Apollo Domain Systems

MANAGEMENT SUMMARY

UPDATE: *Since we last updated this report, Apollo has strengthened its product line by announcing new workstations, resource/departmental servers, software products, and communications facilities. These product introductions are an attempt to make the Domain systems more competitive, particularly with products from Sun Microsystems—Apollo's chief rival.*

Apollo Computer, once the leading supplier of technical computing workstations, is now fighting to regain its primacy. Until a few years ago, Apollo experienced the same rapid growth Sun Microsystems—the technical workstation market leader—now enjoys. Annual sales revenues and profits grew at double- and even triple-digit rates. More importantly, Apollo gobbled up more market share than Sun Microsystems, its primary competitor, and secondary competitors Hewlett-Packard, Digital Equipment Corporation, and IBM. For example, according to Dataquest (San Jose, California), an independent market research and consulting firm, Apollo accounted for 28 percent of the technical workstations purchased during 1985, whereas Sun captured only 24 percent of the market and Digital Equipment accounted for only 8 percent.

However, Apollo's success did not last. A number of sales were lost to the competition. More importantly, Sun Microsystems used an aggressive marketing mix featuring more attractive products, lower prices, and effective customer support strategies to surpass Apollo in market share. According to Dataquest, 26 percent of technical workstation sales during 1986 (the last year for which figures are available) went to Sun while Apollo accounted for 24 percent. Sun Microsystems continued to outpace Apollo in market share by several percentage points during 1987.

A major reason for Apollo's decline can be related to past product and marketing strategies. One of its major flaws was an architecture centered almost exclusively around proprietary components. Apollo allowed the Domain workstations to keep their proprietary system architecture when the market trend was toward using nonproprietary components and facilities for technical workstations. Facilities such as the Aegis operating system, D3M data base, and Apollo Token-Ring LAN (formerly known as the Domain LAN) gave Apollo's systems an unmistakably proprietary image. The proprietary tools made it difficult to port applications over from another vendor's system, to connect another computer for the purpose of information distribution, and to find appropriate packaged application systems for the processing task.

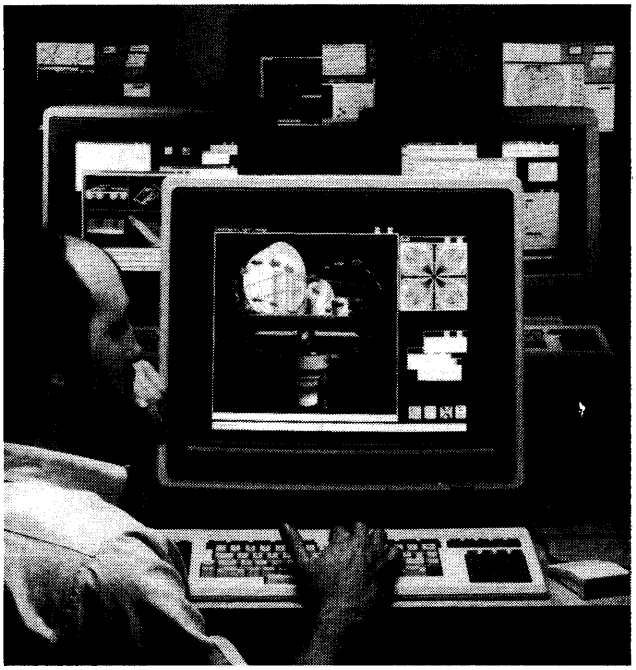
Although Domain stations could be configured with the industry-supported AT&T UNIX or Berkeley UNIX and IEEE 802.3 TCP/IP Ethernet, Apollo marketed and supported those products on a secondary level. As a matter of

The Apollo Domain Systems comprise a family of 32-bit workstations and resource/departmental servers oriented towards diverse computing tasks.

Both proprietary and industry-standard facilities are featured. Mainstream personal computing can be integrated into the Domain processing environment.
MODELS: DN3000; DN4000 Personal Super Workstation; DN570, DN580, DN570 Turbo, DN580 Turbo, and DN590 Turbo workstations; and DSP90, DSP500, DSP3000, DSP4000, and DSP9000 resource/departmental servers.
MEMORY: 2M to 32M bytes on DN stations; to 256M bytes on DSP servers.
DISK CAPACITY: 72M to 1.6G bytes.
WORKSTATIONS: Up to 125 workstations on the DSP resource/departmental servers.
PRICE: $4,990 to $69,900 for basic workstations; up to $195,750 for resource/departmental servers.

CHARACTERISTICS

MANUFACTURER: Apollo Computer Inc., 330 Billerica Road, Chelmsford, Massachusetts 01824. Telephone (617) 256-6600.



Apollo has refined the capabilities of its Domain workstations and servers in an attempt to make the products more competitive with alternative solutions from the likes of Sun Microsystems, the leading technical workstation vendor.

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CHART A. SYSTEM COMPARISON

MODEL	DN3000	DN4000 Personal Super Workstation	DN570 and DN580	DN570 and DN580 Turbo	DN590 Turbo
SYSTEM CHARACTERISTICS					
Microprocessor type	MC68020	MC68020	MC68020	MC68020	MC68020
Microprocessor cycle time	12.5MHz	25MHz	16.7MHz	20MHz	20MHz
Operating system	Aegis, Domain/IX	Aegis, Domain/IX	Aegis, Domain/IX	Aegis, Domain/IX	Aegis, Domain/IX
Number of serial/parallel I/O ports	1 serial RS-232-C standard	3 serial RS-232-C standard	2 serial RS-232-C standard	2 serial RS-232-C standard	2 serial RS-232-C standard
MEMORY					
Minimum capacity (bytes)	4M	4M	2M	2M	4M
Maximum capacity (bytes)	8M	32M	16M	16M	16M
DISK STORAGE					
Minimum capacity (bytes)	72M	155M	154M	154M	154M
Maximum capacity (bytes)	348M	348M	—	—	—
NUMBER OF WORKSTATIONS	1	1	1	1	1
COMMUNICATIONS PROTOCOLS	Apollo Token-Ring LAN, IEEE 802.3 Ethernet, PCI, NFS, RFS, TCP/IP, MAP, TOP, X.25, DECnet, VT100, RJE, BSC, SNA, LU6.2/2.1	Apollo Token-Ring LAN, IEEE 802.3 Ethernet, PCI, NFS, RFS, TCP/IP, MAP, TOP, X.25, DECnet, VT100, RJE, BSC, SNA, LU6.2/PU2.1	Apollo Token-Ring LAN, IEEE 802.3 Ethernet, PCI, NFS, RFS, TCP/IP, MAP, TOP, X.25, DECnet, VT100, RJE, BSC, SNA, LU6.2/PU2.1	Apollo Token-Ring LAN, IEEE 802.3 Ethernet, PCI, NFS, RFS, TCP/IP, MAP, TOP, X.25, DECnet, VT100, RJE, BSC, SNA, LU6.2/PU2.1	Apollo Token-Ring LAN, IEEE 802.3 Ethernet, PCI, NFS, RFS, TCP/IP, MAP, TOP, X.25, DECnet, VT100, RJE, BSC, SNA, LU6.2/PU2.1
PURCHASE PRICE ($)	4,990 (entry-level config.)	13,900 (entry-level config.)	DN570, 39,900 (basic sys. pkg.); DN580, 49,900 (basic sys. pkg.)	DN570 Turbo, 46,900 (basic sys. pkg.); DN580 Turbo, 54,400 (basic sys. pkg.)	69,900 (basic sys. pkg.)

Note: A dash (—) in a column indicates that the information is unavailable from the vendor.

fact, the UNIX tools could not run on a Domain in native mode. UNIX could run only if Aegis was employed. Also, communications gateways had to be set up so Domains could communicate with other computers connected to Ethernet; the workstations did not have a direct connection to Ethernet. Moreover, Ethernet could not be used to network the Domains, themselves, thereby complicating distributed processing within a multivendor environment.

Apollo also lost market share because of its slowness in turning over its product line and its failure to introduce significant product enhancements in a timely manner. Moreover, Apollo was not very innovative with the Domain line; it became more of a "follower" than a "leader." Apollo's conservatism in product design reduced its influence on the customer base. Customers could not depend on Apollo to meet growing or new processing needs.

By contrast, other vendors released competitive and innovative products long before Apollo brought its solutions to market. For example, Sun had its 2-MIPS 3/100 workstations and 4-MIPS 3/200 workstations on the market before Apollo could release its 2-MIPS and 4-MIPS DN500 machines. Moreover, Sun has a 10-MIPS workstation; Apollo has yet to introduce a product that directly competes with the Sun 10-MIPS workstation. As another example, Digital Equipment, Hewlett-Packard, and Sun Microsystems were doing IEEE 802.3 Ethernet networking long before Apollo decided to add that Ethernet to its repertoire of distributed processing solutions.

Another factor which caused Apollo to lose market share and computer installations was inconsistency in product and customer servicing and support. Apollo started out with a fine customer education and product support program. However, the quality of maintenance service and customer training declined as Apollo grew. According to

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DATA FORMATS

BASIC UNIT: 32-bit word.

INTERNAL CODE: ASCII.

MAIN STORAGE

Main memory on the Domain workstations and servers ranges from from 2M to 256M bytes. See Chart A for capacities of specific models.

PROCESSING COMPONENTS

A Motorola MC68020 microprocessor, a Motorola MC68881 floating-point co-processor, a memory management unit (MMU), and standard I/O are the main components of the *DN3000* and *DSP3000* central processor. The clock in the central processor drives the MC68020 and MC68881 at a speed of 12.5MHz.

The MC68020 microprocessor has a full 32-bit CPU, with 16 general-purpose, 32-bit data and address registers; an instruction cache; a high-speed 32-bit execution unit; an instruction prefetch and decode unit; and a bus controller unit. A three-stage pipeline architecture is employed for instruction processing.

The MC68881 floating-point co-processor is integrated with the MC68020. It is responsible for increasing the speed of single- (32-bit) and double- (64-bit) precision floating-point arithmetic operations. The co-processor interface to the MC68020 allows overlapped execution of MC68020 and MC68881 instructions.

