Apollo Domain Systems

MANAGEMENT SUMMARY

As the promise of the 32-bit supermini began to flower in the late 1970s, a group of small but aggressive minicomputer companies invaded the 32-bit market in the early '80s introducing powerful superminis with equally appealing support and pricing. One of these companies, Apollo Computer, Inc., introduced the Domain family of systems that includes the Models DN300, DN420, and DN600. A Domain system (often referred to as a "node" by Apollo) is part of an integrated computer environment that can consist of as few as one to as many as 200 workstations tied together by a high-speed, baseband communications network. In addition, each node has free access to data and programs stored at any other node.

The Domain systems are designed to perform in a wide range of technical and business environments that include: interactive computer-aided engineering and computer-aided design applications; engineering/scientific problem solving; computer-aided software engineering; publishing, making use of Domain's text processing, font generation, and graphics capabilities; interactive financial modeling, simulation, and statistical analysis; and computer-aided manufacturing.

Each Domain node includes a 32-bit processor; from .5 to 3.5 megabytes of main memory implemented with 64KB RAM technology with error checking and correction available; optional dedicated high-speed disk drives, line printers, and other peripherals; and a network-wide virtual memory operating system supporting up to 15 concurrent processes per mode, with each process able to address up to 16 megabytes of virtual memory.

The Apollo Domain Systems are a series of powerful, 32-bit computers that offer up to 3.5MB of main memory, multi-window graphics capabilities, and the ability to support multiple concurrent processes, with each process having a virtual address space of up to 16MB.

MODELS: DN300, DN420, and DN600.
MEMORY: .5 megabytes to 3.5 megabytes.
DISK CAPACITY: Up to 758 megabytes.
WORKSTATIONS: Over 200 computational nodes (workstations).
PRICE: $12,900 to $62,000.

CHARACTERISTICS

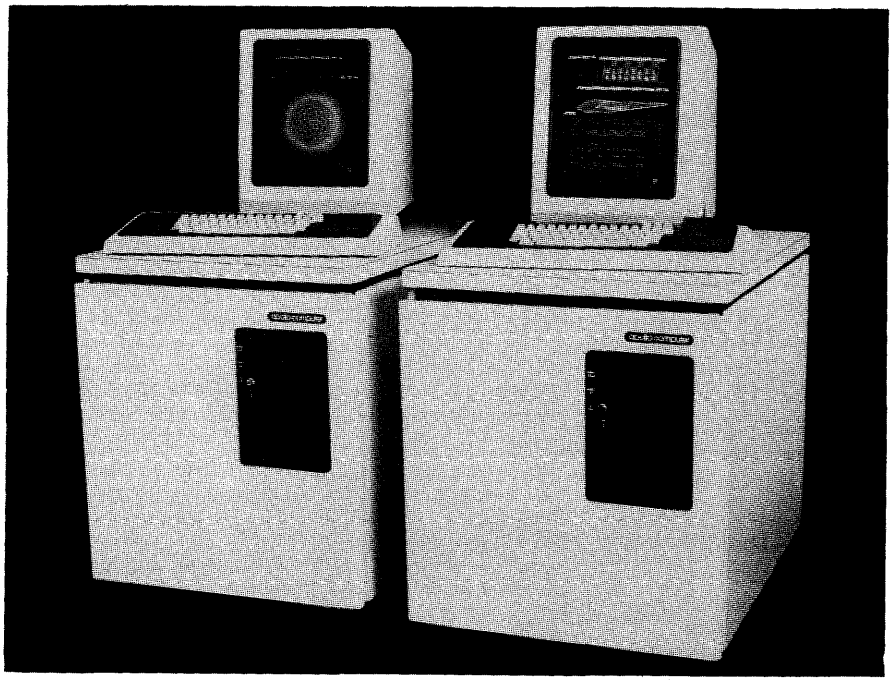
MANUFACTURER: Apollo Computer Inc., 15 Elizabeth Drive, Chelmsford, Massachusetts 01824. Telephone (617) 256-6600.

CANADIAN ADDRESS: At present, no Canadian offices.

DATA FORMATS

BASIC UNIT: 32-bit word; VLSI with demand paging hardware.

FIXED POINT OPERANDS: Byte, word, 32-bit longword and ASCII.



Apollo's Domain Systems, Models DN300, DN420, and DN600, are 32-bit VLSI systems that offer from 512KB to 3.5MB of main memory, up to 768 megabytes of disk storage, and the ability to support multiple concurrent processes, with each process having a virtual address space of up to 16 megabytes.

