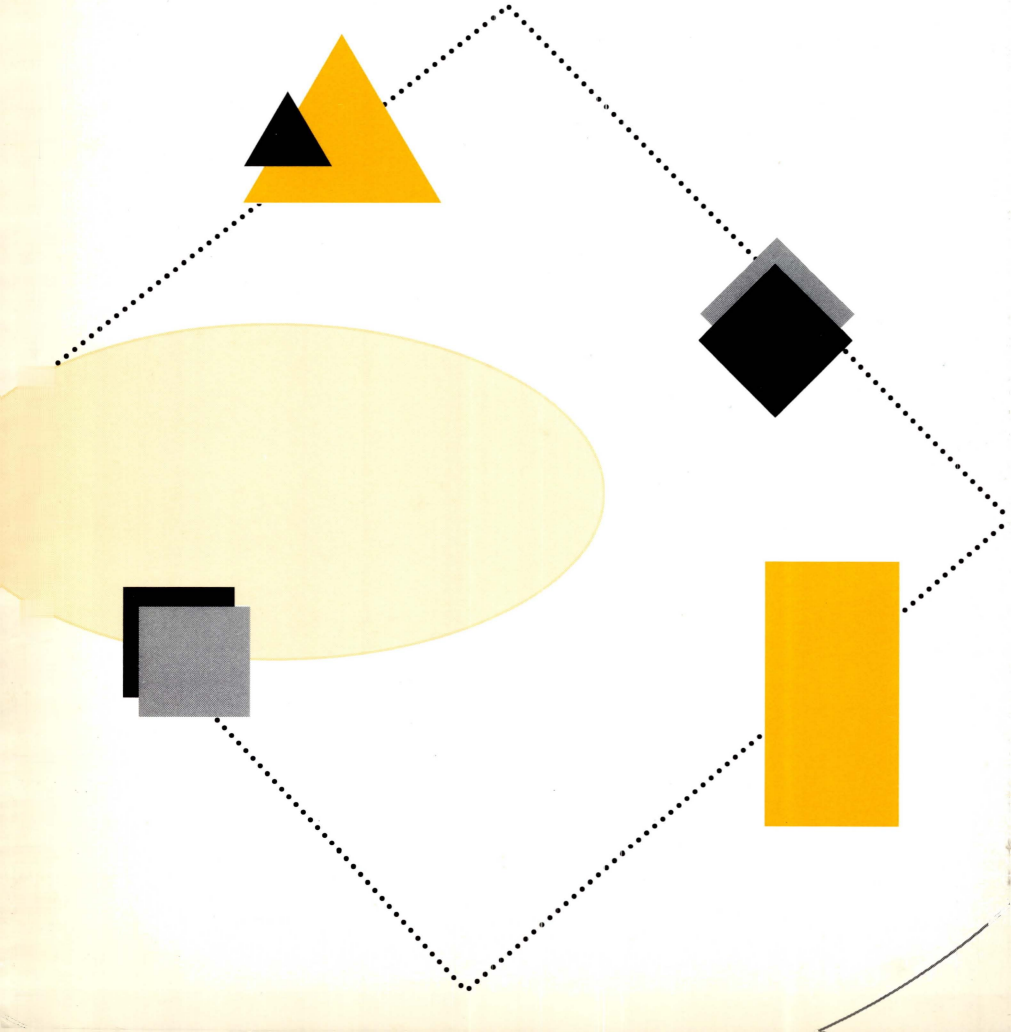
DIGITAL'S GUIDE TO CONFIGURING MEMORY

for system performance

digital



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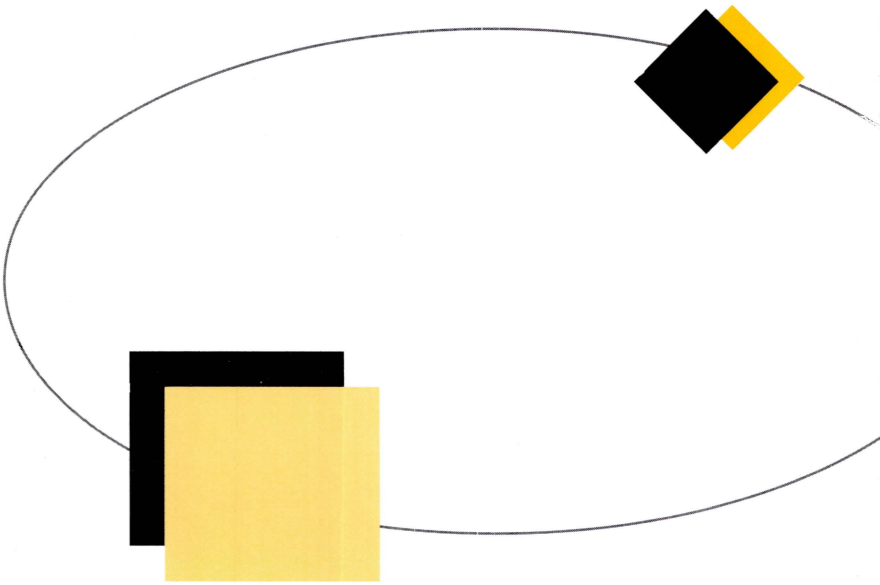

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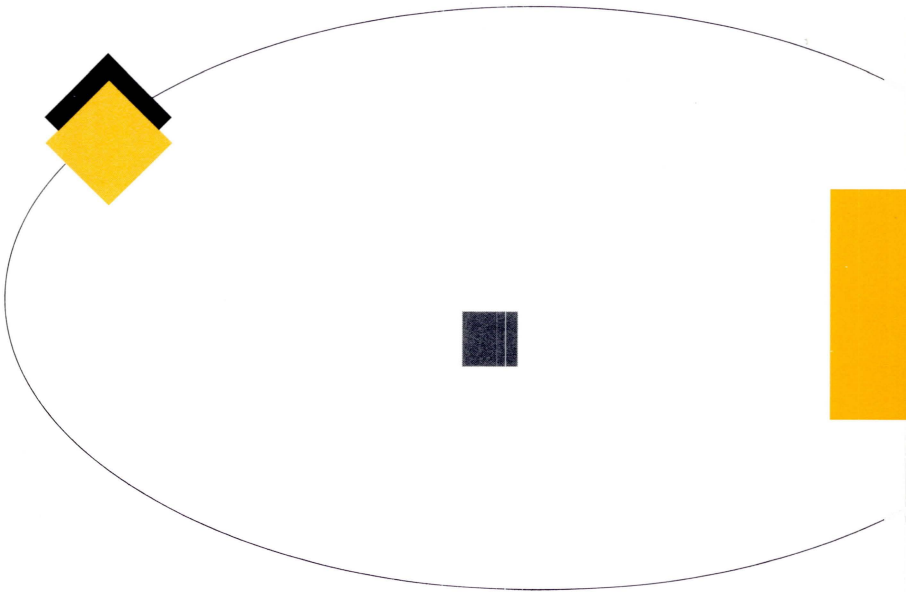


chapter 1 MEMORY: THE KEY TO SYSTEM PERFORMANCE

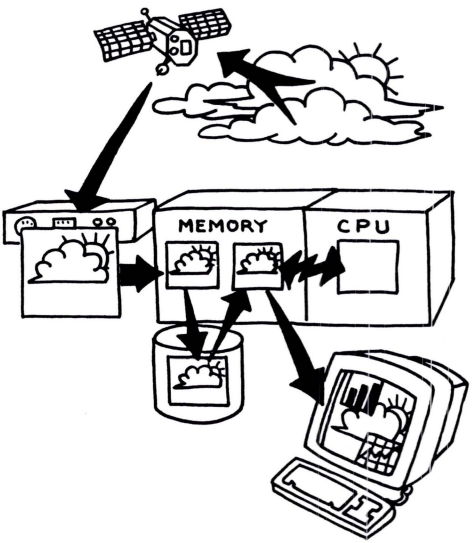
This chapter addresses:

