MEMORY MANAGEMENT FOR CD-ROM WORKSTATIONS

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The nature of the memory in IBM compatible microcomputers can be confusing to understand and worse to manage. If you are lucky, everything runs fine on the CD-ROM workstation or network and an article on memory management will be interesting but lack immediacy. Try to load other software concurrent with CD-ROM software or to implement network access and you may be due for a crash course in DOS memory, its limitations, and management.

Running CD-ROM software usually demands considerable memory resources. Software in general has become more memory-hungry with time, and CD-ROM software have a reputation for being very hungry. Many CD-ROM products state that 640K RAM memory is required; this is not the exact memory requirement of the CD-ROM software. The CD-ROM software itself uses some of the 640K RAM as does DOS. Rarely will the exact memory requirement of a CD-ROM software be readily accessible. Sales representatives usually will not know it and only experienced technical support staff may know. CD-ROM workstation/network managers should try to learn the exact memory requirement of their CD-ROM software. Knowing their memory requirement helps greatly in selecting the level of solution(s).

Addressing memory shortfalls may involve considerable tinkering and patience and involve seemingly endless rebooting. This two-part series presents memory management schemes known to the author with more solutions available than one person can know or that one site can pursue. Offering practical advice this article addresses itself to CD-ROM workstation managers and assumes a knowledge of AUTOEXEC.BAT and CONFIG.SYS files, Microsoft Extensions, and DOS commands.

Careful consideration of the variety of solutions detailed here should indicate several courses of action for addressing a specific

memory problem. Consideration should encompass further readings from the bibliography. Most articles in this bibliography offer more detailed information on particular products or techniques. However, a sure thing can rarely be foretold in addressing memory shortfalls or conflicts.

A specific solution may sound great on paper but actual experimentation may reveal inadequate memory savings or may simply freeze up the microcomputer. CD-ROM workstation hardware and software environments vary considerably and what works for one may not work for another. Memory management can be a continuing odyssey and seem an endless learning process. The author invites comment and sharing of experience.

TYPES OF MEMORY

Understanding memory involves some basic terminology. Three basic types of RAM memory can be found in IBM or compatible microcomputers: conventional, extended, and expanded. Conventional memory is found in all microcomputers and is limited by DOS to one megabyte in size. One megabyte is shorthand for an actual 1024K of memory (with K representing one thousand). The first 640K of the 1024K conventional memory is used by application software like CD-ROM software. The last 384K of the 1024K conventional memory is reserved for system use including monochrome and color monitor adapters, network adapters, and the microcomputer's ROM BIOS (read-only-memory basic-input-output-system). This upper 384K of conventional memory is known as high memory and is not completely utilized by the microcomputer system.

The first 640K of conventional RAM used by application software is the number widely recognized as DOS' memory limitation. In this first 640K, DOS itself uses memory including its operating system, device drivers like Microsoft Extensions, and DOS file buffers. Therefore some number less than 640K is the actual amount available for an application software like CD-ROM software. If the actual amount of conventional memory left over is insufficient for a software than a memory insufficiency or "RAM cram" appears. Technically DOS is not limited to using just the first 640K of conventional memory and it is a soft limit. There are work-arounds to increase usable memory beyond 640K for application software.

Extended memory is found on 80286 and higher microcomputers. The first generation of microcomputers (8086/8088 aka PC or PC/XT) do not have extended memory. Extended memory is not necessarily present in 80286 and higher microcomputers and may not be a feature on budget models. Extended memory starts after the first megabyte (1024K) of conventional memory and can tally up to a total of 16

megabytes. Microcomputers advertised as having one megabyte of memory actually have 384K of extended memory beyond the standard first megabyte of conventional memory. Technically there is one megabyte of conventional memory and 384K of extended memory in these "one megabyte" microcomputers.

Another confusion in extended memory terminology is the name given to the first 64K of extended memory: High Memory Area or HMA. Utilization of HMA started with Quarterdeck's DESQview and Microsoft Windows version 2.10. HMA is extended memory starting right above the 1024K of conventional memory and exists due to a bug. HMA is not the same as high memory (see above) which is the last 384K of the 1024K conventional memory.