The MMU is tightly integrated with the MC68020 microprocessor, standard I/O, and I/O bus. The MMU is responsible for executing read and write operations initiated at the CPU and I/O control levels; for transferring data

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CHART A. SYSTEM COMPARISON (Continued)

MODEL	DSP90	DSP500	DSP3000	DSP4000	DSP9000
SYSTEM CHARACTERISTICS					
Microprocessor type	MC68020	MC68020	MC68020	MC68020	Does not apply
Microprocessor cycle time	—	—	12.5MHz	25MHz	Does not apply
Operating system	Aegis, Domain/IX	Aegis, Domain/IX	Aegis, Domain/IX	Aegis, Domain/IX	Aegis, Domain/IX
Number of serial/parallel I/O ports	2 serial RS-232-C standard	—	1 serial RS-232-C standard	3 serial RS-232-C standard	—
MEMORY					
Minimum capacity (bytes)	2M	8M	4M	4M	2M
Maximum capacity (bytes)	3M	32M	8M	8M	256M
DISK STORAGE					
Minimum capacity (bytes)	—	348M	72M	155M	268M
Maximum capacity (bytes)	—	—	348M	348M	1.6M
NUMBER OF WORKSTATIONS	—	4 - 8 typical	4 - 8 typical	4 - 8 typical	2 - 125
COMMUNICATIONS PROTOCOLS	Apollo Token-Ring LAN, IEEE 802.3 Ethernet, PCI, NFS, RFS, TCP/IP, MAP, TOP, X.25, DECnet, VT100, RJE, BSC, SNA, LU6.2/PU2.1	Apollo Token-Ring LAN, IEEE 802.3 Ethernet, PCI, NFS, RFS, TCP/IP, MAP, TOP, X.25, DECnet, VT100, RJE, BSC, SNA, LU6.2/PU2.1	Apollo Token-Ring LAN, IEEE 802.3 Ethernet, PCI, NFS, RFS, TCP/IP, MAP, TOP, X.25, DECnet, VT100, RJE, BSC, SNA, LU6.2/PU2.1	Apollo Token-Ring LAN, IEEE 802.3 Ethernet, PCI, NFS, RFS, TCP/IP, MAP, TOP, X.25, DECnet, VT100, RJE, BSC, SNA, LU6.2/PU2.1	Apollo Token-Ring LAN, IEEE 802.3 Ethernet, PCI, NFS, RFS, TCP/IP, MAP, TOP, X.25, DECnet, VT100, RJE, BSC, SNA, LU6.2/PU2.1
PURCHASE PRICE ($)	16,000 (entry-level config.)	47,900 (basic sys. pkg.)	17,900 (basic sys. pkg.)	12,400 (entry-level config.)	195,750 (entry-level config.)
COMMENTS	Can serve as either a compute, file, peripheral, or communications server.	Can serve as either a compute, file, peripheral, or communications server.	Based on the DN3000 architecture.	Based on the DN4000 architecture.	Designed to serve as a compute server, primarily. Contains from 1 to 8 computational elements (CEs). Each CE is rated at 4.45 MIPS.

Note: A dash (—) in a column indicates that the information is unavailable from the vendor.

reports from Dataquest and interviews conducted by Datapro, users have been displeased with the lack of product support and customer education servicing received. Sales opportunities have been lost because customers have been dissatisfied with the level of product and customer support rendered.

Apollo's slowness in entering new markets with its technical workstations contributed to its loss in market share. While Sun Microsystems ventured forth into new market segments (e.g., earth science, advertising, electronic publishing, financial analysis, and econometrics) to increase sales activity, Apollo stayed within the traditional technical workstation niches—CAD/CAM/CAE and software engineering.

Realizing that it had to redefine its approach to the marketplace to keep from losing ground, Apollo overhauled its strategies and tactics on the product development and marketing fronts. Those changes have resulted in a more competitive company. Apollo is on the upswing.

Apollo's turnaround is due to a number of factors. To begin with, product support and customer servicing has been improved. The quality of field engineering was upgraded. Apollo is now bringing more effective troubleshooting and service responsiveness to the Domain customer. For example, Apollo now offers four-hour response times to service requests. To meet the demands for more effective education and training programs, it provides more in-depth educational and training classes for system operators, programmers, administrators, and end users. Classes now cover all aspects of Domain system usage. Because of these improvements, customers do not voice as many complaints as they did several years ago.

between the CPU and I/O controllers; for dividing virtual memory address space into pages and pages into segments; and for moving pages and segments of memory between main memory and the online storage devices.

The virtual memory management scheme implemented in the hardware and software of the DN3000 permit a process to up to 256M bytes in size. The MMU works on 1024-byte physical page sizes and has separate protection and statistics information for each page. The MMU works in conjunction with the MC68020 and I/O controllers for translating virtual addresses into physical addresses and vice versa.

The following I/O control components are included within the central processor:

- **An interface for an RS-232-C serial port**
- **Interfaces for a low-profile keyboard and a mouse**

Both the *DN4000 Personal Super Workstation* and the *DSP4000* central processor feature the following:

- **A 20MHz MC68020 microprocessor**
- **A 20MHz MC68881 floating-point co-processor**
- **An 8K-byte cache memory—used to increase the rate at which instructions are executed**
- **An MMU**
- **A virtual memory architecture supporting a 256M-byte virtual address space per process**
- **Standard I/O interfaces for three RS-232-C serial ports, a keyboard, and a mouse**

A *PC co-processor option* can be added to the DN3000 and DN4000 systems. This co-processor option, complete with

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CHART B. DISK/DISKETTE DEVICES

MODEL	72MB Fixed Disk	155MB Fixed Disk	154MB Fixed Disk	268MB Fixed Disk
Type	Winchester	Winchester	Winchester	Winchester
Size (inches)	5.25	5.25	5.25	—
Formatted capacity per drive (bytes)	72M	155M	154M	268M
Interface/controller	—	ESDI interface	—	—
Number of drives per interface/controller	—	—	2	—
Supported by	3000 models	3000 and 4000 models	500 models	DSP9000
Purchase Price ($)	—	4,700	5,000	—

Note: A dash (—) in a column indicates that the information is unavailable from the vendor.

By improving product maintenance and customer support services, Apollo increases it chances to keep existing customers and attract new ones.

Industry-standard solutions are now more common within the Domain environment. Apollo is taking a more active role in responding to customer calls for systems with commonly available facilities. This technical workstation vendor is removing the proprietary architecture label placed on the Domain systems.

The Domain systems now support UNIX and IEEE 802.3 TCP/IP Ethernet in a native mode. Industry-supported data system facilities such as the Oracle relational data base and GKS graphics are now part of the Domain computing environment. In addition, Apollo has added widely accepted multivendor protocols—such as the Sun-developed Network File System (NFS), the AT&T-developed Remote File System (RFS), and the industry-developed Manufacturing Automation Protocol (MAP) and Technical Office Protocol (TOP)—to its repertoire of communications and networking solutions.

Moreover, Apollo is actively promoting the industry-standard Domain system. As a primary example, Apollo sells low-end workstations—the DN3000 and DN4000—with Domain/IX as the primary operating system. This contrasts with previous low-end systems—such as the DN300 and DN330—which were packaged with Aegis as the primary operating system.

Apollo has also overhauled the Domain system product line to increase its competitiveness. It has withdrawn older, less powerful Domain systems, such as the DN300, DN460, and DN566 workstations and DSP80 and DSP160 servers; increased the power of some of the existing models, such as the DN570 and DN580 workstations; and added the DN3000, DN4000, and DN590 Turbo workstations and DSP500, DSP3000, DSP4000, and DSP9000 servers.

The enhanced Domain product line provides Apollo with more competitive products at the low, mid-range, and high ends of the technical workstation spectrum. The Domain 3000, 4000, and 500 series of workstations and servers and the DSP9000 server offer greater price/performance, cost-effectiveness, configurability, and operation capabilities than the systems they replace.

a PC co-processor board and software, permits the DN3000 or DN4000 to execute MS-DOS programs. The MS-DOS programs run on the DN3000 and DN4000 as tasks in windows.

The *DN570* and *DN580* workstations each have a CPU subsystem that features the following:

- **A CPU board with a 16.7MHz MC68020 microprocessor; a 12.5MHz MC68881 floating-point co-processor; and interfaces for a keyboard, mouse, data tablet, and two RS-232-C serial ports**
- **An optional floating-point accelerator directly coupled to the CPU board, CPU and floating-point accelerator operations are automatically overlapped**
- **An MMU**
- **A virtual memory architecture supporting a 64M-byte virtual address space per process**

A bus on the CPU board interconnects the MC68020, MC68881, floating-point accelerator, and standard I/O. A CPU-MMU bus carries communications between the CPU board and MMU. The CPU bus-Apollo VME bus adapter connects the CPU bus to the Apollo VME bus. An MMU-Apollo VME bus interconnect carries communications between the MMU and Apollo VME bus. A memory interconnect carries communications between the main memory and the MMU.

The *DN570 Turbo*, *DN580 Turbo*, and *DN590 Turbo* each feature a CPU subsystem with a 20MHz MC68020 microprocessor, a 16.7MHz MC68881 floating-point co-processor; an optional floating-point accelerator; an MMU; and interfaces for a keyboard, mouse, data tablet, and two RS-232-C serial ports. A 16K-byte cache is used in the DN580 Turbo and the DN590 Turbo to quicken main memory access for the CPU, thus increasing overall system performance.

The floating-point accelerator in the DN590 Turbo is an enhanced version of that in the DN570 Turbo and DN580 Turbo workstations. It produces more floating-point performance than floating-point accelerators in the DN570 Turbo and DN580 Turbo workstations.

The virtual memory architecture of the DN570 Turbo and DN580 Turbo provides a 64M-byte virtual address space for each process. The DN590 Turbo workstation runs with a 2G-byte virtual address space per process.

A bus on the CPU board interconnects the MC68020, MC68881, cache memory, and standard I/O. A memory interconnect carries communications between the main memory and the MMU. The Apollo VME bus interconnects all DN590 Turbo subsystems—the CPU board,

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CHART B. DISK/DISKETTE DEVICES (Continued)

MODEL	281MB Disk	348MB Fixed Disk	442MB Fixed Disk
Type	Removable	Winchester	Fixed
Size (inches)	—	5.25	—
Formatted capacity per drive (bytes)	281M	348M	442M
Interface/controller	—	EDSI interface	EDSI interface
Number of drives per interface/controller	2	2	4
Supported by	500 models	3000, 4000, and those with the Multibus I/O bus	Models with the Multibus I/O bus
Purchase Price ($)	—	—	22,000

Note: A dash (—) in a column indicates that the information is unavailable from the vendor.

For example, the DN3000, the present entry-level Domain workstation, provides greater performance, configurability, and cost-effectiveness than the DN300, the previous entry-level Domain workstation. A basic DN3000 offers three times the performance of the DN300 at nearly two-thirds the price. A basic 1.2-MIPS DN3000 costs $9,490, or $7,908 per MIPS; in contrast, a basic 0.6-MIPS DN300 workstation had cost $15,900, or $26,500 per MIPS. The DN3000 also offers more than twice the amount of physical memory than the DN300—8M bytes versus 3M bytes—and nearly five times more fixed disk storage—348M bytes versus 70M bytes.

The DSP500 is a better bargain than the DSP90 and DSP160. For example, the basic, 8M-byte DSP500 server package offers approximately 1.3 times more performance than the DSP160 and costs $29,000; in contrast, an equally configured DSP160 server had cost $47,000. The basic DSP500 file server package provides more disk capacity than the basic DSP80 file server package while being priced within the same price category as the DSP80 file server. The basic DSP500 file server comes with 696M bytes of disk and costs $47,900 ($69 per 1M bytes of disk) while the older DSP80 file server came with 442M bytes of disk and cost $38,900 (or $88 per 1M bytes of disk). Furthermore, both the DSP500 compute and file servers can run on either the Apollo Token-Ring LAN or IEEE 802.3 Ethernet; in contrast, the DSP80 and DSP160 only ran on the Apollo Token-Ring.

Apollo is committed to increasing the functionality of the Domain system. This commitment is shown by the addition of communications tools such as IEEE 802.3 TCP/IP Ethernet, LU6.2, the Sun's Open Network Computing (ONC) platform (which includes the industry-supported NFS protocol), MAP, and TOP and the enhancement of existing tools, such as the Domain/SNA-3270 emulator. These products provide the Domain systems with the openness required for working in a multivendor, departmental or distributed processing environment.