- *Why memory is a key factor in system performance*
- *What factors should be considered when determining your memory needs*
- *How to determine whether your system's current memory is sufficient*

Introduction

Memory is critical to system response and overall performance. Data in storage devices — such as magnetic disks — must be loaded into memory before they can be processed. Similarly, processed data destined for printers or other output devices have to pass through memory first.

Memory is the fastest means for a system to access data and instructions. When more memory is added to a system, more data and processor instructions can be stored in memory, reducing the number of accesses required to move data from secondary storage devices in order to satisfy processor requests.



Memory is the fastest means for a system to access data and instructions.

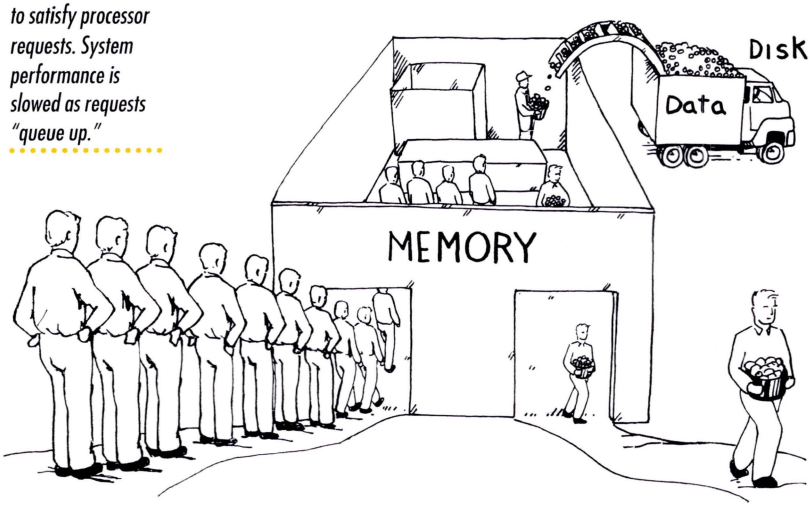
Determining Your Memory Needs

The amount of memory your system needs depends on a number of factors, including:

- *The system's processing capabilities.*
  The amount of memory needed increases with the speed of the system processor(s). Faster processors increase the volume of data and instructions that systems can process. Large-capacity memory allows processors to access data more quickly.

  Vector processors typically need more memory than traditional processors due to their high processing capabilities. Multiprocessors need sufficient memory to satisfy the total processing capability of all the processors.

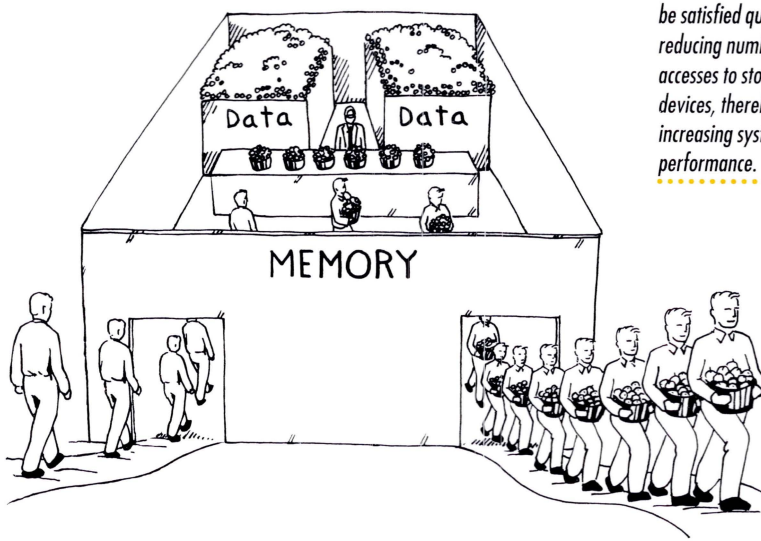
Without enough memory, a system must access storage frequently in order to satisfy processor requests. System performance is slowed as requests "queue up."



As examples, Digital offered a maximum memory capacity of 64 Mbytes for the VAX-11/780 at its maturity. In contrast, the VAX 6000 Model 520 — a multiprocessor system 25 times faster than a VAX-11/780 — currently offers a maximum capacity of 512 Mbytes, with 1 Gbyte planned in the near future.

- *The type of applications that are running.*
Applications that place a heavy demand on memory, such as imaging and 3D graphics applications, often show performance improvements when memory capacity is increased. In contrast, applications that are limited by other factors — such as processing power — exhibit little performance improvement with increased memory.

More memory allows more processor requests and instructions to be satisfied quickly, reducing number of accesses to storage devices, thereby increasing system performance.



More memory is needed for ULTRIX versions of applications, as opposed to VMS versions of applications (see Chapter 2 "ULTRIX Versions of Applications").

- *The number of users being supported.*
  Every user logged on a system requires memory resources. Even single-user systems may require increased memory if more than one process is being run simultaneously.
- *The type and amount of storage devices on the system.*
  In a well-balanced system, storage technologies — including memory, magnetic disk, tape, and optical storage devices — are configured to complement one another and to match the application environment.
- *Your performance expectations.*
  Your memory requirements will be dependent on the level of performance you expect and need in terms of response and runtimes.

It is also important to plan for future as well as current memory needs. By configuring sufficient memory at the beginning, you can prevent performance problems arising when applications expand or more users need to be supported.

Obviously, configuring the right amount of memory will be a key decision in your getting the best performance from your system.

Memory Subsystem Speed Is Another Factor in System Performance

The speed of a memory subsystem determines how fast processors can access data stored in memory. Today's faster processors demand faster memory subsystems to fully utilize processing power. That is the reason why Digital designs its memory subsystems to incorporate system and memory characteristics that optimize overall system performance.

Elements of the Memory Subsystem

The memory subsystem is made up of a number of elements, each affecting overall subsystem speed. Key factors affecting subsystem speed are the access time of the Dynamic Random Access Memory (DRAM) parts on the memory module, the total length of the electric circuits on the memory, the protocol used to access memory, the bandwidth of the memory bus, the access time of the system cache, and the caching scheme.