Expanded memory exists as a standard for accessing memory outside the first 640K of conventional memory. Expanded memory is accessed by the microcomputer through a 64K memory window or "page frame" set aside in high memory. The microcomputer moves data in pieces to and from the expanded memory board through this 64K high memory window. Expanded memory has two technical specifications; Lotus-Intel-Microsoft Expanded Memory Specification 4.0 (LIM EMS 4.0) and AST/Quadram/Ashton Tate Enhanced Expanded Memory Specification (EEMS).

The EEMS standard includes the LIM EMS 4.0 standard with added capability. Expanded memory can be installed into any microcomputer including the 8086/8088. It can be installed with an add-in expanded memory board in 8086/8088, 80286, and higher microcomputers. It can be created from extended memory using special software in 80286 and higher microcomputers. If purchasing an expanded memory board, consider boards that support all expanded memory standards like AST's RAMpage; it supports EEMS and LIM EMS 4.0. Some boards like the Intel AboveBoard support only LIM EMS 4.0 and do not support EEMS. Extended memory is rapidly growing in eminence as a memory resource and is more preferable than an expanded memory board on 80386 or higher microcomputers.

CONFIG.SYS

Memory can be saved in the CONFIG.SYS file; examine each line critically. Small savings should not be overlooked. Small savings can make the difference in whether a memory-hungry CD-ROM software runs or not. Small savings can also offset memory lost to other software like screen-blankers, time-delayed hard disk parkers, and network drivers.

Set CONFIG.SYS' BUFFERS= at a minimum. BUFFERS are DOS' disk

cache; in a test microcomputer, each DOS BUFFER consumes 528 bytes or 1/2K RAM. BUFFERS are unnecessary if a disk caching software is being used. If using disk caching software, set BUFFERS=1; in a test microcomputer, reducing BUFFERS= from 20 down to 1 saved 9.8K RAM. A BUFFERS= statement is needed in CONFIG.SYS if using disk caching software; its absence results in a higher default number being set by DOS. Be sure to install floppy disk caching in addition to hard disk caching when setting BUFFERS=1. With BUFFERS=1 and no floppy disk caching, floppy disk read and write operations will be agonizingly slow. If disk caching software is not being used, the BUFFERS should be set at what the CD-ROM search software specifies so that performance is not hindered. DOS version 4.0+ moves BUFFERS into expanded memory by itself to save conventional memory.

Set FILES= to a minimum. FILES specifies how many disk files are to be used at once. Some application software require a specific FILES=number. In a test microcomputer, each FILE consumes 52 bytes of RAM. Try setting FILES= no higher than 30 with a minimal setting being FILES=10. Reducing FILES= by an increment of 10 saves 528 bytes (1/2K)RAM.

For DOS 3.3 or later, try setting STACKS= to 0,0 (eg STACKS=0,0) to stop DOS from allocating interrupt stacks. While STACKS= are usually not needed, some device drivers, RAM-resident software, or application software may need them. If STACKS= is not written in CONFIG.SYS, DOS will set a default of 9,128 which consumes 3280 bytes of memory. Setting STACKS=0,0 freed up 3.2K RAM in a test microcomputer.

Specify LASTDRIVE= no higher than the highest drive actually being used including the CD-ROM drive(s). For single CD-ROM player workstations with one hard disk drive, LASTDRIVE= is usually no higher than D because the hard disk is the C drive and the CD-ROM player can be the D drive. Networked environments particularly with those with fileservers may need more drive letters.

During installation, some CD-ROM products set up the CD-ROM drive as the L drive automatically (as seen in CONFIG.SYS and the MSCDEX specification in the AUTOEXEC.BAT). Change it; reducing LASTDRIVE= from L to D saves 0.7K RAM. Each drive specified costs 80 bytes. If LASTDRIVE= is not written in CONFIG.SYS, DOS will set a default of LASTDRIVE=E. For a single CD-ROM player workstation with one hard disk drive, this is overly generous by one drive letter and costs an extra 80 bytes of RAM.

The DOS environment exists in conventional memory as a pool of systemwide information available to programs and batch files. In

other words, the environment takes up valuable RAM which needs to be conserved. 160 bytes of RAM is the default environment size for DOS 3.2 and later (128 bytes for DOS 3.1).