Furthermore, Apollo is attempting to increase market share by becoming more innovative with Domain system design. It is trying to become more of a "leader" instead of a "follower."

Apollo's newfound innovativeness is demonstrated by its DSP9000 resource/departmental processing server. The DSP9000 is significant because it is the first resource/

MMU, graphics subsystem, mass storage subsystem, I/O peripheral subsystem, and communications and networking options.

The DSP90 and DSP500 central processors feature MC68020 microprocessors, floating-point accelerators, optional floating-point accelerators, cache memory, MMUs with virtual memory management facilities, and standard I/O.

The engine of the DP9000 is the Compute Element (CE). Up to eight CEs can reside in the DSP9000. Each CE is a 32-bit microprogrammed computer featuring a proprietary architecture. Every CE delivers 4.45 MIPS and 11.8 MFLOPS of performance.

GRAPHICS ARCHITECTURE

The graphics processing subsystem of a Domain system consists of a graphics accelerator, a display processor, and display memory. Both 2-D and 3-D figures and images are produced in monochrome or color. Interactive scaling and rotation, picking and highlighting, shading/pattern filling, zoom and pan, and wireframing are supported. The display screen can be divided into windows and viewports. Graphics resolution is either 1,024-by-800 pixels, 1,280-by-1,024 pixels, or 1,600-by-1,280 pixels.

An eight-frame board within the display subsystem of the graphics subsystem displays up to 256 colors simultaneously from a palette of 16 million or more. A four-plane frame board is available for users requiring fewer colors (16 simultaneous from a palette of 256 or 4,096).

INPUT/OUTPUT CONTROL

The DN3000 and DN4000 workstations and the DSP3000 and DSP4000 servers feature a 6MHz PC/AT-compatible peripheral bus. This bus supports the diskette, mass storage, peripheral I/O, and communications and networking controllers.

Besides supporting the Apollo-supplied peripheral and communications options, the peripheral bus of the Domain 3000 and 4000 workstations and servers also supports IBM PC XT/AT-compatible peripheral options used on systems from other vendors. PC XT/AT-compatible input devices, mass storage subsystems, communications devices, monitors and video systems, printers, other output devices, and voice processing systems can be placed on the 3000 and 4000 products via this bus. There are seven PC AT-compatible 16-bit board slots and one PC XT-compatible 8-bit board slot for connection options.

The DN570, DN580, DN570 Turbo, DN580 Turbo, and DN590 Turbo workstations use the Apollo VME bus to

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CHART C. WORKSTATION DISPLAYS

MODEL	DN3000 Display	DN4000 Display	DN570 Display	DN580 Display
CHARACTERISTICS				
Screen size (diagonal)	15 or 19 inches	15 or 19 inches	15 inches	19 inches
Resolution, pixels	1,024 horizontal x 800 vertical	1,280 horizontal x 1,024 vertical	1,600 horizontal x 1,280 vertical	1,280 horizontal x 1,024 vertical
Imagery	Monochrome or color	Color	Color	Color
Total colors or shades/no. simult. displayed	256/16 colors or 16 million/256 colors on color display	16.7 million/256	16 million/256	16 million/256

departmental server to offer up to 35 MIPS of processing power. None of Apollo's competitors have a product that matches the data crunching capabilities of the DSP9000. With the DSP9000, customers have a server that meets a wide range of compute demands across the spectrum of complex program execution. Workstation users can assign workstation programs to the DSP9000 to increase workstation performance and can use the DSP9000 to handle those compute-intensive applications—such as chemical analysis and econometrics—which are too large or complex for a workstation.

Another example of Apollo's product innovativeness is provided by its Network Computing System (NCS) communications platform, which is unique to the technical workstation market. NCS enables an installation to use a network of different computers to execute a single application. On the surface, it looks to the workstation user as if NCS takes an array of different computers and turns it into a parallel processor—a multiprocessor system that uses all available processors to execute a single application transparently.

NCS permits installations to design and run distributed applications across a network of different computers. Individual parts of a workstation-based application are offloaded to those computers best suited for the task—supercomputers, mainframes, minicomputers, parallel processors, or data base machines. For instance, for a workstation-based business simulation program, NCS assigns data base, simulation, analysis, and report generation tasks to more powerful systems to quicken execution and response times and provides the workstation with the interface to monitor or view application processing. Program-to-program communications are used so application subroutines can communicate with each other. A single interface is used for connecting the entire range of computing resources.

An enhanced marketing effort is another reason why Apollo is making a turnaround. Apollo moved into new markets to increase sales activities. Apollo is no longer just competing in traditional technical workstation computing segments. It has initiated a policy of pursuing sales in the newer and emerging technical workstation marketplaces—earth science, advertising, electronic publishing, financial analysis, and econometrics. By offering Domains in those market segments that have high growth potential for automation with technical workstations, Apollo hopes to increase sales.

coordinate communications among the CPU subsystem; memory; and mass storage, peripheral I/O, and communications options.

As an option, a Multibus I/O bus can be added to a DN5XX workstation. This I/O bus is used to support Multibus-compatible I/O, communications, and application accelerators and associated co-processors. Four slots are provided for controllers or option attachments.

An industry-standard VME I/O bus also can be added to a DN590 Turbo workstation configuration, so industry-standard VME-compatible I/O devices, communications options, application accelerators, and associated co-processors can be employed. Four slots are provided for controllers or option attachments. A VME adapter allows VME-based devices and options to communicate across the Apollo VME bus with the workstation's CPU subsystem and memory.

The DSP90 is equipped with a five-slot Multibus I/O bus. The DSP500 uses the VME and Multibus I/O buses to connect peripheral, communications, and computational aid options. Like the DSP90 and DSP500, the DSP9000 uses a Multibus chassis to connect peripherals and communications controllers and options.

CONFIGURATION RULES

There are two types of Domain 3000 workstations: DN3000 and DN3040. The DN3000 runs at 1.2 MIPS and accommodates the following:

- **A 15-inch or 19-inch monochrome or color workstation display with a 1,024-by-800 pixel resolution**
- **4M or 8M bytes of physical memory**
- **A 72M-, 155M-, or 348M-byte Winchester disk drive**
- **A 1.2M-byte diskette drive**
- **A 60M-byte, 0.25-inch cartridge tape drive**
- **One standard RS-232-C serial port**
- **Optional serial/parallel interface boards; each board contains two RS-232-C serial ports and one Centronics parallel port**

The DN3040 is an industrialized (ruggedized) version of the DN3000. Because the DN3040 is designed for the manufacturing shop floor and other harsh environments, it is not discussed in this report. A full description of the DN3040 can be found in the *CAD/CAM/CAE Systems* volume of the *Datapro Manufacturing Automation Series*.

The DN4000 workstation accommodates the following:

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CHART C. WORKSTATION DISPLAYS (Continued)

MODEL	DN570 Turbo Display	DN580 Turbo Display	DN590 Turbo Display
CHARACTERISTICS			
Screen size (diagonal)	15 or 19 inches	19 inches	—
Resolution, pixels	1,280 horizontal x 1,024 vertical	1,280 horizontal x 1,024 vertical	—
Imagery	Color	Color	Color
Total colors or shades/no. simult. displayed	—	—	16.7 million/—

Note: A dash (—) in a column indicates that the information is unavailable from the vendor.

Apollo is currently making adjustments within its indirect sales channel to increase the market visibility of Domain computers. By recruiting additional distributors, dealers, and value-added resellers to its network of existing resellers, Apollo increases sales potential. The resellers give Apollo access to those customers it cannot reach through a direct sales force.

Sales have also increased because Apollo has aggressively pursued more OEM agreements, which have been signed with a variety of vendors in several market and product segments. Apollo signed agreements with graphics and CAD/CAM/CAE workstation vendors such as Mentor Graphics and GE Calma, with financial security trading workstation vendors such as Programmit and Prophecy Development, and with general-purpose computer system vendors such as Concurrent Computer and Wang. By entering more of these agreements—in which Apollo supplies Domains to other vendors for customization for vertical or specialized markets—Apollo increases its installed base.

Entering into more joint marketing agreements has helped Apollo recover from its sluggish performance. The company has formed joint marketing agreements with computer system suppliers and software developers in a variety of markets. For example, Apollo has established joint marketing agreements with Concurrent Computer to penetrate more deeply into the online transaction processing marketplace as well as the manufacturing, scientific, and engineering environments; with Wang Laboratories to concentrate on office automation and MIS sales; with Intellicorp and Teknowledge to penetrate more deeply into the expert system segment; and with Prophecy Development Corporation to concentrate on sales within the financial services system arena. Under these agreements, Apollo and the joint marketing vendors promote each other's products, providing access to customers the others could not have reached as effectively via their own direct sales forces. Sales potential for Apollo is thus increased, since it can reach more customers than before.

Because of these updated product strategies and marketing efforts, the company is once again experiencing high growth rates for sales revenues. Sales have been growing at rates ranging up to 80 percent for the last several fiscal quarters. However, despite this renewal, Sun continues to outgain Apollo in market share. As a matter of fact, Sun has moved ahead of Apollo in the number of systems its has in the aggregate base of installed technical workstations. According to Sun, it has over 50,000 workstations

- **A 15-inch monochrome or 15- or 19-inch color workstation display with a 1,024-by-800 pixel resolution**
- **4M or 32M bytes of physical memory**
- **A 155M- or 348M-byte Winchester disk drive**
- **A 1.2M-byte diskette drive**
- **A 60M-byte, 0.25-inch cartridge tape drive**
- **Three RS-232-C serial ports as standard and expansion options for Centronics parallel interfaces and additional RS-232-C interfaces**
- **Interfaces to the Apollo Token-Ring or IEEE 802.3 Ethernet network**
- **Domain workstation communications options for communications across X.25 media and SNA communications lines**

The DN570 runs at a speed of 1.3 MIPS and features a 15-inch color workstation display with a 1,024-by-800 pixel resolution. The DN580 has a 19-inch color workstation display with a 1,280-by-1,024 pixel resolution. The DN570 Turbo workstation operates with a performance rating of 2.5 MIPS and features a 15- or 19-inch color display with a 1,024-by-800 pixel resolution. The DN580 Turbo drives applications at 2.5 MIPS and uses a 19-inch color workstation display with a 1,280-by-1,024 pixel resolution. The DN590 Turbo workstation runs at 3.5 MIPS and accommodates a color workstation display.

All DN500-type workstations accommodate the following:

- **2M or 4M bytes to 16M bytes of physical memory**
- **A mass storage controller supporting one or two 154M-byte Winchester disk drives**
- **ESDI mass storage controllers supporting one or two 348M-byte Winchester disk drives**
- **Mass storage controllers supporting up to four 442M-byte Winchester disk drives**
- **Cartridge and reel tape drives**
- **Two RS-232-C serial ports as standard and expansion options for Centronics parallel interfaces and additional RS-232-C interfaces**

The DSP90, DSP500, DSP3000, DSP3040, DSP4000, and DSP9000 are workstation servers, expanding network resource sharing capabilities. They off-load compute, data

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installed in the technical workstation computing arena. In contrast, Apollo reports that there are approximately 45,000 Domain systems in the same market.