- *DRAM access time* — The measure of time it takes to retrieve one bit of information from an individual DRAM.
- *Memory protocol* — This describes how the memory system works, what read and write operations are implemented, and what data integrity techniques — such as ECC — are used.
- *Bus bandwidth* — The amount of data that can flow to and from memory across the bus in a given amount of time.
- *Memory access time* — The time it takes for memory to respond to a CPU request for data.
- *System cache access time and the caching scheme* — Both these factors relate to system cache, superfast memory residing within the CPU. To maximize average memory subsystem speed, the system retains recently accessed data in system cache. The goal is to satisfy subsequent requests for data from the cache — eliminating the time it would take to access memory and transfer data across the bus.

It is important to understand how memory speed or memory access time is being defined when you are comparing the speed of memory products. There are a variety of contributing factors that can be measured in a variety of different ways. For example, Digital's MS65A memory options have an access time of 448 nanoseconds. This figure represents the minimum amount of time — determined through simulation — that it takes for the memory to respond to a request when: (1) the data is not in the cache; (2) the bus is available; and (3) the memory is not busy.

Maximizing Memory Performance

Interleaving is a technique Digital implements in many of its memory subsystems in order to maximize memory performance. Interleaving enhances overall system performance by allowing multiple accesses to memory in parallel, thereby increasing effective memory bandwidth. In systems that offer such memory interleaving capabilities, the way memory is configured is as important to system performance as the amount of memory. For example, a VAX 6000 Model 420 with 128 Mbytes of memory should be configured with two 64-Mbyte memory options rather than one 128-Mbyte memory in order to allow two-way interleaving.

Systems that depend on specific memory configuration for optimal interleaving performance include the VAX 6000 and VAX 8000. Chapter 3 describes specific configuration guidelines for the respective systems.

Adequate Memory Capacity Supports Faster System Response Time

A system's memory management optimizes the utilization of memory resources and satisfies processor requests as quickly as possible. The VMS operating system manages memory by allocating sections of memory — called "pages" (see "Hard Page Fault Rate") — to system and

user tasks in a multistep process. When a task (an application or part of an application) needs memory space, the memory manager retrieves the task from a secondary storage device (such as a disk) and allocates pages of main memory — called a working set — to the task. Many tasks run on a VMS system at once, each with its own set of memory pages. The memory manager allocates memory by reassigning pages from inactive tasks (that is, tasks that are waiting for data to be read from a disk) to active tasks.

To be efficient, a memory manager needs sufficient memory to satisfy task requests without accessing secondary storage frequently. When there is insufficient memory available, the memory manager cannot allocate an adequate number of memory pages to each task. Disk accesses (known as "hard page faults") are required to bring pages of the application into memory from disk as needed.

Increasing memory capacity eliminates or reduces disk accesses, resulting in better utilization of CPU power, faster user response time, and shorter application runtimes.

With few exceptions, the ULTRIX memory manager operates in a similar fashion. For example, ULTRIX allows an application to take as much memory as needed while VMS sets a memory limit based on user parameters. Tasks running on ULTRIX cannot share program code, in contrast with VMS, which allows such sharing.

How to Determine Whether You Have Sufficient Memory

You can determine whether your existing memory configuration is sufficient by looking at two important statistics: memory utilization and hard page fault rate. These statistics can be obtained for VMS systems with Digital's system monitoring software tools such as the new DECperformance (DECps), the VAX Performance

Advisor (VPA), the Software Performance Monitor (SPM), and the VMS Monitor. I/Ostat and VMstat as well as a number of public domain products can provide similar performance statistics for ULTRIX systems.

Memory Utilization

Memory utilization statistics show the percentage of system memory being used. Large, multiuser timesharing systems often experience significant, unpredictable increases in utilization during peak periods. Sufficient memory is needed to accommodate peak period demands. Memory utilization should not exceed 85 percent of available memory during such peak usage periods.

Hard Page Fault Rate

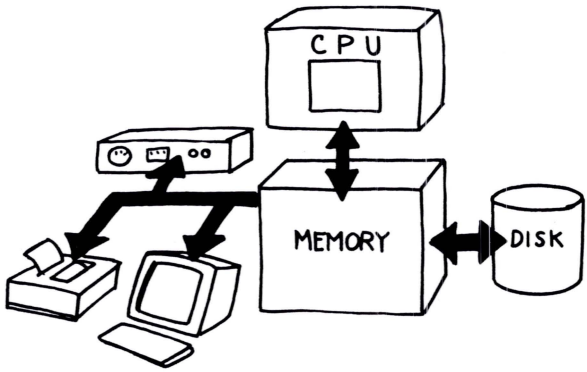
The hard page fault rate shows how often the system must access secondary storage to obtain "pages" of user applications or data. When memory capacity isn't large enough for an application's requirements, the number of hard page faults increases, degrading system performance. The most important factor in determining the impact of hard page faults on overall performance is the I/O subsystem. The speed of the I/O subsystem and the location of paging files are key elements to how quickly hard page faults can complete.

Hard page faults have a large impact on overall performance in a single-stream processing environment because the processor(s) cannot proceed until a page fault is completed. In multistream operations, where many tasks are executing in parallel, one task can execute while another is waiting for a page fault to complete, thus reducing any performance degradation.

Page faults are costly, in terms of missed instructions, on faster processors. For example, in the time it takes a VAX 6000 Model 410 to complete a hard page fault, 175,000 CPU operations can be executed. In the same amount of time, approximately 300,000 instructions can be executed on a VAX 6000 Model 510.

Since excessive hard page faults can also be caused by poor system tuning, it's important to use a software tool — such as Digital's Autogen — to tune the system. If an excessive number of hard page faults continue after system tuning, then more memory is needed.

The guidelines in Digital's *VMS Performance Guide* note that a system's hard page fault rate should not be greater than 10 per second per VUP (based on the VAX-11/780). Many industry specialists state that today's powerful systems should not have a hard page fault rate of more than one per second per VUP.



Memory is the fastest means for a system to access data. For instance, with enough memory an image can be displayed immediately. Without enough memory, the system must access a storage device to call up the image.

Summary

Memory is a pivotal factor in determining the type and amount of work your computer system can do. Key factors in getting the best performance from your system include configuring the right amount of memory and configuring memory according to the interleaving rules associated with a particular system.

To determine the amount of memory your system requires, you need to carefully examine several factors, such as your system's processing capabilities, the applications it will be running, the number of users you expect to support, the type and amount of storage devices configured with the system, and your own performance expectations. You should also take your future needs into consideration.