If the environment size has been increased as specified by SHELL=C:\COMMAND.COM /P/E:## in CONFIG.SYS, ensure that the increase is minimized in order to conserve RAM. For DOS 3.2 or later, ## in the SHELL= statement above represents the environment size in bytes from 160 to 32,767 (32K!). (For DOS 3.1, ## in the SHELL= statement represents the number of bytes divided by 16 and rounded up; this ranges from 11 to 62).

Frequently the environment will be automatically increased by a software installation process. A SHELL= statement will be automatically inserted into CONFIG.SYS with the /E: size specified as 320 (thus doubling the default of 160). /E: may even be set higher thus wasting even more RAM. This automatic setting of environment size is usually overly generous in order to avoid conflict in the wide variety of microcomputers in which a particular software may be installed.

Use memory analyzers or ENVCOUNT.COM to determine the bytes actually filling up the environment and then trim the SHELL= environment size down. ENVCOUNT.COM prints a message stating the number of bytes currently being used by the environment. Without feedback from a memory analyzer or ENVCOUNT.COM, the environment can be trimmed down in size by increments until DOS flashes "out of environment space" during bootup. Put some PAUSE lines in the AUTOEXEC.BAT to watch for this message. Otherwise it will flash quickly onscreen during the bootup process and it may not be noticed.

Look critically at all CONFIG.SYS device drivers (i.e., DEVICE=XXXXX) and eliminate unneeded ones; ANSI.SYS can usually be eliminated. If a mouse is being used, check the memory consumed when loading it as a device (e.g., DEVICE=MOUSE.SYS) in CONFIG.SYS as opposed to loading it in AUTOEXEC.BAT (eg MOUSE.COM). In a test microcomputer, a version of Microsoft's MOUSE.COM used 4.4K more RAM than running the mouse by its device driver MOUSE.SYS. However running the mouse as a device driver leaves it permanently loaded in memory whereas it can be loaded and unloaded from memory if MOUSE.COM is used.

If the CD-ROM workstation already has expanded memory configured, load Microsoft Extensions' MSCDEX.EXE into expanded memory with the "/E" parameter and free up 4K conventional memory. This is only worth doing if expanded memory is already being used for other purposes. The expanded memory management software that sets up

paging to expanded memory consumes some conventional memory itself. Running expanded memory on a test 8086/8088 microcomputer with an expanded memory board consumed 4K of conventional memory; this loss of conventional RAM was exactly offset by loading Microsoft Extensions into expanded memory. Therefore expanded memory needs to be utilized for additional purposes than simply shifting Microsoft Extensions.

AUTOEXEC.BAT

Like the CONFIG.SYS file, know what each line of the AUTOEXEC.BAT file does and gather savings where available. Again, small savings should not be overlooked. Microsoft CD-ROM Extensions software usually appears in the AUTOEXEC.BAT file as MSCDEX.EXE. MSCDEX loads buffers for itself each of which consume 2K RAM. The number of buffers is specified by the /M:## parameter after MSCDEX. Using /M:10 would consume 20K of RAM; therefore minimize buffers if memory is in short supply. A minimal number of buffers is four which is the default; higher numbers offer better performance at the expense of memory.

The bytes consumed by the DOS environment can be minimized in the AUTOEXEC.BAT file. Look at environment variables in AUTOEXEC.BAT like PATH, COMSPEC, APPEND, and PROMPT and those specified by SET; all of these take up RAM. Shortening PATH statements as much as possible will minimize usage of RAM bytes. Include only the essential directories in PATH and use short two-letter names for directories in order to save characters in PATH. Reducing a PATH statement from 50 characters to 14 characters freed up 36 bytes of RAM in a test microcomputer.

AUTOEXEC.BAT may be loading in RAM-resident software. Most RAM-resident (aka TSR or terminate-and-stay-resident) software permanently reside in conventional memory thus reducing available memory. Some RAM-resident software may be desirable or required like a screenblanker or Microsoft Extensions. Others may be optional and can be removed if absolutely necessary.

