beautiful world!

Hexadecimal. A number based on 16 rather than the binary base-2. If 16 is the 4th power of 2 then any hexadecimal number is equivalent to a 4-bit binary number. It is a way of writing large binary numbers in shorthand. For example, instead of writing 2 (base-10), we can write 0010 in binary or 02 in base-16. Ten in base-10 is 1010 in binary and OA in hexadecimal. Letters A through F are used as numbers 10 to 15 in hex. Most computer math is expressed as hexadecimal or hex for short. Thus the address 73,728 (base-10) is 1010,0000,0000,0000 (base-2) or C0,00 (base-16). This is the starting address for BIOS in some computers. On the memory map, C0,00 starts at the point 00 on the X-axis and C0 on the Y-axis. The Y-axis hex number is called a "page" of memory.

Computer Language. A system of writing operations in terms understandable to humans that can be translated into commands that machines can understand, or machine language. "C++" is a language commonly used in modern microcomputers.

LAN—Local Area Network. Autonomous personal computers interconnected by a communications network in order to share programs and data between them. In general it refers to all the software, hardware and firmware necessary to accomplish this task.

Local Bus. A bus which operates within a device to speed up the device's function by operating at a higher clock speed than the mother board's bus can physically tolerate. It is usually associated with some kind of co-processor—an evolution towards parallel and distributed processing.

Memory Map. A layout of where each device resides in terms of its address as a pair of 2 hexadecimal numbers. Thus, the address hex number C0,00 represents the location (OO,CO) `in Cartesian coordinates on the map. Memory maps help conceptualize how efficiently memory can be utilized. It also helps fix bugs in sick computers by using software utilities.

Micro-Code. Firmware programs written in binary numbers residing in the microprocessor chip tell the programmable logic circuits inside it how to do functions coded as instructions in the computer's machine-language such as addition, subtraction and addressing. Machine-language is the form in which the operating system is written. Micro-code basically decodes machine language instructions so that the microprocessor can create hardware circuit connections which will follow the machine-language instruction.

Mother Board. A printed circuit board which connects together the buses, ports, channels, RAM and ROM memory, BIOS, microprocessor chips and expansion connectors responsible for the operation of the computer.

Multi-Access. The ability of many workstations together to have access to the same computer, virtually at the same time. LAN operating systems allow the network to schedule accesses to file servers, peripheral devices and work stations according to a handshake protocol. The system looks to be simultaneous because all events happen at electronic speed.

Multi-Tasking. Advanced operating-system techniques allow

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many programs to operate virtually simultaneously on the same computer. The computer's memory and processor is divided into many virtual machines. Each program is assigned a virtual machine to run on, as if it were the only one running in the system. For example, OS/2 allows an Intel 80486 microcomputer to simulate as many as 15 Intel 8086 machines (the original IBM-PC), giving each a custom configuration and program. All programs appear to run simultaneously because events happen at electronic speeds.

Number-Crunching. Taking raw data, massaging it with the computer and turning it into a finished product.

Object-Oriented Programming. A method of modular programming such that all software tasks become completely self-contained programs on their own, with a set of generalized inputs and outputs. Each module runs simultaneously in a multi-tasking operating system and is considered an object represented by an icon describing its structure or function. Programming with objects becomes a matter of creating the right objects and connecting them so that they serve together a greater purpose than themselves. This concept simplifies the job of creating new programs for applications. Languages such as C++ by Bell Labs and Borland Software enforce top-down programming design and a robust, fault-tolerant, reliable code. Consequently, the software is easy to use and useful.

On-Line Service. A telephone network providing computer access by modem to useful services such as databases, e-mail, forums, free programs, shopping services, games, news, and many others. Examples: Compuserve, Prodigy, America On-Line.

Operating System. The only program a computer ever runs. Surprise! The program booted up is merely a sub-routine in the operating system. The operating system translates the wants and needs of the introduced program into commands understandable to the BIOS, controllers, and processors.