Several system monitoring tools are available to help you determine what your memory configuration should be. These tools can provide information on your system's memory utilization and the hard page fault rate — two critical areas that can impact system performance.

chapter 2 PLANNING FOR YOUR MEMORY NEEDS

This chapter addresses:

- *How to plan for the memory requirements of your system*
- *Memory requirements of common VMS and ULTRIX applications*
- *General guidelines for the memory requirements of common user applications*

Introduction

The amount of memory your system requires depends on several factors, including system configuration, the operating system, and user applications. The following "rules of thumb" can help you plan for your Digital computer system's memory needs.

Processing Power

Digital VAX VMS systems use an average memory capacity of 10 Mbytes per VUP (or SPECmark) of processing power. This average represents a range of configurations that vary with the application environment and system configuration. For example, a VAX 4000 Model 300 supporting 70 ALL-IN-1 users requires more memory than the same system supporting only 20 ALL-IN-1 users.

Peripherals

Adding magnetic disk capacity or terminals to a system increases the need for more memory.

System Software

A portion of the operating system — whether VMS or ULTRIX — is resident in memory at all times. The exact amount of memory allocated to system software varies with the system processors, operating system, and physical memory size.

Resident system software occupies a larger percentage of total memory in smaller capacity systems. VMS system software occupies 20 to 25 percent of total memory on systems with 32 Mbytes of memory or less. On larger systems with 256 Mbytes of memory or more, the system software takes approximately 10 percent of memory.

ULTRIX Versions of Applications

ULTRIX versions of applications require more memory than do VMS versions of the same applications for several reasons. ULTRIX automatically sets aside 10 percent of system memory capacity as a cache to improve application performance. System managers will sometimes increase the size of this cache if their systems are running I/O-intensive applications, which further reduces the amount of available memory. ULTRIX also does not allow memory sharing between processes. This means that multiple copies of an application must be resident in memory when more than one user is running the same application at the same time.

All these factors, combined with application-specific characteristics such as program code efficiency (locality), determine how much additional memory an application will need in order to run on an ULTRIX system versus a VMS system.

Server System Applications and Workstation Applications

Server systems provide "services" — such as database and compute services — to other systems, while workstations are usually standalone systems. Because their services are often I/O-intensive, server systems frequently need large memory caches to improve file I/O performance. Workstations also frequently need large amounts of memory to support fast response times in sophisticated graphics and window environments.

The total amount of memory needed for either depends on the number and types of applications running on the respective systems. For example, a server that provides both database and compute services will need more memory than a server dedicated to database services only. Similarly, workstation users often have many processes — perhaps as many as 40 or 50 — running at one time, and consequently require large memory capacity.

ALL-IN-1

Digital recommends approximately 1.5 Mbytes of memory for each ALL-IN-1 user on VMS systems. A system that supports an average of 100 active ALL-IN-1 users at a time should be configured with at least 150 Mbytes of memory in addition to what is required for other system and user applications.

Rdb/VMS

Two Mbytes of memory is recommended for each active Rdb/VMS user.

DECwindows

DECwindows running under VMS requires at least 12 Mbytes of memory. On ULTRIX, DECwindows requires a minimum 16 Mbytes of memory. The number and size of applications running under DECwindows will determine the additional memory required.

DECram

DECram for VMS, a Digital software product, improves I/O performance by creating "pseudo disks" in memory. Such memory is managed by VMS and is not available to other processes. If you wish to use DECram, you will need enough memory for your working processes plus whatever you wish allocated to the DECram pseudo disk.

User Applications

User applications vary greatly in their demands for memory. Such factors as complexity, data intensity, and graphics capabilities all play a role in an application's memory requirements. Digital provides information on minimum memory requirements for its software products in SPDs (Software Product Descriptions) and in release notes accompanying the software. Many third-party vendors also provide similar memory requirements for their products.

In some cases you may have to run the applications on your system to determine the exact memory requirements for your environment because of such variables as database size, options, and other unique characteristics.

General User Application Guidelines

Some general guidelines for estimating user application memory requirements include:

- Large scientific applications such as finite element analysis or electrical circuit design simulations can require 50 Mbytes or more per user.
- Window applications require more memory than non-window applications.
- Imaging applications require large amounts of memory. One image displayed on a high-resolution monitor requires approximately 3 Mbytes of memory. Many imaging programs also include an "Undo" capability that allows users to return to a previous version of an image. This feature requires that the system hold two images in memory simultaneously, doubling memory requirements.
- Data entry/validation applications usually require small amounts — less than 1 Mbyte per user — of memory.

chapter 3 CONFIGURING FOR PERFORMANCE

This chapter addresses:

- *How to configure memory for optimum system performance*

Introduction

It's important to configure memory properly in order to take advantage of optimum system performance. When you configure the right amount of memory, applications run faster and runtimes are reduced.

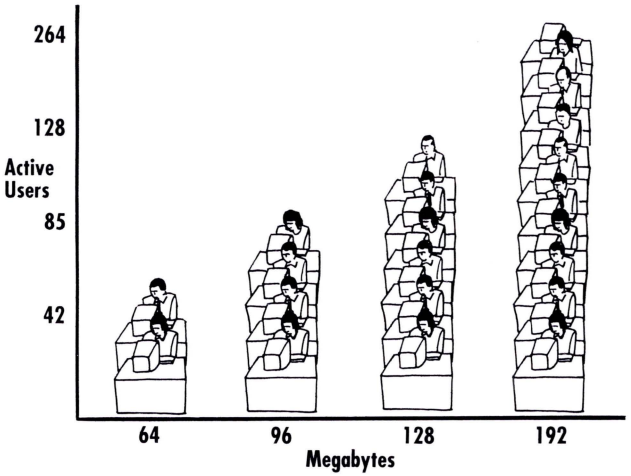
But how do you decide what is the right amount of memory? As a rule of thumb, you can anticipate that your Digital VAX VMS system will need:

> *1 to 1.5 Mbytes of memory per active user*
>
> *50 Mbytes of memory per batch job*
>
> *20 percent of the sum of those two figures for the free list*
>
> *20 percent of the sum of those two figures for the VMS operating system*

Take as an example an engineering design department of 200 "subscribers," 100 of whom are active users, using such applications as electronic mail and a text editor, as well as submitting simulations (4 jobs) to a batch queue. In this case, the formula above would advise:

> *150 Mbytes (100 active users × 1.5 Mbytes)*
> *+*
> *200 Mbytes (50 Mbytes × 4 batch jobs)*
> *+*
> *70 Mbytes (20% [for free list] of 350 Mbytes)*
> *+*
> *70 Mbytes (20% [for VMS] of 350 Mbytes)*
> *=*
> *512 Mbytes (Total for optimum performance)*

In this benchmark, increasing the memory on a VAX 6000 Model 510 allows you to add more users while maintaining a 6- to 15-second response time across such frequently used ALL-IN-1 applications as electronic mail, word processing, and time management.



More memory can mean more users for VAX 6000 systems.