Optional RAM-resident software could include a print spooler, time-delay hard disk parker, RAM disk, disk cache, or keyboard macro software. RAM assigned to a print spooler software could be freed up with the purchase of an external print spooler. An external print spooler provides the benefit of print spooler without the loss of limited memory resources. Ensure that each RAM-resident software is justified given the available memory resources.

When DOS loads a program, it gives the program a complete copy of

the environment which consumes additional memory. The memory consumed by this program-assigned environment is freed when the program is exited and unloaded from memory. However RAM-resident software remain in memory after being loaded and many do not deallocate the memory space given to them for the environment. Therefore a minimal (or no) environment should be specified before loading any RAM-resident software in AUTOEXEC.BAT.

The smaller the environment before loading RAM-resident software, the less memory is permanently lost. A copy of the environment can consume several hundred bytes and each RAM-resident software gets a copy. Minimally, PATH may be necessary to specify before loading RAM-resident software so that the RAM-resident software functions. However it may be possible to save RAM by specifying other environment variables like PROMPT, COMSPEC, APPEND, and SET after the RAM-resident software are loaded by AUTOEXEC.BAT.

MEMORY ANALYZERS

Memory analysis software provide a look into the allocation of memory resources inside a microcomputer. Commercial software usually provides a more detailed analysis while public domain software offers a simple analysis. Examining the comings and goings of memory with changing microcomputer configurations is essential in minimizing memory utilization.

Memory resources can be examined in detail by memory analyzers like ASQ, InfoSpotter, MEMORY MASTER's PMAP, NETROOM's DISCOVER, QRAM/QEMM's Manifest, 386MAX's 386Util, All Charge 386's Allmenu, and Norton Utilities' SYSINFO. Lots of tinkering with AUTOEXEC.BAT and CONFIG.SYS files is usually involved and memory analyzers quickly reveal whether changes have been beneficial or detrimental to memory.

WHICH DOS VERSION?

As the operating system, DOS itself consumes some of conventional memory's 640K. Successive DOS versions consume more of this 640K. A test microcomputer was booted clean with no AUTOEXEC.BAT or CONFIG.SYS files thus letting DOS set defaults for FILE=, BUFFERS=, LASTDRIVE=, STACKS=, and FCBS=. IBM-DOS 2.1 used 19K memory and 616K was available for application software. MS-DOS 3.10 used 35K memory and 599K was available for application software. MS-DOS 3.30 used 48K memory and 586K was available for application software. MS-DOS 4.01 used 56K memory and 575K was available for application software.

Check on the DOS version required by CD-ROM or network

applications. Use as old a version of DOS as possible to minimize RAM consumption thus freeing up memory for software. DOS 3.3 is always supported and DOS 4 can be avoided. DOS 3.2 or higher is required for low-density 3.5 inch floppy disk drives and DOS 3.3 of higher is required for high-density 3.5 inch floppy disk drives. Microsoft CD-ROM Extensions version 2.1 requires DOS 3.1 or higher.

Consider changing to Microsoft's DOS 5.0 (Rosch 1991). Released in mid-1991, DOS 5.0 uses as little memory as possible thus making up to 620K of conventional memory available. DOS 5.0 loads itself into less conventional memory than earlier versions. In addition, DOS 5.0 can load the operating system, device drivers, and RAM-resident software into high memory on microcomputers with extended memory. Extended memory is present on 85% of all microcomputers shipped and is installed on 80286, 80386 and higher models. While extended memory is unavailable on 8086/8088 (aka PC or PC/XT) microcomputers, those microcomputers can still benefit from DOS 5.0's basic reduction in conventional memory use.

Consider changing to Digital Research's DR DOS 5.0 (Duncan 1990, Rosch 1991, Schmidt 1990). DR DOS, an alternative operating system to Microsoft's or IBM's DOS, minimizes its utilization of conventional memory on 80386 and 80486 microcomputers or 80286 microcomputers with the Chips and Technologies' NEAT or LEAP CHIPset. Conventional memory is freed up by loading the operating system, DOS file buffers, device drivers, network drivers, and RAM-resident software into extended memory; this makes over 620K conventional memory available for CD-ROM or other software. 8086/8088 microcomputers should avoid DR DOS since it consumes more memory than regular DOS.