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APOLLO DOMAIN SYSTEM COMPARISON CHART			
MODEL	**DN300**	**DN420**	**DN600**
SYSTEM CHARACTERISTICS			
Date of Introduction	January 1983	November 1981	July 1982
Date of First Delivery	February 1983	December 1981	August 1982
Operating Systems	Aegis, Aux	Aegis, Aux	Aegis, Aux
Upgradable From	—	DN300	DN300, DN420
Upgradable To	DN420, DN600	DN600	—
MIPS	.5	.5	.5
Relative Performance (based on a rating of the DN300 at 1.0)	1.0	2.5	2.5
MEMORY			
Minimum Capacity (bytes)	.5MB	.5MB	.5MB
Maximum Capacity (bytes)	1.5MB	3.5MB	3.5MB
Type	MOS	MOS	MOS
Cache Memory	No	4KB	4KB
Cycle Time, Nanoseconds	200	200	200
Bytes Fetched Per Cycle	2	2	2
INPUT/OUTPUT CONTROL			
Number of Channels	1 block multiplexer	1 block multiplexer	1 block multiplexer
High-Speed Busses	Internal background, Domain network	Internal bus, Domain network	Internal bus, Domain network
Low-Speed Busses	None	IEEE-488, Ethernet	IEEE-488, Ethernet
Minimum Disk Storage	1.2MB	1.2MB	1.2MB
Maximum Disk Storage	35.2MB	758MB	758MB
Number of Workstations	200+	200+	200+
Communications Protocols	X.25, HASP, 3270	X.25, HASP, 3270	X.25, HASP, 3270

The DN300 Desktop computer is a single-user 32-bit system designed to put the high performance of a supermini on the user's desk. The DN300 can also become part of the shared-resource computing environment as one of the many workstations connected together by the Domain network. The DN420 and DN600 are large, multi-user systems designed to perform a variety of functions in a vast communications network. The systems are connected by a high bandwidth coaxial cable that allows resource sharing throughout the network.

A performance enhancement module (PEB) available with Domain systems contains both cache memory and a floating point processor on a single printed circuit board. The 4KB cache memory reduces effective memory cycle time while the floating point processor portion of the PEB

FLOATING POINT OPERANDS: Single (32-bit) and double (64-bit) precision floating point arithmetic functions. Apollo offers a performance enhancement board (PEB) that combines both a hardware floating point unit and a cache memory on a single 19″ x 19″ printed circuit board.

The 4KB, write through cache uses a two-way set associative structure and retains least recently used (LRU) information to achieve a cache hit-rate of approximately 90%.

The floating point unit, which uses a 2900 bit-slice technology, has been designed to conform to the proposed IEEE floating point standard. In addition to the traditional single (32-bit) and double (64-bit) floating point arithmetic functions, the processor has implemented several special purpose instructions, including a polynomial evaluation primitive, absolute value, negate, conversions between single and double precision, conversions from integer to floating point, and save and restore. Typical execution times for floating

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provides single precision (32-bit) and double precision floating point arithmetic functions, plus several special-purpose instructions, register-state save and store, and a polynomial evaluation primitive.

Two operating systems are available with Domain systems: Aegis and AUX. Aegis, a network-wide virtual memory operating system, is geared to support highly interactive operations. Domain's AUX—based on UNIX System III—runs as an autonomous subsystem in one or more of the available user processes.

The Domain programming environment includes ANSI-standard Fortran 77, Pascal, and C as well as a wide range of standardized software tools. Key software support capabilities include an advanced high-level language debugger; X.25, IBM Hasp and 3270 communications support; asynchronous ASCII terminal emulation; a font editor allowing users to interactively create and modify character sets and graphic symbols; and 44 graphics primitives callable from user programs. In addition, the Domain Distributed Data Management (D3M) system lets users organize and access information located anywhere in a Domain processing network.

A full range of peripheral devices is available for Domain systems. For high-speed, on-line mass storage, disk units available include 34-, 68-, 158-, and 300-megabyte disk drives. A full complement of line printers and letter-quality printers is also available, as are magnetic tape units. In addition, the Domain Server Processor, DSP80, lets users connect a wide variety of shared peripheral devices to a Domain system.

In addition to the Apollo software described above, a growing library of third-party software can provide support for scientific, engineering, modeling, CAD/CAM, and decision support applications.

COMPETITIVE POSITION

In the competitive 32-bit marketplace, the Apollo Domain systems must not only compete with the big guns in the industry including DEC's VAX-11 family, Data General's MV/family, Wang's VS Systems, Perkin-Elmer's 3200 Series, and Prime's 50 Series, but also the strong crop of newcomers that have invaded the industry in the '80s including the BTI 8000, Charles River Data Systems Universe Series, Convergent Technologies Megaframe, and Accelerated Data Systems Infinity series.