VAX 6000 Systems

VAX 6000 Model 500 and Model 600

MS65A memory options are advanced, high-performance memory products that offer high bandwidth and large capacity for all VAX 6000 models. If you're running VMS Version 5.4 or later, it's recommended that you use MS65A memories because they offer higher performance, flexibility, higher capacity, and better reliability. In addition, built-in MS65A capabilities support the VAX 6000 Models 500 and 600 write-back cache feature, providing additional performance enhancements on these systems. Write-back cache reduces traffic on the system bus, allowing more processors to operate more efficiently. Because the bus is more available to CPUs and I/O, overall performance of multiprocessor systems using MS65A memories increases by as much as 33 percent versus systems using MS62A memories.

MS65A memory provides higher bandwidth than MS62A memory. Systems configured with MS62A memories need more interleaving to achieve the same overall memory bandwidth. MS65A memories reach the maximum bus bandwidth of 100 Mbytes per second with two-way interleaving. MS62A memories require four-way inter-leaving to saturate bus bandwidth. Refer to the following chart for additional details.

MS65A Options

Number of Memory Modules	Maximum Bandwidth (MB/s)
1	62.5
2 (Interleaved)	100.0
4 (Interleaved)	100.0
8 (Interleaved)	100.0

MS62A Options

Number of Memory Modules	Maximum Bandwidth (MB/s)
1	36.68
2 (Interleaved)	73.4
4 (Interleaved)	100.0
8 (Interleaved)	100.0

VAX 6000 Models 400/300/200

The MS62A-BA 32-Mbyte memory option is available for VAX 6000 Models 400/300/200. The MS62A-BA memory option is not configurable on VAX 6000 Model 500/600 systems and offers lower performance than the MS65A memories on the Model 400/300/200 systems. As noted earlier, it's recommended that you use MS65A memories because they offer higher performance, flexibility, higher capacity, and better reliability.

If you upgrade your system from a VAX 6000 Model 400/300/200 to a VAX 6000 Model 500/600, you must remove all MS62A memory options and install MS65A memories. In most cases, you will want to increase your system's memory capacity at the same time to support the faster processors.

Interleaving

Interleaving is a performance-enhancing feature that provides access to multiple memory modules in parallel. VAX 6000 systems can perform two-, four-, or eight-way mixed-module interleaving. Interleaving increases the effective memory bandwidth of VAX 6000 systems. Bandwidth is the amount of data, per second, that can be transferred to or from memory.

Multiprocessor systems need a higher level of interleaving to provide faster access to data.

Systems with vector processors require two to four times the memory bandwidth of their traditional scalar processor equivalents and therefore require higher levels of interleaving.

VAX 4000 Systems

VAX 4000 Model 500

MS690 memories provide a 64-bit-wide data path — twice the width of the data path on VAX 4000 Model 300 memories — boosting the amount of data that can be transferred to and from memory in a given amount of time on Model 500 systems and providing better system performance. Configuring with 128-Mbyte MS690-DA memory options allows you to reach the maximum memory capacity of 512 Mbytes.

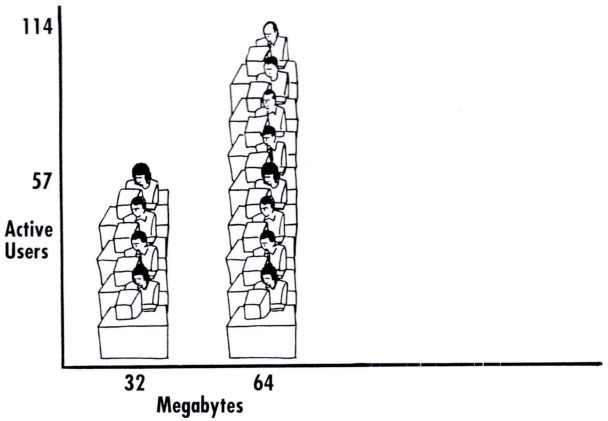
VAX 4000 Model 300

It is recommended that you use 64-Mbyte modules (MS670) on these systems to provide higher capacity (a total of 256 Mbytes).

The MS670 memory also matches the high performance of VAX 4000 Model 300 systems. The higher memory bandwidth matches the increased I/O capacity you need for I/O-intensive applications such as transaction processing, database applications, office applications, and engineering and graphics-intensive software. The memory's unique design — including a dual-ported memory controller and private bus — frees up the processor for more compute-intensive tasks.

VAX 4000 Model 200

MS650 memory options support fast-page mode data access on VAX 4000 Model 200 systems, speeding up access to application data. MS650 memory options are compatible with MicroVAX 3300/3400/3800/3900 systems and DECsystem 5400 systems.



More memory can mean more users for VAX 4000 systems.

In this benchmark, increasing the memory from 32 Mbytes to 64 Mbytes allows you to add 57 more users, yet maintain a 6- to 15-second response time across such frequently used ALL-IN-1 applications as electronic mail, word processing, and time management. These applications were tested on a VAX 4000 Model 300 system with RF31 disks.

DECsystem/DECstation Systems

DECsystem/DECstation memory options are specific to system models, supporting the individual system architectures. The maximum memory capacity of these systems varies from 24 Mbytes on DECsystem 3100/2100 systems to 480 Mbytes on DECsystem/DECstation 5000 Model 200/240 systems.

DECsystem/DECstation 5000 Model 133/125/120

You need to plan your memory requirements carefully on DECsystem/DECstation systems to achieve maximum memory capacity. Depending on the applications you intend to work with (3D versus 2D imaging applications for example), it's recommended that you initially configure a minimum 64 to 128 Mbytes and grow from there.

Another important point to consider is that you cannot configure MS01-CA 16-Mbyte memory options together with MS01-AA 4-Mbyte options on the same system. If you think you will need more than 32 Mbytes of memory now or in the future, configure 16-Mbyte options from the beginning. This eliminates the need to replace memory options on your system at a later time. Using 16-Mbyte memory options, you can configure up to 128 Mbytes of memory on your system. Configured with 4-Mbyte options, capacity is limited to only 32 Mbytes.

A similar guideline applies to DECsystem/DECstation 5000 Model 200/240 systems.

You cannot configure MS02-CA 32-Mbyte memory options together with MS02-AA 8-Mbyte memory options on the same system. Again, if you anticipate memory requirements greater than 120 Mbytes, you should configure only 32-Mbyte options on your system. Using the 32-Mbyte options, you can achieve a maximum system capacity of 480 Mbytes. Configured with 8-Mbyte options, the maximum memory capacity is 120 Mbytes. One of your most important considerations when purchasing memory is that initial planning can save future trouble and expense.

Summary

While there are a number of factors to consider when configuring memory, one of the most important factors is to select the proper size memory options that enable you to reach the system's maximum memory capacity. By careful selection of memory, you can satisfy both your present requirements and your future needs.