INCREASING MEMORY FROM HIGH VIDEO MEMORY

EEMRAM (Mendelson 1989, Smith 1989) is a non-memory resident free utility that can increase conventional memory from 640K to a maximum of 736K. EEMRAM requires an EEMS standard expanded memory board or a LIM 4.0 expanded memory board that supports mapping of page frames into video memory addresses. The amount of increase depends on the microcomputer's hardware and on the microcomputer's monitor adapter card.

EEMRAM uses expanded memory to fill in after the first 640K of conventional memory and continues to the point where high memory is allocated for the monitor's video adapter. With a monochrome video card, 64K of RAM is added and with a CGA card, 96K of RAM is added. These additions appear as increased memory for application software including network software. Standard LIM EMS 4.0 expanded memory boards like Intel's AboveBoard will not work with EEMRAM.

Another common scheme to increase memory utilizes the memory allocated to EGA and VGA video cards. Conventional memory can be increased dramatically beyond 640K if the application software does not require EGA or VGA graphics. Graphics mode is not used by most bibliographic CD-ROM software; they run in simple ASCII text mode displaying text, lines, boxes, and windows. The onscreen EGA/VGA display may be in color but it is not a graphic bit-mapped picture and is simply composed of ASCII text characters.

The high memory set aside for EGA/VGA color graphics can be tapped into. Expanded or extended memory is not required. Several software provide such video memory capability: VIDRAM (supplied with QRAM and QEMM), Above640 (supplied with AboveLAN), EDOS (Smith 1989), and most memory management software like QEMM, 386MAX, Move'Em, and Memory Commander. For example, VIDRAM is a EGA/VGA video memory utility and it works on any microcomputer with an EGA or VGA color card with at least 256K memory. On an 8086/8088 microcomputer with an EGA video card, VIDRAM increased conventional memory by 96K for a total of 736K conventional memory. This provides ample room for network software. Several trick memory boards that tap into high memory also utilize memory space allocated to EGA and VGA (see ALLChargeCard section below).

MEMORY MANAGERS

QRAM (Poor 1990) is a memory management software for 8086/8088 and 80286 microcomputers with LIM EMS 4.0 or EEMS expanded memory. For microcomputers without expanded memory QRAM will only work for those with Chips and Technologies' NEAT chip set with shadow RAM. QRAM runs as a device driver in the CONFIG.SYS file and increases memory beyond 640K in its default configuration. The default DEVICE=QRAM.SYS configuration increased RAM by 64K on a test 80286 microcomputer with expanded memory and monochrome monitor; color systems will produce additional savings. QRAM comes with companion software to fine-tune memory allocation to produce savings beyond the simple default. With additional tinkering, additional memory savings can be derived by shifting device drivers, LASTDRIVE, BUFFERS, FILES, FCBS, mouse drivers, and network software out of the lower 640K of conventional memory and into high memory.

Move'Em (Miller 1990) is another memory management software for 8086/8088 and 80286 microcomputers. Move'Em requires either of two equipment configurations: (1) LIM EMS 4.0 or EEMS expanded memory board, or (2) Chips and Technologies' NEAT, LEAP, or AT/386 CHIPset. Move'Em uses expanded memory to fill in after the first 640K of conventional memory thereby increasing the availability of high memory. Move'Em then shifts device drivers, RAM-resident

software, and network software out of the lower 640K of conventional memory into this high memory. Like VIDRAM, Move'Em uses high video memory to increase conventional memory by 96K for a total of 736K. On microcomputers with LIM EMS 3.2 expanded memory boards, Move'Em will free up 64K of high memory for use but the expanded memory board will be unusable by other software looking for expanded memory.

ALL ChargeCard (Alison 1990, Enyart 1989, Faust, 1990, Holtzman 1989, Marks 1989, Morrissey 1988) is a small microcomputer board that installs directly into the microprocessor CPU socket of 80286-based microcomputers and revamps memory management so that the microcomputer appears to have up to 960K of conventional memory. To do this, ALL ChargeCard taps into unutilized high memory above 640K. ALL ChargeCard can shift out device drivers, RAM-resident software, DOS' FILES and BUFFERS, and network software. ALL ChargeCard works only in 80286 microcomputers whose 80286 microprocessor CPU chips are pressed in (unsoldered).