Apollo is still chasing Sun—it will probably do so unless Sun somehow falters. Because Sun has shown continued progress in revenue, profit, and market share growth and has strongly demonstrated its desire to remain the market leader, it will not be easy for Apollo to regain the market dominance it once had.

COMPETITIVE POSITION

Although the Domains can be positioned against a variety of technical workstation products from an array of vendors—including Digital Equipment, Hewlett-Packard, and IBM—Apollo's primary competition is provided by Sun Microsystems.

Apollo and Sun account for over 50 percent of the marketplace activity. Thus, the strategies and tactics used by both vendors are oriented towards taking sales away from each other.

When comparing individual workstation capabilities, Datapro finds that neither line has a complete advantage over the other in price/performance and processing capabilities. For example, the DN4000, a high-performance, desktop workstation, provides more disk and memory, capacity to accommodate graphics and data base applications than the Sun-3/60, Sun's high-performance, desktop workstation. The DN4000 supports up to 348M bytes of disk storage and 32M bytes of memory, while the Sun-3/60 only accommodates up to 282M bytes of disk storage and a maximum memory capacity of 24M bytes. Furthermore, the DN4000 provides more MIPS than the Sun-3/60—4 versus 3. The display resolution on the DN4000 is better than that of the Sun-3/60—1,280-by-1,024 pixels versus 1,152-by-900 pixels. However, the DN4000 is priced higher than the Sun-3/60. The DN4000 costs $5,700 per MIPS for a basic system configuration; in contrast, the Sun-3/60 costs $4,300 for a similar configuration.

When the DN590 Turbo—Apollo's top-of-the-line Domain workstation—is compared to the Sun-3/260, it is found that the Sun-3/260 supports more memory (32M bytes) than the DN590 (16M bytes) but less disk storage (1.1G bytes versus 1.3G bytes). The DN590 Turbo offers a greater display resolution than the Sun-3/260—1, 280-by-1,024 pixels versus 1,152-by-900 pixels. The Sun-3/260 offers more performance (4 MIPS) than the DN590 Turbo (3.5 MIPS). Moreover, the Sun-3/260 is more cost effective than the DN590 Turbo. For a basic system, the Sun-3/260 costs $14,450 per MIPS, while the DN590 Turbo is priced at $19,913 per MIPS.

The Domain workstation product line does not provide as strong a growth path as the Sun workstation product line. For instance, Domain workstations range in performance

storage, peripheral, and communications services from individual workstations or provide a cluster of workstations with extra compute power, data storage, peripheral, and communications options.

The DSP90 can be configured with the following:

- 2M or 3M bytes of physical memory
- One to five Multibus-compatible I/O or communications subsystem controllers or attachments
- Multibus-compatible mass storage units—i.e, 442M-byte Winchester disk drives
- Cartridge and reel tape drives
- Two RS-232-C serial ports as standard and expansion options for Centronics parallel interfaces and additional RS-232-C interfaces

The DSP500 is available in a choice of compute server or file server configurations. Three file server packaged systems are available: with 8M bytes of physical memory, 696M bytes of mass storage, a 60M-byte cartridge tape drive, and a VME- or Multibus I/O bus; with 8M bytes of physical memory, 696M bytes of mass storage, and a VME- or Multibus I/O bus; and with 16M bytes of physical memory, 696M bytes of mass storage, a reel tape drive, and a VME- or Multibus I/O bus.

Two DSP500 compute server packaged systems are available. The first includes 16M bytes of physical memory, a 348M-byte Winchester disk drive, a 60M-byte cartridge tape drive, and a floating point accelerator. The second includes 32M bytes of physical memory, a 348M-byte Winchester disk drive, and a floating point accelerator.

The DSP3000 and DSP4000 each accommodate up to eight workstations. The architectures of the DSP3000 and DSP4000 resemble those of the DN3000 and DN4000, respectively. The DSP3000 and DSP4000 run at speeds ranging from 2 MIPS to 4 MIPS and support up to 8M bytes of physical memory; a 72M-, 155M-, or 348M-byte Winchester disk drive; a 60M-byte cartridge tape drive; and RS-232-C and Centronics ports. A workstation display and keyboard are not usually provided; however, they can be placed on the system for system administration tasks.

The DSP9000 provides compute, mass storage, peripheral, and communications servers for up to 125 workstations. It accommodates one to eight 4.45-MIPS computational elements, 2M to 256M bytes of physical memory, and Multibus-compatible mass storage options for up to 1.6G bytes of mass storage.

All the Domain DN workstations and DSP servers can be configured to run on either the Apollo Token-Ring Network (formerly called the Domain Network) or IEEE 802.3 Ethernet network. Also, options are provided for attaching to X.25 or SNA data communications lines.

CHART A, CHART B, and CHART C and the information provided in the CENTRAL PROCESSOR, I/O CONTROL, I/O UNITS and COMMUNICATIONS CONTROL sections of this report provide more detailed configuration information.

INPUT/OUTPUT UNITS

CHART B describes the Winchester disk drives used on the Domain System workstations and servers.

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from 1.2 to 3.5 MIPS. In contrast, the Sun workstations range in performance from 1.5 to 10 MIPS.

When comparing the individual capabilities of the resource/departmental servers, Datapro finds that some of the Domain servers offer advantages in price/performance, cost-effectiveness, and configurability when compared to Sun servers, while others do not. For example, the DSP9000, the top-of-the-line Domain server, provides up to 35 MIPS and can accommodate approximately 125 workstations. In contrast, the Sun-4/280 server runs at 10 MIPS and accommodates only about 50 workstations.

When the DSP3000 is compared to the Sun-3/60 SunServer workstation server, it is found that the DSP3000 offers 1.8 times more disk capacity than the Sun-3/60 SunServer—a 384M-byte capacity versus a 282M-byte capacity. However, it is lacking in compute power. The DSP3000 is rated at 1.2 MIPS; the Sun-3/60 SunServer is rated at 3 MIPS. Furthermore, the DSP3000 is lacking in workstation support. The DSP3000 accommodates up to 8 workstations, whereas the Sun-3/60 SunServer provides disk storage, printer, communications, and compute services for 6 to 15 networked workstations. Moreover, the DSP3000 is not as cost effective as its competitor. The DSP3000 costs $14,450 per MIPS, whereas the Sun-3/60 SunServer costs $4,967 per MIPS.

The Domain workstation server product line demonstrates greater growth potential when compared to the Sun servers. For instance, the Domain workstation servers range in performance from 1.2 to 35 MIPS and accommodate up to 125 workstations. In contrast, the Sun workstation servers range from 1.5 to 10 MIPS and only accommodate up to 50 workstations.

Both Apollo and Sun offer transparent network resource sharing and peer-to-peer or requester-to-server distributed applications processing capabilities. Apollo uses its Network Computing System (NCS) package or Sun's Open Network Computing (ONC) program to achieve transparent resource sharing and distributed application processing. Sun uses its ONC package or NCS to achieve competitive networking capabilities.

By giving LU6.2 capabilities to the Domain workstations and servers, Apollo is attempting to provide greater networking capabilities than the Sun workstations and servers. The Sun workstations and servers do not support LU6.2. The LU6.2 communications capabilities eliminate the overhead and complexities for workstation-to-IBM or SNA-host system communications.

These and other competitive advantages of the Domain systems, together with Apollo's market distribution, new product development directives, and systems support programs, continue to help Apollo accumulate sales. However, we do not see Apollo displacing Sun as the market leader. Apollo has just started to put together a program to do what Sun has been doing for a while—producing innovative, market-leading products. Furthermore, as we have

The specifications for the display monitors used on the Domain Systems workstations are presented in CHART C.

The specifications for Apollo Computer-supplied printers and magnetic tape drives are provided below.

Apollo Computer provides four types of magnetic tape drives for software loading, file backup, archival storage, and data interchange. The 0.25-inch cartridge tape drive stores up to 60M bytes of data on a removable cartridge. The *MDS-1600* is a 25-inch-per-second (ips), 1600 bit per second (bps), nine-track tape drive. The *MSD-6250* is a 25-ips, 6250/1600 bpi, nine-track tape drive. The fourth type, a nine-track model, reads and writes at either 800, 1600, or 6250 bpi.

Hard copy devices include a multimode printer/plotter (MMP) and a laser printer. The HCD-MMP employs dot matrix character formation technology and outputs copy at up to 500 characters per second (cps). Resolution is 72 by 72 dots per inch (dpi).

The *HCD-LP26S+* laser printer outputs copy at 26 pages per minute (ppm). Resolution is 300 dpi.

OTHER PERIPHERALS: In addition to using Apollo-supplied peripheral units, customers can employ third-party devices. Available devices include peripheral storage devices, printers and plotters, displays, graphics equipment, laboratory automation equipment, and factory automation equipment.

Users that connect specialized devices or non-Apollo peripherals to their system can use the General Purpose Input/Output (GPIO) software to write the device drivers required for device or peripheral connectivity and functionality.

COMMUNICATIONS CONTROL

Communications among systems occur over the RS-232-C media, Apollo Token-Ring LAN, IEEE 802.3 Ethernet LAN, X.25 media, or SNA facilities.

In addition to supporting printers, plotters, data collection equipment, and realtime or special-purpose peripherals, the RS-232-C serial communications lines, attached to the Domain RS-232-C ports, can be used for local UNIX-system-to-UNIX-system communications (i.e., UNIX electronic mail, virtual terminal functions, and file transfer).

The *Apollo Token-Ring Network Interface* is a LAN communications processor that allows a Domain system to communicate with other systems on the Apollo Token-Ring Network—Apollo's 12 bps token-passing bus network. The LAN processor provides the hardware resources and protocols for data link, media access, data transmission, and data reception services.

The *Apollo 802.3 Network Controller* connects a Domain system to an IEEE 802.3 Ethernet network. The LAN processor implements the IEEE 802.3-specified data link, media access, data transmission, and data reception services for communicating with similar and dissimilar systems. The TCP/IP protocol and related communications services are supported by the Apollo 802.3 Network Controller.

The *Domain Networking Ethernet Gateway* contains the a controller, intelligent transceiver, control software, and TCP/IP software for allowing a cluster of networked Domain

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shown, Domains are weak in some areas of price/performance and capabilities when compared to competing Sun products. Those weaknesses will keep Apollo from unseating Sun from its position of primacy in the technical workstation market.

ADVANTAGES AND RESTRICTIONS

The most significant advantage of the Domain systems is their communications and networking capabilities. The communications and networking scheme has many distinguishing factors that make them a desirable tool for distributed processing.

To begin, Domain workstations are network independent—there are choices for local area networking. Intergroup workstation networks at the departmental level are linked by either the proprietary Apollo Token-Ring LAN or the industry-supported IEEE 802.3, TCP/IP-based Ethernet.

Aegis and Domain/IX operating systems and associated network control facilities allow Domain system users on a workgroup or departmental network to transparently share the entire network's resources. The network provides a user with a single-system image of the files and programs running on the network. Users access remote files and programs as though they resided on the local workstation.