In general terms, you can anticipate that your Digital VAX VMS system will require a minimum of 1 to 1.5 Mbytes per user, 50 Mbytes of memory per batch job, 20 percent of the sum of those two figures for the free list, and 20 percent of the sum of those two figures for the operating system. For example, a system supporting a design department of 200 people running both office applications and design simulations would require 512 Mbytes of memory for optimum performance.

chapter 4 THE DIGITAL DIFFERENCE

This chapter examines:

- *Factors you should consider when selecting a memory product*
- *Why Digital's leadership design, full compliance with system architectures, and high-performance features make Digital memory products your best choice*

Introduction

To get the best performance from your system, you need memory products that are designed as an integral part of your system architecture, that use the best technologies available on the market, and that are fully tested to ensure the highest quality parts and manufacture.

- *Integration* – Digital's memory products are tightly integrated with system architectures.
- *Testing* – Digital's memory products are developed under the most comprehensive qualification and testing program in the industry.
- *Design* – Leading-edge design techniques and advanced memory technologies contribute to the sophistication and outstanding functionality of Digital's memory products.

Leadership Design

Accumulated experience in memory design, combined with the most advanced design tools and methodologies, allows Digital to create complex memory products incorporating advanced ECC codes and performance-enhancing features, such as interleaving and fast-page mode.

Using advanced computer simulation, Digital engineers design memories and verify the designs before any hardware products are ever built. This allows the engineers to implement memory features that optimize system performance. In addition, Digital engineers run thousands of CPU hours of design and test simulations to develop memory. This is particularly important for memories such as the MS65A — a complex product that incorporates advanced error checking, interleaving capabilities, and a sophisticated bus interface among its features.

In contrast, memory products that are built by non-Digital memory vendors can incur reduced performance or reliability problems due to design variances. The design of these memories is based on observations of the original product. Testing of these memories under actual operating conditions may not be done until the product is installed during field test in a customer's system. For example, one shortcoming of a specific non-Digital memory product (the DATARAM DR600) is that it does not implement a command queue. That means that the memory relies on a system bus throttle that was never meant to handle the amount of traffic it will receive. When two or more DATARAM memories are added to the VAX 6000, the system bus is suppressed every time a memory command is received. This will greatly reduce the number of users the system can support.

Full Compliance

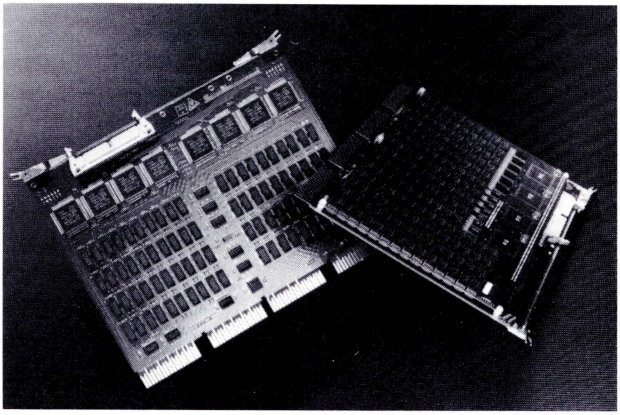
All Digital memory designs are fully compliant with, and take advantage of, the strengths of the system architecture. Digital's engineers work together on the system and memory design, ensuring complete integration, the highest performance, and correct operation across the entire range of operating parameters.

With Digital's fully compliant memories, you can take advantage of system enhancements when they occur. Non-Digital-designed memory products may not match Digital's system/memory design in fine detail, causing the product to become obsolete when enhancements are introduced. For example, future Digital fault-management features will incorporate rule-based systems that depend on intimate knowledge of the memory design to manage exception or fault conditions. Non-Digital memories that are non-compliant could generate inappropriate actions resulting in data integrity problems or even system failure.

The DATARAM DR600 memories do not work on VAX 6000 Model 500 and Model 600 systems. This means that your upgrade path ends with the VAX 6000 Model 400 if you purchase a product such as the DATARAM memory.

Advanced Semiconductor Technologies

Advanced technologies such as high-density Dynamic Random Access Memory (DRAM) and gate arrays ensure the superiority of Digital's memory products. Digital utilizes the industry's leading 4-Mbit DRAMs, providing large capacity in small packages. These high-density DRAMs enhance memory reliability because the reduction in the number of parts required means fewer points of failure.



Digital's MS650-BC (left) uses 4-Mbit DRAMs thereby taking advantage of the higher reliability offered by this technology. Using 1-Mbit DRAMs, Clearpoint's design requires more parts and is subject to more points of failure.

High-performance Features

Digital utilizes performance-enhancing features such as caching, interleaving, and high-speed interconnects to give your system high-speed access to data stored in memory.

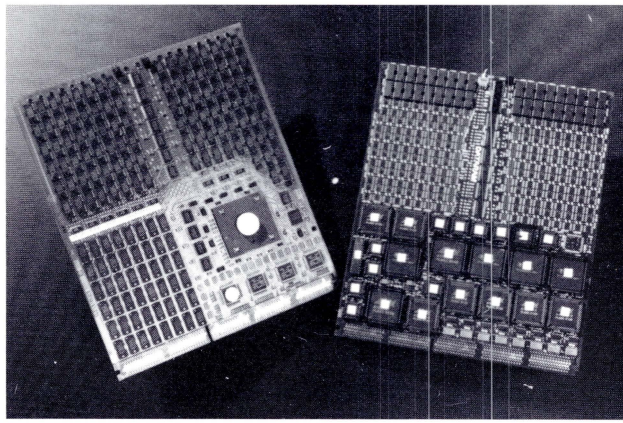
For example, the MS670 memory's high bandwidth of 40 Mbytes per second supports the full power of a VAX 4000 Model 300 system. The VAX 4000 Model 200 memory subsystem supports fast-page mode data access, a feature that enhances performance by increasing effective memory bandwidth.

VAX 6000 systems also enhance performance through interleaving, increasing sustained bandwidth up to the bus capacity of 100 Mbytes per second. VAX 6000 Model 500 and Model 600 memory subsystems also support write-back caching, allowing multiprocessors to operate more efficiently.

Digital's MS65A memories offer significantly higher performance than competitors' products. For example, DATARAM's DR600 product is based on Digital's five-year-old MS62A memory, which provides lower performance than MS65A memory.

The MS65A performs read operations in seven bus cycles, while the DATARAM product requires 10 bus cycles. In fact, the DR600 requires more bus cycles than the MS62A. The additional wait states required by the DATARAM product mean that Digital's MS65A memories perform read operations 42 percent faster than the DR600.

Digital's benchmarking comparing the MS65A to third-party memories shows that Digital's memory is superior in latency (the time it takes the memory to respond to memory access from the CPU or I/O module). Digital's memory also outperforms third-party offerings in bandwidth — how quickly data is returned to the CPU. For example, Digital's MS65A memory will return data 33 percent faster than the DATARAM memory. Digital's memory will return data at 60 single stream (60 Mbytes per second), as compared to approximately 41 Mbytes per second for the DATARAM memory.



Digital's MS65A (left) uses very large scale integration (VLSI) while DATARAM's design uses large scale integration (LSI), requiring more parts and offering more points of failure.

Reliability

When a computer system stops working, for whatever reason, the consequences can be disastrous. Around-the-clock system availability is essential for enterprises such as hospitals, financial institutions, and airlines.