Other trick memory boards that tap into high memory are available and are designed for the different levels of microcomputers from 8086/8088 through 80386. These high memory boards free up more conventional memory with the amount of gain depending on individual equipment configuration. It is advisable to contact the manufacturer and read cited references before purchase. These high memory boards include the Memory Enhancement System (Marks, 1989), Hicard and HicardAT (Faust, 1990, Koontz, 1990, Marks, 1989, Olsen, 1989, Sloan 1990), and Maximizer (Faust, 1990, Marks, 1989).

QEMM (Derfler 1991, Howard 1990, Marks 1989, Mendelson 1990) and 386MAX (Alison 1990, Derfler 1991, Howard 1990, Marks 1989, Rosch 1988) are the best known memory management software for 80386 or above microcomputers. Both need extended memory to work and can convert it into expanded memory. Both move device drivers, BUFFERS, RAM-resident software, and network shells/drivers into high and extended memory thus freeing up conventional memory. QEMM can save a bit more conventional memory than 386MAX. QEMM will load CONFIG.SYS' LASTDRIVE=, FILES=, and FCBS= statements into high memory; all of these consume some conventional memory. 386MAX will not shift these.

Memory Commander, All Charge 386, and Invisible RAM 386 (Mendelson 1990) are other 80386 or higher memory management software with some features in common with QEMM and 386MAX. Some of the extended memory management functions of QEMM and 386MAX can be provided by DOS 5.0 or RAM-MAN/386 which comes bundled with NETROOM (see below).

Turbo EMS (Coffee 1990, Mendelson 1989) will load device drivers and RAM-resident software into high memory. For 80286 or higher microcomputers with expanded memory or a Chips & Technologies NEAT or NEATSX CHIPset, Turbo EMS loads device drivers and RAM-resident software into high memory so that conventional memory is conserved. In doing so Turbo EMS itself uses only 2K of conventional memory. However for plain 8086/8088 microcomputers or any 80286 or higher microcomputer without extended memory, Turbo EMS consumes 34K of conventional memory.

LANSpace (Connor 1989, Derfler 1991, Koontz, 1990, Marks 1989) works with 80286 or higher microcomputers with at least 64K of extended memory. LANSpace shifts Novell NetWare's NET3/NET4 software and NetBIOS into the first 64K of extended memory -the HMA area. LANSpace saves 36K to 56K of memory. NetBIOS can be loaded and unloaded upon demand. The capability to load IPX into high memory is planned.

Like LANSpace, AboveLAN (Derfler 1991, Koontz, 1990) works with Novell's NetWare and loads its NET3/NET4 files into at least 64K of extended memory. On an 80286 or higher microcomputer, this yields a gain of 36K of conventional memory. Like LANSpace, NetBIOS can be loaded or unloaded. Additional memory savings up to 96K can be realized with the bundled Above640 software, a video memory utility for microcomputers with EGA or VGA color cards. AboveLAN also comes bundled with memory analyzer software and Above Disc, an expanded memory emulator.

NETROOM (Derfler 1991) goes many steps farther than LANSpace and AboveLAN. NETROOM loads LAN workstation software (IPX as well as NET3/NET4 and the LAN adapter driver), non-LAN device drivers (eg mouse, CD-ROMs, VDISK, disk caches), DOS resources (eg COMMAND.COM, FILES, BUFFERS, FCBS), and RAM-resident software into high memory, extended memory, and expanded memory. NETROOM runs on 8086/8088 microcomputers with expanded memory; NETROOM runs on 80286 and 80386 or higher microcomputers with expanded or extended memory. Only the first 64K of extended memory is used (the HMA or High Memory Area); additional memory savings are gained shifting to expanded memory.

NETROOM runs on Novell NetWare, IBM PC LAN, Banyan VINES, LANtastic, 3Com 3+Share and 3+Open, LAN Manager, and DCA 10Net. NETROOM offers considerable value, has been well-reviewed, and comes bundled with DISCOVER, a memory analyzer, and RAM-MAN/386, a memory management software for 80286 microcomputers with the NEAT CHIPset or for 80386 or higher microcomputers. NETROOM is not intended for shifting out of conventional memory any large RAM-resident software with which a user interacts; a companion

software HEADROOM handles those.