The Domain networking architecture provides the openness required for departmental processing. The Domain-PCI package links IBM PCs and compatibles to Domain computers running on an Apollo Token-Ring or IEEE 802.3-recommended TCP/IP Ethernet network, allowing the PCs to access Domain programs, files, and peripherals. The UNIX uucp command provides electronic mail, file transfers, and remote logins and command executions over RS-232-C cabling or LAN media. The TCP/IP, ONC, RFS, MAP, and TOP protocols and the facilities conforming to the OSI ISO communications model provide industry-standard tools for conducting remote logins, remote command executions, data transfers, and file transfers between similar or dissimilar systems running on IEEE 802.3 Ethernet or using X.25 communications facilities.

The Apollo-supplied SNA emulators permit the Domain workstations to do remote logins, file transfers, and program-to-program communications with IBM System/370-architecture mainframe and supermini host systems having MVS or VM operating systems. The DECnet communications facilities permit the Domain workstations to interact with DECnet-connected Digital Equipment computers. The XCOM6.2 performs file transfers between Domain systems and IBM mainframes, IBM System/3X minicomputers, PCs, Digital Equipment MicroVAX systems, and DECnet and SNA gateways using the industry-supported LU6.2 protocol.

systems with shared access to existing IEEE 802.3 Ethernet transport facilities. With this facility, Ethernet- or Apollo Token-Ring-networked Domains to share information with workstations, mid-range, and large-scale systems on other Ethernet networks.

The *Domain X.25 Gateway* package contains the facilities for connecting a single Domain system or a cluster of networked Domain systems to international public packet switching networks or private X.25 networks for remote or long-distance communications. Included in the package is the intelligent communications controller, line interfaces, two synchronous lines, the X.25 protocol with extensions, and two modem cables, and control software.

The *Domain/ComController* is an intelligent Multibus card that lets Domain systems interface with IBM and IBM-compatible Systems Network Architecture (SNA) environment. The Domain/ComController card supports two interface ports. A single port can be used at 19,200 bits per second (bps); both ports can be used simultaneously at 9600 bps on each port.

The Domain/ComController supports both the IBM 3274-1C cluster controller and a SDLC data link interface. Either the 3274-1C or the SDLC data link interface can be connected to a Domain/ComController port for communications with IBM SNA computers.

SOFTWARE

OPERATING SYSTEMS: There are two operating systems available for the Domain systems: Aegis and Domain/IX. Aegis and Domain/IX can run independently of one another, or they can run concurrently.

***Aegis* is a proprietary multiprogramming, multitasking operating system that features the following:**

- **Virtual memory support for direct execution of large programs**
- **Network-distributed file system with access control list security and protection facility**
- **Support for sharing CPU power, peripherals, and communications with workstations connected to the Apollo Token-Ring LAN or IEEE 802.3 Ethernet LAN**
- **Concurrent, multiwindow Display Manager Environment providing "virtual terminals" and screen-oriented editing to programs, text, and graphics**
- **Interprocess communications, process creation, and event synchronization to coordinate execution of separate programs**
- **On-line HELP facility, including documentation of access to system services**
- **Shell command line interpreter for running system operator jobs and system administration tasks**

Apollo's *Domain/IX* is a combination of AT&T UNIX System V and Berkley 4.2 UNIX. It contains the kernels; programming environment; command shells; and file manipulation, communications, text processing, programmer's workbench, and system administration utilities of both de facto industry-standard operating systems. Applications written for either System V or Berkeley 4.2 can be executed using Domain/IX. System V applications are executed in

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One of the most important components within Apollo's open system approach to networking is the IEEE 802.3, TCP/IP Ethernet LAN. This Ethernet is one of the most popular forms for interconnecting information systems and workstations—especially at the departmental level. By employing such a network, the Domain workstations and servers have a common communications channel for interacting with other technical workstations, with office workstations and IBM PC and PC-compatible microcomputers, and with host computers.

Support for Sun Microsystem's Open Network Computing (ONC) platform enables Apollo to communicate with systems supporting that communications platform. It is important for Apollo to have ONC for the Domains because almost all the major vendors have incorporated it, or a subset of it, into their repertoire of communications solutions. Those using ONC, or a portion of ONC (like the NFS file system), can perform file transfers, remote logins, and remote command execution with each other transparently.

The MAP and TOP protocols enable the Domains to address specific communications requirements within the manufacturing, engineering, and research and development applications environments.

The SNA and DECnet emulators are also important. Such facilities are needed in those departmental or distributed processing environments where workstations are frequently called upon to access data, files, and application services residing in IBM MVS or VM environments or Digital Equipment VAX/VMS environments.

Of special significance within the Domain-SNA channel is the LU6.2 protocol with a PU2.1 support facility for peer-to-peer communications. This facility reduces the complexities and performance degradations experienced when host intervention is required for interconnecting systems, sharing resources, uploading and downloading files, and passing data between programs. Moreover, it offers a transparent interface between Domains and IBM System/370 mainframes and System/3X minicomputers for distributed processing tasks.

Of similar significance within the Domain-DECnet channel is Domain/Access. This facility allows resource sharing between Domains and VAX/VMS systems, offering a transparent interface for distributed processing tasks.

The Domain workstations bring mainstream personal computing to the Domain computing environment. PC-compatibility products include the Domain-PCI, Domain/PC Emulator, and a PC co-processor option. With the Domain-PCI package, as mentioned previously, mainstream personal computing is delivered to the Domain computers via Apollo Token-Ring or IEEE 802.3 Ethernet networking. The Domain/PC Emulator software product enables MS-DOS applications to execute on the **the System V mode and Berkeley 4.2 applications are executed in the Berkeley 4.2 mode. System V and Berkeley applications can run independently of one another or concurrently.**

Besides containing the System V and Berkeley 4.2 facilities, utilities, and tools, Domain/IX also features facilities designed specifically for the Domain environment. Of special significance are the modifications made for distributed processing. The UNIX file system has been enhanced for distributed processing; that is, it has been developed into a network file system.

The UNIX file system of a Domain network appears to all users as a single file structure, although the data may be located on various system nodes. With Domain/IX, any workstation or server can demand pages from anywhere in the network—eliminating the need for a local disk for every workstation.

Furthermore, Domain/IX provides transparent sharing of CPU power, peripherals, and communications among workstations connected to the Apollo Token-Ring LAN or IEEE 802.3 Ethernet LAN. Aiso, the Aegis communications options listed in the COMMUNICATIONS subsection can be employed under the Domain/IX environment.

Other features of Domain/IX include a wide range of graphics libraries; support of bit-mapped monochromatic and color displays; advanced windowing system; improved system administration; and improved online documentation and reference services.

DATA BASE MANAGEMENT: Apollo offers two data base management systems to Domain users: Oracle and D3M.

***Oracle*, developed by the Oracle Corporation from California, is offered to users through Apollo's Software Supplier Program. A relational data base, Oracle provides high-level data manipulation and query facilities that operate on sets of records simultaneously.**

Apollo's *Domain Distributed Data Management (D3M)* data base management system is specifically designed for the distributed processing environment. It allows users to organize and access information located anywhere in a Domain processing network. Users may combine whole or partial views of many individual data bases into a single, logical data base for both query and update purposes.

Features of D3M include Codasyl-compliance with relational access functions; distributed data base support with aggregate schemas; ease of use features that include query with update functions, automatic subschema generation, implicit disk allocation, and electronic file drawer (no programmer needed); program callable relational query functions; and distributed recovery and concurrency control.

D3M is comprised of a set of software packages. Included is a query/update language; report writing package; an interactive, form- and command-driven data base description tool; an aggregate schema compiler to create logical combinations of multiple data bases located anywhere in a network; a runtime library for binding applications to 3DM; and data base maintenance utilities.

LANGUAGES: Pascal, Fortran-77, C, and Lisp are supported on the Domain systems.

COMMUNICATIONS: Domain networking encompasses Apollo Token-Ring Network (formerly entitled the Domain

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MC68020-based Domain central processor; PC co-processor boards or options are not required. A PC co-processor option—complete with a PC co-processor board—permits MS-DOS applications to run in a display window on DN3000 and DN4000 workstations.

The PC-compatibility products preserve investments in MS-DOS application and file systems. Customers can upgrade to Domain workstations from PCs and compatibles without sacrificing investments in PC applications or data bases, or they can add Domain workstations to a PC environment without creating a network of incompatible systems.

Another advantage centers around the software environment. The Domain systems deliver a flexible operating environment for business, technical, and professional support computing. Users select the operating system that best suits application needs.

Aegis is available for those customers whose applications and task-handling requirements can be met with a proprietary operating environment. However, the proprietary facilities of the Domain systems—the Aegis operating system, D3M data base, and Apollo Token-Ring LAN—can increase the cost of using the system. Apollo's proprietary tools limit application portability options and narrow the applications base. The proprietary architecture also makes it more expensive to migrate from one type of architecture to another.

Domain/IX is available for those customers whose applications and task-handling requirements cannot be met by Aegis or for those who require an operating system based on UNIX. Domain/IX brings both AT&T UNIX System V and Berkeley 4.2 BSD UNIX capabilities to the Domain system.

Customers also have the option of configuring a Domain system with both Aegis and Domain/IX; i.e., Aegis and Domain/IX can reside on the same machine. The operating systems can run independently of one another or concurrently.

Running both Aegis and Domain/IX on the same Domain computer preserves the life of existing applications systems, widens the applications base, and increases operational capabilities.

Applications availability is not a problem with the Domain series. A variety of third-party vendors have developed production-run software for the Domain system architecture and have taken existing software programs and modified them for the Domain workstation. The applications base covers both commercial and technical computing disciplines—for instance, office automation, electronic publishing, econometrics, financial planning and analysis, manufacturing resources management, architectural and civil engineering, artificial intelligence, physical sciences, factory automation, and mechanical and electrical engineering applications are provided. (For

Network), IEEE 802.3 Ethernet, X.25, TCP/IP, MAP, TOP, NFC, NFS, RFS, DECnet, VT100, RJE, BSC, SNA, and LU6.2 communications. In addition to exchanging information with entry-level, low-end, mid-range, and large-scale departmental and organizational systems and other technical workstations, the Domain systems can exchange information with IBM Personal Computers.

Apollo Token-Ring LAN link, media access, data transport, and presentation software facilities are incorporated into the operating systems. IEEE 802.3 Ethernet network interface software works in conjunction with the operating systems to perform Ethernet networking support for Domain nodes that are directly connected to IEEE 802.3 Ethernet networks.

***Domain Networking-Ethernet Gateway* software supplies the control code for the Ethernet gateway and provides the resources for file transfers, remote logins, and remote command execution.**

***Domain X.25 Gateway* software enables a Domain system or a cluster of Domain computers to access a system on international public packet-switching networks or on private X.25 networks. It includes a file transfer service and facilities for virtual terminal.**

The *Network Computing System (NCS)* is a set of distributed computing products for developing and running application programs across networks of multivendor computers. It distributes modules, or parts, of a single application program to those departmental or enterprise systems and specialized computers best suited for a task—minicomputers, mainframes, superworkstations, compute servers, artificial intelligence engines, data base machines, automatic test equipment, simulators, parallel computers, and supercomputers. With NCS, application processes are off-loaded to another system to gain higher levels of computer interactivity.