Memory plays a key role in system availability because processors are powerless if memory is "down." Digital's superior memory reliability — combined with advanced error detection and recovery technologies — assure you of the highest levels of system availability.

Digital implements the most comprehensive qualification and testing programs in the industry. To ensure that only the highest-quality DRAM parts are used in its memories, Digital conducts stringent qualification tests of DRAM parts and vendors. When a vendor makes a change, such as opening a new manufacturing facility, Digital conducts requalification tests to ensure that product quality remains consistently high. Digital also requires vendors to test 100 percent of their components before shipping. And Digital tests its own memory products for correct operation at varying temperatures and voltages over periods of several hours.

Digital is also a leader in developing and implementing memory Error Correction Codes (ECC), robust self-tests, and fault-management techniques. These built-in memory subsystem features provide data integrity and very high system availability by detecting memory errors and recovering from the errors automatically.

Conclusion

Business and industry have grown to rely on continuous system availability. There is no room for system failure, and that includes memory products. Look at the areas of compliancy, performance, and reliability as well as cost when making your memory purchase. When you do, you'll probably come to the same conclusion Digital's customers did in a study conducted by Boston Research Group in October 1991. The study, which surveyed a range of Digital's customers with workstations, low-end systems, VAX 8000 and VAX 6000 systems, reported that customers who had purchased non-Digital memories reported five times more memory problems than customers who had purchased Digital memories.

chapter 5 COMMON QUESTIONS ABOUT MEMORY

This chapter answers commonly asked questions about memory products.

Q: Why is memory so crucial to system performance?

A: All data stored on secondary storage, such as magnetic disk, must be loaded into memory before it can be processed. Similarly, data destined for printers or other output devices have to pass through memory. Larger capacity memories can hold more data and instructions. When memory is increased, the number of times a system must go to secondary storage or output devices is reduced. The result is improved response times and shorter runtimes.

Q: How much memory do I need to get the system performance I want?

A: In general terms, the amount of memory you need depends on your system's processing capability, the applications you are running, the number of active users you are supporting, and the performance expectations you have. Let's examine these factors one at a time.

Faster processors need more memory because they process more information more quickly.

Applications that place a heavy demand on memory, such as imaging and I/O-intensive applications, often show performance improvements when you increase memory capacity.

The more users your system supports, the more memory you need. For a single-user system, your memory needs increase when you increase the number of processes running at the same time. And finally, you — or the users your system supports — have requirements and expectations of system performance. If these expectations aren't being met, you need to look into increasing memory capacity.

In specific terms, Chapters 2 and 3 of this document provide memory requirement guidelines for various Digital systems and application environments.

Q: Do I currently have enough memory?

A: Use Digital's performance monitoring software tools to analyze your memory utilization and your hard page fault rate. If your memory utilization is more than 85 percent at peak times, or your hard page fault rate is greater than one per second per VUP, you may need more memory.

Such performance tools include DECps, the VAX Performance Advisor (VPA), Software Performance Monitor (SPM), and VMS Monitor utility for VMS, and I/Ostat and VMstat for ULTRIX.

Q: How can I know whether I'm selecting the right memory product?

A: Quality, compliance, reliability, and performance are the key factors to consider when you are choosing memory products from among different vendors. Here are some questions to ask before you make your decision:

Was the memory designed as part of your system's architecture?

Memory products that are designed as an integral part of system architecture offer the highest levels of performance and reliability because they are fully compliant with the system architecture and take full advantage of system strengths. In contrast, products that are retrofitted by memory vendors to be compatible with one or more system and vendor architectures can incur reduced performance or reliability problems due to design variances.

What guarantee do you have of memory reliability and durability?

Reliability and durability directly impact the availability of your system. Memory products that are built to have the fewest points of failure and have undergone the most rigorous testing procedures are the most reliable. Memory subsystems that incorporate the best ECC techniques and automatically map around uncorrectable memory errors are the most durable.

Does the memory use system features and leading technologies?

Memory speed, an often-cited metric, depends on a range of factors including DRAM speed, system cache, bus speed, and performance-enhancing techniques such as interleaving. It is important to take all these factors into account when comparing the "speed" of memory products. Looking at only one element, such as DRAM speed, does not tell you how the product will perform overall.

chapter 6 MEMORY CONFIGURATION CHARTS

MEMORY OPTIONS BY SYSTEM

VAX 6000 Systems

MODELS	6600	6500	6400	6300	6200
MEMORIES					
MS65A-DA (128 MB)	•	•	•	•	•
MS65A-CA (64 MB)	•	•	•	•	•
MS65A-BA (32 MB)	•	•	•	•	•
MS62A-AB (32 MB)			•	•	•

VAX 4000 and VAX 3000 Systems

MODELS	4500	4300	4200	3900	3800	3600	3500	3400	3300
MEMORIES									
MS690-DA/UD (128 MB)	•								
MS690-CA/UC (64 MB)	•								
MS690-BA (32 MB)	•								
MS670-CA (64 MB)		•							
MS670-BA (32 MB)		•							
MS650-BC/BJ (32 MB)			•	•	•	•	•	•	•
MS650-BA/BF (16 MB)			•	•	•	•	•	•	•
MS650-BB/BH (8 MB)			•	•	•	•	•	•	•

MEMORY OPTIONS BY SYSTEM

DECstation/DECsystem

MODELS	5900	5100	5000 200	5000 240	5000 133	5000 125	5000 120	2100	3100
MEMORIES									
MS02-CA (32 MB)	▲		▲	▲					
MS02-AA (8 MB)			▲	▲					
MS01-CA (16 MB)					▲	▲	▲		
MS01-AA (4 MB)					▲	▲	▲	▲	▲
MS40-BA (8 MB)									
MS42-CA (16 MB)									
MS42-BA (12 MB)									
MS42-AB (4 MB)									
MS42-KA (4 MB)									
MS44-DA (32 MB)		▲							
MS44L-BA (8 MB)									
MS44-AA (4 MB)									

VAXstation/VAXsystem/VAXserver — MicroVAX

MODELS	4000 VLC	4000 60	3100 76	3100 30	3100 40	3100 38	3100 48	3100 30	3100 40	3100 80
MEMORIES										
MS02-CA (32 MB)										
MS02-AA (8 MB)										
MS01-CA (16 MB)										
MS01-AA (4 MB)										
MS40-BA (8 MB)	◆									
MS42-CA (16 MB)				◆	◆	◆	◆			
MS42-BA (12 MB)				◆	◆	◆	◆			
MS42-AB (4 MB)				◆	◆	◆	◆			
MS42-KA (4 MB)				◆	◆	◆	◆			
MS44-DA (32 MB)		◆								■
MS44L-BA (8 MB)	◆							■	■	■
MS44-AA (4 MB)		◆								