ADDITIONAL NETWORK CONSIDERATIONS

Each network microcomputer runs network software establishing and maintaining network communications. Network operating systems vary in their memory demand upon the microcomputers being networked. This variation is due to brand differences as well as configuration eg centralized CD-ROM player(s) accessed by fileserver or decentralized CD-ROM player(s) with peer-to-peer access. 4K to over 100K of memory can be lost to network software on a networked microcomputer.

Additional memory can be lost to Microsoft CD-ROM Extensions, optical disk network software, and other DOS and software resources noted in sections above. These memory losses can be offset by combinations of techniques, hardware, and software outlined above. The memory overhead forced upon a networked microcomputer by the network operating system and the optical disk network software should be determined. Software and drivers should be shifted out of the networked microcomputer's lower 640K of conventional memory as much as possible; resources can be shifted into high memory, extended memory or expanded memory.

Some network operating systems have software that can be shifted into expanded memory (eg Novell's EMSNET) or extended memory (Novell's XMSNET). While aftermarket software like AboveLAN, LANSpace, and NETROOM can shift out NET3/NET4 from conventional memory, the latest release of the Novell NetWare shell provides this for free with EMSNET and XMSNET. Using Novell's EMSNET3 rather than NET3 saves 36K of conventional memory; this savings may be all that is needed and further tinkering or product purchase is unnecessary.

When specifying equipment for stand-alone or networked microcomputers, plan for maximum memory flexibility. Try to specify a minimum hardware/software level of an 80386sx microcomputer with at least 1 megabyte of extended memory, a memory management software, and VGA color monitor. When specifying purchase of a microcomputer with 1 megabyte of extended memory, beware of microcomputers advertised as having one megabyte of memory; they may actually have only 384K of extended memory. Purchasing 2 megabytes of extended memory would be even better and add on little cost. 2 megabytes of extended memory would afford space for a print spooler and considerable disk caching in addition to network software and DOS resources. Look for inexpensive clone 80386sx microcomputers with reputable BIOS chips like Phoenix, AMI

or Award; these will work fine and provide savings compared to more expensive name-brand 80386sx microcomputers.

In the future, 80386sx or similar microcomputers will be even less expensive and thus even easier to specify as networked workstations. AMD is beginning to produce 80386 chips in addition to Intel; this should result in a lowering of 80386 microcomputer prices similar to what happened to the 80286 chip and microcomputers. Using products and techniques outlined above, specifying this minimal 80386sx hardware/software configuration for a networked workstation supports numerous opportunities to conserve memory.

EMULATING EXPANDED MEMORY?

As noted in several options above, the presence of expanded memory provides considerable opportunity for increasing conventional memory by shifting device drivers, network software and DOS resources to high memory. For microcomputers (particularly 8086/8088 and 80286) without expanded memory boards, expanded memory can be emulated by software using hard disk space or extended memory.

Known as LIMulator software, LIMulated expanded memory performs more slowly than normal expanded memory particularly if the hard disk is used to emulate expanded memory. However LIMulated expanded memory does provide expanded memory where none exists. A LIMulator runs from within the 640K of conventional memory and consume around 70K of vital conventional memory. This loss of conventional memory is needed to establish a 64K expanded memory window in conventional memory. Therefore the 70K loss in conventional memory to the LIMulator has to be compensated by gains in shifting software and device drivers out of conventional memory to expanded memory.

EMS40.SYS (Boling 1989, Somerson 1990) converts the 384K of extended memory commonly found on "one megabyte" 80286 microcomputers into LIM EMS 4.0 expanded memory. If QRAM could utilize this LIMulated expanded memory, then device drivers, LASTDRIVE, BUFFERS, FILES, FCBS, and network software can be shifted into high memory. EMS40.SYS was tested with QRAM and QRAM did not recognize the LIMulated expanded memory. Similarly NETROOM specifies that it does not work with LIMulated memory on 8088/8086 or 80286 microcomputers.