NCS performs intervendor program-to-program communications by using the TCP/IP, MAP, TOP, NFS, RFS, Apollo Token-Ring Network, IBM SNA, and DECnet protocols and the following components:

- **Remote Procedure Call Runtime Environment—handles packaging, transmission, reception of data, and error correction between the client and server subroutines**
- **Network Interface Definition Language—allows application programmers to create remote computing facilities across heterogeneous computer networks**
- **Network Interface Definition Compiler—compiles Apollo's Network Interface Definition Language into a portable C language source code which runs on both sides of the connection (client and server computers)**
- **Location Broker—lets application programs determine at runtime (during program execution) which of the network's remote computers can provide the required services to the client computer**

Currently, NCS is supported fully in environments with MS-DOS-based microcomputers; Sun Microsystems SunOS-based workstations; UNIX System V computers; Berkeley UNIX systems; Digital Equipment VAX/VMS and ULTRIX-32-based systems; Cray supercomputers; Alliant, Convex, and Multiflow Computer minisupercomputers; and Ridge Computers high-end superminicomputers. Source code has been provided for the aforementioned products so they can participate in NCS with Domain systems.

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details on Domain systems for a manufacturing or engineering perspective, refer to the *CAD/CAM/CAE Systems* volume of *Datapro's Manufacturing Automation Series.*)

Application accessibility is heightened through Apollo's efforts to distribute applications from some of the solution suppliers. For example, Apollo offers DocuGraphix Automated Documentation and Management System—a document processing system—and Prophecy Development Corporation's Contessa—an analysis and planning system for financial traders and analysts in brokerage and security industries. Also, Apollo's *Catalogue of Applications for Domain Systems* gives customer access to packaged software from third-party solution suppliers.

In addition to end-user software, systems and applications development software from third parties is available, offering more performance and functionality than Apollo-developed tools. For example, Focus, a fourth-generation language and data base management system from Information Builders and Unify's Acell application development system are available.

In addition to acquiring third-party software, Domain users also can obtain third-party add-on hardware. Customers have access to application- or environment-specific hardware products which Apollo does not manufacture or distribute, peripherals Apollo does not produce, or alternatives to Apollo peripherals. Included are co-processors, I/O peripherals, interface devices and controllers, and storage drives.

By using merchant components and industry-standard facilities—such as PC/AT, VSEbus, Multibus I/O support—in the Domain systems and promoting the usage of an operating system that is compatible with the industry-supported AT&T UNIX System V and Berkeley 4.2 UNIX, Apollo can reduce the cost of migrating from or to another vendor's system that employs those facilities. In addition, these commonly available facilities enable Apollo to provide Domain system users with access to numerous low-cost peripherals and a broad applications base.

The Domain systems offer a growth path for both workstations and servers; however, upgrades are expensive. Because there are no field upgrade options, customers must reinvest in processors and in some peripherals when moving to the next highest performance model.

USER REACTION

Datapro's 1987 Computer Users Survey elicited responses from eight Domain system users. Their systems had an average installed life of 28 months. Some of the models included in the ratings are no longer actively marketed by Apollo. Four users had purchased their systems and two rented or leased from Apollo; and two leased from a third party.

Support for Sun Microsystems' Open Network Computing (ONC) enables Apollo to communicate with those systems supporting that communications platform. ONC provides the RPC, XDR, and NFS protocols and programs for transparent remote login, remote command execution, data transfer, and file transfer.

Apollo's version of the Manufacturing Automation Protocol (MAP) and Technical Office Protocol (TOP) programs allows the Domain systems to communicate with those systems using MAP or TOP communications on IEEE 802.3 Ethernet.

***Domain/VACCESS* is a transparent communications product that supports file transfer, file management, and remote login to Digital Equipment VAX/VMS systems over Department of Defense standard TCP/IP and industry-standard Ethernet protocols.**

***VT100 Terminal Emulator* emulates a Digital Equipment terminal and allows communications through RS-235-C ports and Ethernet.**

***RJE Access Gateway* provides shared access to HASP, 2780, 3780 environments from Domain workstations.**

***Domain/LU6.2*, based on IBM's SNA LU6.2 and PU2.1 communications protocols and facilities, extends the Domain systems' communications capabilities to include support for LU6.2 program-to-program communications (Advanced Program-to-Program Communications, or APPC), PU2.1 peer-to-peer connections, and PU2.0 connections. It provides a set of system calls implementing the LU6.2 Application Program Interface (API) for direct access to IBM-based, non-IBM systems, and Apollo workstation resources.**

The *Domain/SNA-3270 Emulator* allows Domain systems to emulate any mix of IBM 3278 Model 2, 3, 4, or 5 terminals and the four-color Model 3279 terminals. The emulator also allows Domain systems to log on to remote IBM or IBM-compatible host computers and transparently gain access to their resources.

***The Domain 5080 Emulator* emulates an IBM 5080 graphics subsystem terminal, allowing users to simultaneously run both mainframe and workstation applications from the same workstation display. The 5080 Emulator uses graphics software to emulate all 5080 graphics order codes and display-list functionality, while supporting Graphics Service Routines (GSR) to take advantage of the graphics hardware on each Domain workstation.**

***XCOM 6.2* provides file transfer capabilities among Apollo workstations and IBM mainframes, System 3X minicomputers, PCs, Digital MicroVAX systems, and DECnet SNA gateways. At the mainframe level, XCOM 6.2 allows transmission from an IBM VTAM application that implements native LU6.2.**

***Domain/Bridge* is a high-speed communications bridge that provides a link between Domain network rings. This connection can be via T1 and equivalent common carrier services, as well as via local area networks, microwave links, fiber optic links, and PABX.**

***Domain/Personal Computer Interconnect (Domain/PCI)* links users of IBM and IBM-compatible PCs to the Domain system. Through the Domain/PCI product, PC users can access the distributed file system of a Domain network, along with system resources, such as printers and other peripheral devices.**

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Seven respondents reported that they had from one to five workstations. One installation had from 15 to 30 workstations.

Two respondents indicated that the systems were being used in a distributed departmental computing scheme—communicating with a host or another network of computer systems. Six said their cluster of workstations were an "island of automation"—used in a standalone mode of operation.

The responses received from these Domain system users represented multipurpose systems, thus justifying Apollo's attempt to address application processing needs other than just CAD/CAM/CAE. According to our survey, the Domains were used for business data processing tasks such as accounting, payroll, and business administration; professional support and high-productivity processing tasks such as software development, electronic publishing, advertising, and business planning; scientific research and interactive problem-solving tasks; and CAD/CAM/CAE tasks. Four respondents reported using either business data processing, professional support, or high-productivity processing applications. Two used their workstations for scientific research and interactive problem solving; another two used their workstations for CAD/CAM/CAE work.

All of the respondents cited in-house development as one of the means of obtaining software. In addition, the respondents said they also went to independent software houses and contract programmers for software. Three said they purchased software from independent software vendors. Six stated that some of their software came from Apollo. One reported that a contract programming firm was used to create software for the Domain workstation.

When asked about system operability and functionality, the respondents rated the Domains as follows:

	Excellent	Good	Fair	Poor	WA*
Ease of operation	5	3	0	0	3.6
Reliability of system	4	3	1	0	3.4
Reliability of peripherals	3	4	1	0	3.3
Maintenance service:					
Responsiveness	4	3	1	0	3.4
Effectiveness	4	3	1	0	3.4
Technical support:					
Troubleshooting	4	4	0	0	3.5
Education	1	7	0	0	3.1
Documentation	3	2	1	1	3.0
Manufacturers software:					
Operating system	4	3	1	0	3.4
Compilers & assemblers	3	4	0	1	3.1
Applications programs	1	7	0	0	3.1
Ease of programming	4	2	2	0	3.3
Ease of conversion	1	5	2	0	3.3
Overall satisfaction	3	5	0	0	3.4

*Weighted Average on a scale of 4.0 for Excellent.

UTILITIES: Included in the set of system utilities are font editors and program development tools such as a high-level debugger, a common code generator, and a binder.

In addition, an application development system is available. Apollo's *Domain Software Engineering Environment (DSEE)* includes a set of four integrated, interactive functions for the software engineer. The DSEE/History Management tool handles all the source code that makes up a project; it offers shared access to the past versions of multiple software modules. DSEE/Configuration Management monitors the construction of a system from its component parts. It controls multiple versions of systems, allows reconstruction of any original software configuration, and compiles the latest modules in the software cycle. Any dependencies in or changes made to an element are detected in DSEE/Advise Management. The advise management function automatically notifies the affected people or projects by adding predefined tasks to their task lists. The fourth tool is DSEE/Task Management, which relates an individual engineer's work to the goal of the organization as a whole.

The *Open Systems Toolkit*, a systems-level development package, can be used in either the Agis or Domain/IX environment. Using the Open System Toolkit, users "customize" the Agis operating system nucleus without modifying the system source code or rebuilding the operating system. Apollo maintains that users who are unfamiliar with the operating system source code can add new features to the operating systems. Users can add new devices, foreign systems, and file types.

***General-Purpose Input/Output (GPIO)* is another type of systems-level development software package. This software package permits Domain users to write device control software to support specialized devices or peripherals that are connected to the IEEE-796 Multibus or one of the RS-232-C serial ports. With GPIO, device drivers are written in a high-level language without concern for the underlying bus structure, assembly language, or other hardware specifics.**

The *Domain/PC Emulator* is an operating environment software package that brings mainstream personal computing to the Domain system. The Domain/PC Emulator is a software product that runs MS-DOS applications on any Domain workstation without additional hardware.

***Open Dialogue* is a windowing system built upon the industry-supported X Window System. It offers a standardized interface into several applications. With Open Dialogue, multiple applications and tasks can run while, simultaneously, local and remote sessions are accessed. Provided with each window are pop-up menus, icons, and graphics and mouse-driven commands.**

GRAPHICS SOFTWARE: There are several graphics processing control software packages available for the Domain.

The graphics functionality of the Domain systems revolves around *Graphics Metafile Resource (GMR)*. GMR integrates the Programmer's Hierarchical Interactive Graphics System (PHIGS) concepts and graphics with the compute power of the Domain workstations. GMS combines two high-level graphics subroutine libraries—2-D GMR and 3-D GMR. The two GMR libraries provide functions including interactive scaling and rotation; complex viewing; interactive drawing; editing and displaying of objects; and picking and highlighting. Graphics objects are created from elements including lines, arcs, circles, polygons, and meshes and labeled with either raster or vector text.

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Overall, despite the favorable ratings, not all of the respondents were totally committed to the Domain systems. When asked if the system did what was expected, seven of eight users stated that it did. However, only four plan future investments in Domain products. Furthermore, two of the eight respondents could not decide whether the Domain systems should be recommended for purchase.

To supplement our survey findings, we telephoned two users. The first user we contacted was the director of data processing at a small market research and consulting firm which specializes in the consumer goods marketplace. The Domains are not networked to a host computer. They are used to run mathematics and statistical analysis programs and to produce documents for market research. In addition, they also run accounting, billing, payroll, and personnel administration applications and customer data bases.

The user stated that the firm moved from a Honeywell Level 6 to a network of Domains because of their performance and system operability.

The user reported that the workstation users were satisfied with the responsiveness and number crunching capabilities of the Domains. However, he also reported that the Domains have not been all that reliable. As a matter of fact, the director rated the Domains' reliability as "fair".