Platform. A term referring to an operating system that can run on any hardware and, therefore, is portable. Also used to describe a computer's combined hardware and operating system. Thus, Mac and IBM operating systems are platforms that can run on each others' machines and, therefore, Mac and IBM are platforms that can run each others' programs, exchange data and communicate on a network.

Processor. The device responsible for operation of the computer. It controls addresses and manipulates data on the bus.

Processor-Intensive. An operating-system task that occupies the majority of the central processor's time in computation of addresses and data. Graphics are a good example.

RAM–Random Access Memory. Electronic storage circuits capable of being accessed by the computer individually and thereby at random using direct addressing. The computer can obtain data from RAM faster than from mechanical disks because it operates at electronic speeds. Faster by more than a thousand times, RAM is used to simulate mechanical disk storage as virtual disks or RAM disks.

Robust. A term describing the ability of software or hardware to tolerate bugs, glitches, viruses and other flora or fauna that inhabit a computer without causing it to cease completely to operate, or to lose its capability to function usefully.

ROM–Read Only Memory. Electronic or optical media which are recorded only once and are forever fixed in circuits or plastic. Like a phonograph record or photograph, ROM can only be read. It is therefore safe from crashes that plague media that can be written on. Programs stored on electronic ROM chips are called firmware since they are indestructable. SCSI (Pronounced "Scuzzy") A technique for daisy chaining a series of storage devices to one controller. SCSI protocol allows computer devices to talk to each other over simple cables similar to the way LANs do.

SCSI (Pronounced "Scuzzy") A technique for daisy-chaining a series of storage devices to one controller. SCSI protocol allows computer devices to talk to each other over simple cables similar to the way LANs do.

Seek Time. The time it takes the computer to retrieve data during a random access to a disk. Generally a function of the speed with which the read/write head can travel to the exact physical location on the disk's platter where the data reside.

Software. A program which translates instructions formed by carbon-based life-forms into commands that can be understood by silicon-based life-forms.

Software Hooks. Features in the operating system and BIOS that allow programs to share common code and data or use other programs for dynamic exchange of data.

Software Utility. A program that adds a housekeeping function not already supplied in the operating system. Many utilities are the kind that always operate in the background; they are called TSRs, or terminate-and-stay-resident programs. TSRs are usually moved into upper and extended memory to save space in core memory. Modern multi-tasking operating systems make TSRs obsolete.

Synchronous/Asynchronous Communication. Words used to describe how a device talks to another device. Synchronous communication requires that devices be paced by a separate clock-wire in order to transfer data. The bus concept is an example, also the parallel port connection for a printer. Asynchronous communication does not require an extra wire for the clock-signal, but is instead modulated on a radio signal which is used to synchronize communication. Telephone modems and serial ports on computers are this type of communication.

Upper Memory. Memory addressable above conventional memory but below extended memory. These addresses are used by BIOS, the video display, and other devices. Most systems have unclaimed space in this region. Memory managers are available to stuff programs normally intended for conventional memory into this loft area, to save conventional memory.

Virtual. Apparent, not real (whatever that is). Simulation by software of memory, devices, time and space. The software simply creates the illusion that something newer or better is happening, when its just the same old stuff in a different package. Virtual events appear simultaneous or coincident only because the real events in the computer happen at electronic speeds (millions of events per second) in comparison to the ability of our brains to distinguish them at millisecond speeds. There are virtual machines, virtual memory, virtual reality (realty?), virtual addressing, virtual programs, etc.

Windows. An operating-system concept using graphic displays, virtual machines and memory, and full 32 bit data architecture. Programs appear in windows on the display. Each window is like a Chinese nested box and contains various dialogue boxes, scroll bars, buttons, icon functions, etc. Many software manufacturers use windows besides Microsoft. IBM, Apple, DEC, and NeXT have their own windows-type environments.

Workstation. An independent microcomputer on a LAN.

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