Above Disc (Coffee 1990), Turbo EMS (Coffee 1990, Mendelson 1989) and SoftBytes all convert extended memory or hard disk space on any microcomputer into LIM EMS 4.0 expanded memory. Memory

experimentalists may wish to try them.

Products mentioned in this article

List prices are given and products are usually available for much less; check microcomputer magazines or local dealers.

386MAX $130 list
386Util (included)
Qualitas
7101 Wisconsin Ave.
Suite 1386
Bethesda MD 20814
301/907-6700

Above Disc
Above640
AboveLAN Single user $120 list. $495 per fileserver list.
Above Software
2698 White Road, #200
Irvine CA 92714
800/344-0116
714/851-2283

All Charge 386 $100 list.
ALL ChargeCard $399 list plus $100 adapter for non-PGA (pin grid array) CPU sockets.
ALL Computers
1220 Yonge St, 2nd floor,
Toronto, Ont. M4T 1W1
Canada
416/960-0111
Or:
Rupp Technology
603 South Broadway, Suite B,
Boulder CO 80303
303/494-5987

ASQ: free (made by Qualitas, the 386MAX vendor).
ASQ is available free from public domain/shareware software libraries or downloaded from public bulletin boards including CompuServe (type GO PCVEN) and PC Magazine's PC MagNet (Library 2 of Utilities). For PC MagNet access information, see editorial credit page in front of PC Magazine.

DISCOVER see NETROOM

DR DOS $199 list.
Digital Research
PO Box DRI
70 Garden Court
Monterey CA 93942
408/649-3896

EDOS see Memory Master.

EEMRAM shareware.
Available with Memory Master or from public domain/shareware software libraries or downloaded from public bulletin boards including CompuServe and PC Magazine's PC MagNet (for access information, see editorial credit page in front of PC Magazine).

EMS40.SYS free.
ENVCOUNT.COM free.
Available from public domain/shareware software libraries or downloaded from public bulletin boards including CompuServe and PC Magazine's PC MagNet (for access information, see editorial credit page in front of PC Magazine).

Hicard
RYBS Electronics
2590 Central Ave
Boulder CO 80301
303/444-6073

InfoSpotter $80 list.
Merrill & Bryan (address, see Turbo EMS).

Invisible RAM 386 $60 list.
Invisible Software
1165 Chess Dr #D
Foster City, CA 94404
415/570-5967

LANSpace $495 per fileserver list.
LANSystems
300 Park Ave South
New York, NY 10010
212/995-7779

Manifest. see QRAM.

Maximizer $170 list.
Softnet Communication

15 Hillcrest Dr.
Great Neck NY 11021
800/627-7060 or 212/302-7060

Memory Commander $130 list. Includes EGA/VGA video memory utility.
V Communications
4320 Stevens Creek Blvd
Suite 275
San Jose CA 95129
800/662-8266 or 408/296-4224

Memory Enhancement System $150 list.
Atlas Technology
3900 Montclair, Suite 301
Birmingham AL 53213
205/871-9555

Memory Master $50 list. Includes EDOS, EEMRAM, PMAP.
Vericomp
PO Box 23360
San Diego, CA 92123
800/876-0400 or 619/277-0400

Move'Em $89 list. Includes EGA/VGA video memory utility.
Qualitas, (address, see 386MAX).

NETROOM $80 single user; $149 four users; $249 ten users; $549 100 users. Includes DISCOVER and RAM-MAN/386.
Helix Software
47-09 30th St.
Long Island City, NY 11101
718/392-3100 or 800/451-0551

PMAP see MEMORY MASTER.

QEMM $100 list. Includes MANIFEST and VIDRAM.
Quarterdeck (address, see QRAM).

QRAM $80 list. Includes MANIFEST and VIDRAM.
Quarterdeck Office Systems
150 Pico Blvd.
Santa Monica CA 90405
213/392-9701

Shuttle see Turbo EMS.

Softbytes $50 list.

Vericomp (address, see Memory Master).

Turbo EMS $99 list. Includes Shuttle.
Merrill & Bryan
9770 Carroll Center Rd #C
San Diego CA 92126
619/689-8611

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