Furthermore, according to this interviewee, the company purchased the workstations when Apollo was experiencing rapid growth. The user believes that this had a negative impact on Apollo's system support, which was insufficient when his systems were first installed. The user stated, however, that Apollo's support has improved, but he was unsure whether he would recommend the system to another user.

The second user interviewed was a programmer at a small computer systems consultancy that specialized in developing and installing engineering systems. Domains were used to build software and to provide documentation. The Domains were not networked to any other computer system.

This interviewee gave the Domains high marks for performance and reliability. Furthermore, he complimented them on their user interface. He also said the programming staff liked the applications development tools provided by Apollo.

He stated that obtaining servicing for the Domains has been a problem. Apollo has been slow in providing troubleshooting service and sluggish in responding to service requests.

Overall, this interviewee would recommend the Domains for purchase. As a matter of fact, the manager is planning to purchase more Domain computers. □

2-D GMR provides functionality for two-dimensional applications such as integrated circuit design, PC board layout, and mapping. 3-D GMR offers specialized primitives and viewing functions for mechanical design, architectural applications, and molecular modeling.

GMR stores all graphics data in an editable tree-structured data base called the Graphics Metafile. GMR supports functions that allow users to build, edit, and display graphics objects in the data base in a precision format. Objects can be described in 32-bit integer (2-D) or 32-bit floating-point (3-D) world coordinate systems. The Graphics Metafile can be viewed simultaneously on workstations across a Domain network.

GMR permits users to display and manipulate multiple views of objects in the Metafile at the same time. Users can set up individual viewports which can be used to display all or part of a Metafile. Data in the viewports can be scaled, translated, and rotated. All viewports can be active at once—changes to the Metafile are reflected in all views simultaneously. 2-D GMR also supports a set of 2-D primitives including polylines, closed polylines or polygons, rectangles, circles, and curves. Additionally, users can define and use customized primitives.

***Domain Core Graphics System* is a set of user-callable subroutines that implement the 1979 GSPC Core Proposed Standard Graphics Software System. The Domain Core Graphics System provides programmers with a set of tools for designing graphics applications; it allows programmers to concentrate on developing applications rather than graphics system software. The Domain Core Graphics System adheres to the GSPC Proposal and supports the full range of 2-D and 3-D viewing and image transformations. It supports all Domain computational nodes, allows applications to be device-independent, and supports various types of input devices, such as the touchpad, mouse, data tablet, and keyboard.**

***Domain Graphics Kernel System (GKS)* is a set of user-callable subroutines that implement the proposed Graphics Kernel System (GKS) industry standard. Domain GKS package provides programmers with a high-level interface for incorporating graphics into application software. Domain GKS adheres to the GSPC Proposal and supports the 2-D and 3-D viewing and image transformations. It supports all Domain computational nodes, allows applications to be device-independent, and supports various types of input devices, such as the touchpad, mouse, data tablet, and keyboard.**

***Graphics Primitives Resource (GPR)* offers program developers a set of graphics routines for building graphics applications.**

***Graphics Service Routines (GSR)* is a direct hardware interface for customizing graphics application designs. Low-level graphics routines instructions and routines are made available to original equipment manufacturers (OEMs) and sophisticated end users for performance tuning their products.**

APPLICATIONS: Apollo produces and markets *Domain Professional Support Services (DPSS)*, an office automation system that offers word/text/document processing, electronic mail, spreadsheet, and professional productivity facilities. It is composed of the following modules: DPSS/Document, DPSS/Mail, DPSS/File, DPSS/Calc, and DPSS/Calendar. Each tool is accessible through a mouse-and-icon facility. All the DPSS tools can be accessed concurrently on the screen through Domain's windowing capabilities.

Apollo Domain Systems

A variety of applications are available from third-party vendors. There are approximately 1,200 applications solutions available for the Domain systems. Apollo's *Catalogue of Applications* for the Domain Systems lists over over 500 solution suppliers.

Applications from independent software houses and value-added suppliers cover the gambit of established technical processing markets. Applications cover areas such as architecture, construction, education, advertising, electronic publishing, financial analysis, econometrics, project management, electronic engineering, mechanical engineering, industrial engineering, artificial intelligence, software engineering, earth science, chemical engineering, and materials science.

OPERATING ENVIRONMENT

The dimensions for the Domain systems are as follows:

- Both the DN3000 and DSP3000 measure 7 inches high, 21 inches wide, and 17 inches deep; the DN3000 and DSP3000 each weigh about 52 pounds
- The DN570 and DN580 models each measure 24.5 inches high, 13.5 inches wide, and 28.5 inches deep; they weigh approximately 100 pounds each
- The DSP9000 measures 30 inches wide

The recommended operating temperature for the Domain nodes is between 60 and 90 degrees Fahrenheit at 20 to 80 percent relative humidity. The DN3000 and DSP3000 operates at 500 volt-amps. The DN570 and DN580 models operate at 120 V AC ±10 percent.

SUPPORT SERVICES

DOCUMENTATION: Included with a system purchase are manuals for hardware and operating system installation, operation, and system administration.

TRAINING/EDUCATION: Apollo offers a variety of "custom" support and training programs to meet individual customer requirements.

INSTALLATION: Depending on the number of workstations or nodes at a site, it is customary for an Apollo technical support staff member to install Apollo-supplied equipment. The support staff also tests the system. Because the Apollo Domain Systems support two operating systems—Aegis and Domain/IX—an operations manager and a team of programmers must initially install the operating systems since special programming must be performed to support the co-resident operating environment.

MAINTENANCE: The following maintenance schemes are available from Apollo:

- *System Maintenance Agreement (SMA)*—a set of product support services for Domain hardware and software. All parts and labor are included, as is toll-free telephone access to the Apollo Response Center for immediate usage and software advisory support. SMA also includes Aegis software updates and hardware engineering enhancements, including all parts and labor for Apollo-supplied system products. SMA provides fixed monthly maintenance costs
- *Domain Service Plus*—provides the same maintenance services as SMA, in addition to others. Additional services include response time of less than four coverage hours for on-site service calls, an optional second shift, and weekend and holiday coverage. Domain Service Plus only is available within 50 miles of designated Apollo offices in the U.S.
- *Shift Discount Addendum (SDA)*—provides cost savings to users with multiple workstations installed at one location. SDA offers priority access to Apollo's service resources and a discount schedule based on the user's total monthly maintenance charge
- *Volume System Discount Addendum*—provides cost savings to users who have many workstations installed in various locations. A customer receives one set of software update media and documentation and the right to distribute and execute updates on all licensed nodes covered by the addendum
- *Shared Maintenance Agreement*—a program for customers whose service business requirements preclude the use of an outside service organization. Shared maintenance customers take primary responsibility for maintenance of their Domain systems.

PRICING

POLICY: Apollo sells its products via direct sales; discounts are available for quantity purchases.

A detailed price list follows.

Apollo Domain Systems

EQUIPMENT PRICES

		List Price ($)	Monthly Maint. Cost ($)	Field Install. Charge ($)
All Domain computational nodes include a 32-bit processor, memory management unit, interface to the Domain network, integrated bit-mapped graphics display, and detachable keyboard. Bundled with each node is the license to use the Aegis and UNIX operating system, font editor, Graphics Metafile Resource, the Domain/Dialogue user interface management system, 2-D and 3-D graphics primitives, language debugger, software driver, VT100 emulators, Toolkit, and utilities.				
Series 3000 Personal Workstations				
DN3000	Series 3000 workstation with MC68020 processor and MC68881 floating-point co-processor, 15-inch monochrome monitor (1,024-by-800), 4MB memory, integrated IBM PC/AT-compatible peripherals bus, RS-232-C serial port, Token-Ring or Ethernet network interface, and Domain/IX	4,990	NA	NA
DN3000	Series 3000 workstation with MC68020 processor and MC68881 floating-point co-processor, 19-inch monochrome monitor (1,024-by-800), 4MB memory, integrated IBM PC/AT-compatible peripherals bus, RS-232-C serial port, Token-Ring or Ethernet network interface, and Domain/IX	5,990	NA	NA
DN3000	Series 3000 workstation with MC68020 processor and MC68881 floating-point co-processor, 15-inch monochrome monitor (1,024-by-800), 4MB memory, integrated IBM PC/AT-compatible peripherals bus, RS-232-C serial port, Token-Ring or Ethernet network interface, Domain/IX, and 72MB disk	9,490	NA	NA
DN3000	Series 3000 workstation with MC68020 processor and MC68881 floating-point co-processor, 15-inch color monitor (1,024-by-800, 4 color planes), 4MB memory, integrated IBM PC/AT-compatible peripherals bus, RS-232-C serial port, Token-Ring or Ethernet network interface, and Domain/IX	8,900	NA	NA
DN3000	Series 3000 workstation with MC68020 processor and MC68881 floating-point co-processor, 15-inch color monitor (1,024-by-800, 8 color planes), 4MB memory, integrated IBM PC/AT-compatible peripherals bus, RS-232-C serial port, Token-Ring or Ethernet network interface, and Domain/IX	11,300	NA	NA
DN3000	Series 3000 workstation with MC68020 processor and MC68881 floating-point co-processor, 19-inch color monitor (1,024-by-800, 4 color planes), 4MB memory, integrated IBM PC/AT-compatible peripherals bus, RS-232-C serial port, Token-Ring or Ethernet network interface, and Domain/IX	17,400	NA	NA
DN3000	Series 3000 workstation with MC68020 processor and MC68881 floating-point co-processor, 19-inch color monitor (1,024-by-800, 8 color planes), 4MB memory, integrated IBM PC/AT-compatible peripherals bus, RS-232-C serial port, Token-Ring or Ethernet network interface, and Domain/IX	19,800	NA	NA
—	2MB add-on memory for Series 3000 workstations	2,000	NA	NA
DN3000-C1	Series 3000 color workstation includes license to use Aegis and Domain/IX operating systems, MC68020 processor, MC68881 floating-point co-processor, 4MB memory, 15-inch resolution, 1,024-by-800 bit-mapped color display, RS-232-C port, IBM PC/AT-compatible bus, Domain ring interface, keyboard, and mouse	8,400	98	235
DN3000-C7-8MB	MC68020 processor and MC68881 floating-point co-processor, PC/AT-compatible bus, keyboard and mouse, desktop configuration, RS-232-C port, integrated networking, Domain/IX license, 15-inch, 60 Hz, 1,024 by 800 color display, 4-bit planes supporting 16 colors, 8MB main memory, 348MB Winchester disk, 60MB, and ¼-inch cartridge tape	24,900	227	300
Series 4000 Personal Super Workstations				
—	Series 4000 Personal Super Workstation with integrated 25MHz MC68020 processor and 25MHz floating-point co-processor, integrated IBM PC/AT-compatible peripherals bus, 3 RS-232-C serial ports, Token-Ring or Ethernet network interface, Domain/IX, 19-inch monochrome monitor (1,280-by-1,024), and 4MB memory	13,900	NA	NA
—	Series 4000 Personal Super Workstation with integrated 25MHz MC68020 processor and 25MHz floating-point co-processor, integrated IBM PC/AT-compatible peripherals bus, 3 RS-232-C serial ports, Token-Ring or Ethernet network interface, Domain/IX, 19-inch monochrome monitor (1,280-by-1,024), 8MB memory, 155MB disk, and diskette	23,900	NA	NA
—	Series 4000 Personal Super Workstation with integrated 25MHz MC68020 processor and 25MHz floating-point co-processor, integrated IBM PC/AT-compatible peripherals bus, 3 RS-232-C serial ports, Token-Ring or Ethernet network interface, Domain/IX, 15-inch color monitor (1,280-by-1,024, 8 color planes), and 4MB memory	18,900	NA	NA
—	Series 4000 Personal Super Workstation with integrated 25MHz MC68020 processor and 25MHz floating-point co-processor, integrated IBM PC/AT-compatible peripherals bus, 3 RS-232-C serial ports, Token-Ring or Ethernet network interface, Domain/IX, 15-inch color monitor (1,280-by-1,024, 8 color planes), 8MB memory, 155MB disk, and cartridge tape	33,900	NA	NA
—	4MB add-on memory for Series 4000 Personal Super Workstation	4,000	NA	NA
—	8MB add-on memory for Series 4000 Personal Super Workstation	6,500	NA	NA