System	Memory Options	Option Size	Memory Slots	Maximum System Memory Capacity (MB)	Comments
VAX Systems					
VAX 9000-440, 430, 420, 410, 210	MS900-BA	256	2	512	
VAXft 3000	MS520-BB	32	4	128	Memory is mirrored in two zones for full fault tolerance.
VAX 6000—All Models	MS65A-DA MS65A-CA MS65A-BA	128 64 32	6–8	512	For Models 210–460: Requires VMS Version 5.4 or higher. See *Systems and Options Catalog* for ROM requirements. See *Systems and Options Catalog* for Interleaving advice.
VAX 6000 Models 210–460	MS62A-AB	32	6–8*	256	See *Systems and Options Catalog* for Interleaving advice.
VAX 8700/8840	MS88-DA MS88-CA	64 16	8	512	
VAX 8550/8530	MS88-DA MS88-CA	64 16	5	320	
VAX 8650/8600	MS86-DA MS86-CA	64 16	8	260	
VAX 8350/8250	MS820-CA MS820-BA	16 4	8/6	128	Eight modules can be used without battery backup. Six modules can be used with battery backup.
VAX 4000-500	MS690-DA/UD MS690-CA/UC MS690-BA	128 64 32	4	512	The UD option is a memory upgrade requiring the return of either two MS670-BAs or one MS670-CA. The UC option is a memory upgrade requiring the return of one MS670-BA.
VAX 4000-300	MS670-CA MS670-BA	64 32	4	256	
VAX 4000-200	MS650-BC/BJ† MS650-BA/BF† MS650-BB/BH†	32 16 8	4	64	The BF, BH, and BJ versions are the field-installable options. Two BC/BJ options will provide maximum capacity, freeing two slots.
MicroVAX 3800/3900	MS650-BC/BJ† MS650-BA/BF† MS650-BB/BH†	32 16 8	4	64	The BF, BH, and BJ versions are the field -installable options. Two BC/BJ options will provide maximum capacity, freeing two slots.
MicroVAX 3300/3400	MS650-BC/BJ† MS650-BA/BF† MS650-BB/BH†	32 16 8	4 3	64 52	Includes 4 Mbytes of memory on the CPU. The BF, BH and BJ versions are the field installable options. Two BC/BJ options will provide maximum capacity, freeing two slots.
MicroVAX 3100 Model 80	MS44-DA† MS44L-BA†	32 8	6	72	Options require two slots. 8 Mbytes of memory fills first two slots.
MicroVAX 3100 Models 30/40	MS44L-BA†	8	6	32	Options require two slots. Includes 8 Mbytes of memory on the CPU.
MicroVAX 3100 Models 10e/20e	MS42-CA† MS42-BA MS42-KA† MS42-AB	16 12 8 4	1	32 24 	Includes 4 Mbytes of memory on the CPU; 4-Mbyte or 12-Mbyte modules piggyback with either the 8-Mbyte or 16-Mbyte modules.
MicroVAX 2000	MS400-CA	12	1	14	Includes 2 Mbytes of memory on the CPU.
MicroVAX II	MS630-CA MS630-BB	8 4	2	16	Includes 1 Mbyte of memory on the CPU.
VAX -11/780/785	MS780-JA MS780-FA	8 2	16	64	The -JA option includes two 4-Mbyte modules and requires two memory slots. The -FA option includes two 1-Mbyte modules and requires two memory slots.
VAX -11/750	MS750-HB MS750-CA	8 1	8	14	The -HB option includes controller and two 4-Mbyte memory modules.

† For extra value, see volume package memory listing on reverse side of this foldout.

*VAX 6000 models contain 14 available backplane slots. The number of memory slots depends on system configuration.

NEW! Volume Priced Memory Packs

Memory Pack	Quantity	Comments
MS01V-CA	20	
MS01V-AA	80	
MS02V-CA	10	
MS02V-AA	40	
MS40V-BA	40	
MS6VV-BF	20	Includes MS650-BF options
MS42V-CA	20	
MS42V-KA	40	
MS44V-DA	10	
MS44V-BB	40	Includes MS44L-BA options

System	Memory Options	Option Size	Memory Slots	Maximum System Memory Capacity (MB)	Comments
VAXstations					
VAXstation 4000 Model 60	MS44-DA†	32	6	104	Options require two slots. Includes 8 Mbytes of memory on the CPU.
	MS44L-BA†	8			
VAXstation 4000 Model VLC	MS40-BA†	8	6	24	Option requires two slots.
VAXstation 3540	MS60-CA	32	3	96	
	MS60-BA	16			
	MS60-AA	8			
VAXstation 3520	MS60-CA	32	4	128	
	MS60-BA	16			
	MS60-AA	8			
VAXstation 3100					
Models 30/40 and 38/48	MS42-CA†	16	1	32	Includes 4 Mbytes of memory on CPU; 4-Mbyte or 12-Mbyte modules piggyback with either the 8-Mbyte or 16-Mbyte modules.
	MS42-BA	12			
	MS42-KA†	8			
	MS42-AB	4			
Model 76	MS44-AA	4	8	32	
VAXstation 2000	MS400-CA	12	1	14	Includes 2 Mbytes of memory on the CPU.
VAXstation II/GPX	MS630-CA	8	2	16	
	MS630-BB	4			
DECsystems					
DECsystem 5900	MS02-CA†	32	14	448	
DECsystem 5810, 5820	MS62A-AB	32	8	256	
DECsystem 5500	MS220-BA/BF	64	4	256	The AF and BF versions are field-installable options.
	MS220-AA/AF	32	4	128	
DECsystem 5400	MS650-BC/BJ†	32	4	64	The BF and BJ versions are field-installable options.
	MS650-BA/BF†	16			Two BC/BJ options will provide maximum capacity, freeing two slots.
DECsystem 5100	MS44-DA†	32	8	128	Option requires two slots.
DECsystem 5000-240/200	MS02-CA†	32	15	480	Options cannot be mixed in the same system.
	MS02-AA†	8	15	120	
DECsystem 5000-25	MS01-CA†	16	4	40	Option requires two slots. Includes 8 Mbytes of memory on the CPU.
	MS01-AA†	4	4	16	Options cannot be mixed in the same system.
DECsystem 3100	MS01-AA†	4	12	24	Option requires two slots.
DECstations					
Personal DECstation 5000-25/20	MS01-CA†	16	4	40	Options require two slots. Includes 8 Mbytes of memory on the CPU.
	MS01-AA†	4	4	16	Options cannot be mixed in the same system.
DECstation 5000-240/200	MS02-CA†	32	15	480	Options cannot be mixed in the same system.
	MS02-AA†	8	15	120	
DECstation 5000-133/125/120	MS01-CA†	16	16	128	Options require two slots.
	MS01-AA†	4	16	32	Options cannot be mixed in the same system.
DECstation 3100/2100	MS01-AA†	4	12	24	Option requires two slots.

† For extra value, see volume package memory listing on reverse side of the first foldout table.
To order or for prepurchase technical assistance, contact your sales representative or call 800-DIGITAL..