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		List Price ($)	Monthly Maint. Cost ($)	Field Install. Charge ($)
DN570/DN580 Color Computational Nodes				
DN570-2MB	DN570 color computational node includes license to use Aegis and Domain/IX operating systems; MC68020 processor and MC68881 floating-point co-processor, 15-inch 1,024-by-800 color display, 2MB main memory, drawing processor, 8 planes display memory, 2 RS-232-C ports, Domain ring interface, and keyboard	39,900	304	340
DN580-8MB	DN580 color computational node includes license to use Aegis and Domain/IX operating systems; MC68020 processor and MC68881 floating-point co-processor, 19-inch 1,280-by-1,024 color display, 8MB memory, drawing processor, Domain ring interface, 8 planes display memory, 2 RS-232-C ports, and keyboard	49,900	410	340
DN570/DN580/DN590 Turbo Workstations				
DN570-8MB	DN570 Turbo High-Performance AI and ECAD Packaged System with 8MB of memory and 190MB of disk storage	46,900	NA	NA
DN570-8MB	DN570 Turbo High-Performance AI and ECAD Packaged System with 8MB of memory, 190MB of disk storage, and 348MB of ESDI mass storage	52,900	NA	NA
DN580-8MB	High-Performance ECAD and 2-D MCAD Packaged System: DN580 Turbo workstation with 8MB of memory and 190MB of mass storage	54,500	538	315
DN580-8MB	High-Performance ECAD and 2-D MCAD Packaged System: DN580 Turbo workstation with 8MB of memory and 348MB of mass storage	60,900	NA	NA
DN580-8MB	3-D Wireframe Packaged System, including a DN580 Turbo workstation with 8MB of memory, 3DGA, FPX floating-point accelerator, and 190MB of disk storage	63,900	NA	NA
DN580-8MB	3-D Wireframe Packaged System, including a DN580 Turbo workstation with 8MB of memory, 3DGA, FPX floating-point accelerator, 190MB of disk storage, and 348MB of ESDI mass storage	63,900	NA	NA
DN590T-8MB	8MB memory, 24 planes, 16-bit Z-buffer, FPX floating-point accelerator, 3DGA, and 190MB disk storage	69,900	NA	NA
DN590T-8MB	8MB memory, 24 planes, 16-bit Z-buffer, FPX floating-point accelerator, 3DGA, 190MB disk storge, and 348MB of mass storage	75,900	NA	NA
Domain Servers				
DSP90-2MB	Computational server processor includes license to use Aegis and Domain/IX operating systems; 68020 VLSI processor, 68881 floating-point co-processor, 2MB memory, 5 IEEE-796 slots, 2 RS-232-C ports, interface printer port, power supply, and Domain ring interface	16,000	150	315
DFS-90-2MB	File server with 500MB fixed storage capacity includes license to use Aegis and Domain/IX operating systems; 500MB disk storage and controller, DSP90 server processor with 2MB memory, MC68020 CPU, MC68881 FPA, 5-slot IEEE card cage, 2 RS-232-C ports, Domain ring interface, and power distribution unit	40,900	312	435
DSP3000-S	3000 server processor includes MC68020 processor and MC68881 floating-point co-processor, 4MB of memory, 348MB of memory, 5¼-inch Winchester disk, 60MB, ¼-inch cartridge tape drive and controller, 2 RS-232-C ports, IBM PC/AT-compatible bus, Domain ring interface, and Domain/IX and Aegis software licenses	17,490	NA	NA
DSP3000-S1	3000 server processor includes MC68020 processor and MC68881 floating-point co-processor, 4MB of memory, 72MB of memory, 5¼-inch Winchester disk, 60MB, ¼-inch cartridge tape drive and controller, 2 RS-232-C ports, IBM PC/AT-compatible bus, Domain ring interface, and Domain/IX and Aegis software licenses	12,990	129	340
DSP4000-S-4MB	4000 server processor includes MC68020 processor and MC68881 floating-point co-processor, 4MB, diskless, integrated IBM PC/AT-compatible peripherals bus, Token-Ring or Ethernet network interface, 3 RS-232-C ports, Domain/IX.	12,400	NA	NA
DSP4000-S-8MB	4000 server processor includes MC68020 processor and MC68881 floating-point co-processor, 8MB of memory, 155MB disk, cartridge tape, integrated IBM PC/ATcompatible peripherals bus, Token-Ring or Ethernet network interface, 3 RS-232-C ports, Domain/IX.	12,400	NA	NA
—	4MB add-on memory for the Domain Series 4000 server processors	4,000	NA	NA
—	8MB add-on memory for the Domain Series 4000 server processors	6,500	NA	NA
DSP9111	Entry-level configuration includes one computational element, I/O subsystem, 2GB virtual memory per process; operating systems including C compiler and EMACS editor, hardware and software for interfacing with Domain network, Fortran 77 compiler for single CPU, 8MB memory, 268MB disk and controller, cartridge tape drive, 2 Multibus chassis, and expansion cabinet	195,750	2,146	1,925
Multibus-Compatible Options				
MSD-500M	Fixed storage disk with 500MB capacity (442MB formatted) includes cabinet, controller, and cables; controller supports up to 2 drives	22,000	162	245
MSD-1600	Magnetic tape drive and controller, 1600 bpi, 25-ips, 9-track, in cabinet	10,500	147	215
Keyboard Options				
KBD-TPAD	Low-profile detachable keyboard with touchpad pointing device	400	5	NA
KBD-MSE	Low-profile detachable keyboard with mouse pointing device	150	2	NA

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Mass Storage		List Price ($)	Monthly Maint. Cost ($)	Field Install. Charge ($)
MSD-155M	155MB Winchester disk	4,700	54	340
MSD-190M	190MB 5¼-inch Winchester disk subsystem	5,000	80	340
Hard Copy Devices				
HCD-LP26C+	Domain/Laser-26 Centronics parallel version high-quality laser printer, 26 pages per minute, PostScript interpreter integrated into printer's controller, Centronics parallel interface for use with Multibus, controller board, and parallel cable for mounting into Multibus cage	34,900	295	235
Communications				
SFN-ACC-N	Domain/Access-1 Gateway software to provide transparent file access to a VAX/VMS system; hardware that mounts in a DSP80A, DSP90, DSP160, or a node equipped with Multibus controller board, cable, and transceiver	11,500	200	300
COM-PC18	Domain/PCI-8 personal computer interconnect. Allows the linking of 8 PCs to a Domain System network through a single host; provides transparent file access; bundled hardware/softare/documentation package	6,400	200	325
Miscellaneous Options				
DSP9000-CE	Computational element	54,000	250	440
—	15-inch color display to 19-inch color display	3,800	—	—

SOFTWARE PRICES

		List Price ($)	Basic Software Maint.* ($)	Right to Execute Maint.* ($)	Site Soft. Program Maint. 1* ($)	Site Soft. Program Maint. 2* ($)
Licenses to use both the Aegis and Domain/IX operating systems and selected other software programs are included with every node. Media and documentation for the Aegis operating system included at no charge for end users on the following nodes and servers: DN300, DN330, DN460, DN560, DN660, DSP80A, DSP80AR, DSP90, DSP90R, and DSP160. Software program licenses are on a per-node (-N suffix) or per-site (-S suffix) basis. Software programs are licensed to run on designated nodes or server processors. Software programs are licensed for up to 100 nodes at the designated site. A site consists of a building(s) within a half-mile radius.						
Programming Languages						
SFW-FTN-N/S	Fortran 77	1,000	50	5	85	105
SFW-PAS-N/S	Pascal	1,000	50	5	85	105
SFW-C-N/S	Domain/C	1,000	50	5	85	105
SFW-DSEE-N/S	Domain Software Engineering Environment (DSEE)	2,000	60	8	116	148
SFW-COMLSP-R	Runtime license for node (no site license available; no telephone support)	650	26	8	82	114
Operating Systems						
SFW-IX-UPG-N	Provides nodes purchased prior to Feb. 19, 1986 with AT&T UNIX license. Includes one set media and documentation for Domain/IX	485	—	—	—	—
SFW-IX-UPG-S	Provides sites with nodes purchased prior to Feb. 14, 1986 with AT&T UNIX license. Includes one set media and documentation for Domain/IX	9,100	—	—	—	—
Graphics						
SFW-CORE-N/S	Domain/Core Graphics Software	1,000	40	5	75	95
SFW-DIAL-N/S	Domain/Dialogue Programmer's Toolkit	1,200	60	8	116	148
SFW-4014-N/S	Domain/4014 Emulator	750	30	4	58	74
Hardware Support Applications						
SFW-VERS-N/S	Versatec V80 Software Driver Support	200	10	2	24	32
SFW-POST-VERS-N	Postscript Driver for Versatec V80 (node only)	1,040	42	5	77	97
SFW-POST-MMP-N	Postscript Driver for HCD-MMP (node only)	500	20	3	41	53
Communications						
SFW-GPIO-S	General-Purpose I/O Software (requires PNA or DSP80, DSP90, or DSP160) (site only)	2,000	80	10	150	190

The Field Installation Charge for software is based on the location of the site in relation to the Apollo Service Office. The rate is charged for each trip taken to complete the installation. The price for a site located within a 51-mile radius from the Apollo office is $90; 51-100, $180; 101-150, $270; and 151-200, $360. Consult Apollo for locations over a 200-mile radius.

**Basic Software Maintenance (BSM) and Right to Execute Maintenance (RTE) are available on previously licensed software program, per Node/DSP basis. Each software program covered by BSM receives software program updates with media and documentation, the right to executive software program updates on one designated Node/DSP, and one designated contact for telephone support. Each software program covered by RTE receives the right to execute software program updates on one designated Node/DSP. RTE software program updates must be acquired through an associated BSM Node/DS Site Software Program. Maintenance (SM1, SM2, SM3, SM4, SM5) is available for software programs previously licensed per node or site. Each software program covered by Site Software Program Maintenance receives software program updates on all covered Nodes/DSPSs and one designated contact for telephone support. For sites over 100 nodes, order one SM4 option, plus one SM5 option for each additional 25 nodes. Option SM4 is a prerequisite to one or more SM5 options for a given product at a given site.* ■