ADVANTAGES AND RESTRICTIONS

Apollo Computers is riding the crest of the current popularity of the powerful 32-bit superminicomputers. There are many attractive features of the Apollo Domain systems including its networking and graphics capabilities, and the ability to attach up to 200 nodes (or workstations) in a vast communications network. A single user can have the power of the 32-bit system at his desk with the desk-top Domain

point operations range from 2.8 microseconds for single precision addition, to 15.5 microseconds for double precision division.

INSTRUCTIONS: The instruction set of the processor includes both 32 bit data types as well as a 24 bit linear virtual address space.

MAIN STORAGE

GENERAL: The memory management unit (MMU) is a piece of hardware which translates the 24 bit virtual address spaces of the CPU onto the 22 bit physical address in the DOMAIN node. The MMU works on 1024 byte physical page sizes and has separate protection and statistics information for each page. The MMU is actually a two level hierarchy, the frame page table being at the highest level. A lower level cache, called the page translation table contains the most recently used pages and acts as a speed up mechanism to search the page frame table.

CAPACITY: The DOMAIN DN300 supports from .5 to 1.5 megabytes of main memory, while the DN420 and DN600 support from .5 to 3.5 megabytes of main memory. Sixteen megabytes of virtual address space per process can be supported, with up to 15 concurrent processes per user. The DN600 computational node supports an additional 2MB of dedicated dual-ported display memory.

TYPE: High-speed dynamic RAM.

CYCLE TIME: 200 nanoseconds.

CONTROL STORAGE: On the Domain performance enhancement board (PEB), the control unit is made up of a 1024 x 56 loadable control store, a 2910 bit slice microsequencer, which has a five-level deep subroutine stack, and fourteen 2903 ALU/register file devices.

CENTRAL PROCESSOR

GENERAL: The Domain central processing unit is built around a VLSI microprocessor with a 32 bit architecture. The instruction set includes both 32 bit data types as well as a 24 bit linear virtual address space. The physical parameters of the system, most notably the width of the data path, can be viewed in a hierarchical arrangement. At the system level, computer nodes are interconnected with a 1 bit serial packet network. Internal CPU registers and an arithmetic logic unit are all implemented with full 32 bit data paths.

The internal Domain node organization is comprised of several key parts. First, the CPU includes multiple VLSI packages. This CPU is connected to a memory management unit (MMU) which translates the 24 bit virtual address out of the CPU into a 22 bit physical address on the physical memory bus.

The MMU is composed of two parts: one for the CPU and another part for the I/O system. The memory system includes multiple units—each unit containing either ½ or 1 megabyte. Each unit is fully protected with error correction codes. The memory system is expandable to 3.5 megabytes.

REGISTERS: In addition to the 56-bit wide arithmetic logic unit (ALU), there are sixteen 56-bit registers used for command, control, and storage facilities.

ADDRESSING: Each Domain node supports up to 24 concurrent processes. Each of the processes is a 16 megabyte linear virtual address space. Various instructions access data within byte, word, and longword ranges.

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MASS STORAGE							
MODEL	MSD-300M	MSD-68M	MSD-158M	MSD-1.2M	MSD-34M	SMSD-34M	34M-1.2M SMSD-
Type (Winchester, fixed, cartridge)	Removable	Winchester	Winchester	Floppy diskette	Winchester	Winchester, diskette	Winchester, diskette
Controller Model	Apollo-supplied	Apollo-supplied	Apollo-supplied	Apollo-supplied	Apollo-supplied	Apollo-supplied	Apollo-supplied
Drives Per Subsystem/ Controller	2	1	1	1	1	1	1
Formatted Capacity Per Drive, Megabytes	300MB	68MB	158MB	1.2MB	34MB	34MB	34MB (Winchester) 1.2MB (diskette)
Number of Usable Surfaces	—	—	—	2	—	—	—
Number of Sectors/Tracks Per Surface	1,600	77	512	77	—	—	77
Bytes Per Sector or Track	512	256	256	256	546	546	256/546
Average Seek Time	41.7 milli-seconds	154 milli-seconds	55 milli-seconds	154 milli-seconds	25 milli-seconds	25 milli-seconds	154 milli-seconds
Average Rotational/Relay Time	8.3 milli-seconds	108 milli-seconds	12.5 milli-seconds	108 milli-seconds	8.3 milli-seconds	8.3 milli-seconds	108 milli-seconds
Average Access Time	50 milli-seconds	262 milli-seconds	67.5 milli-seconds	262 milli-seconds	33.3 milli-seconds	33.3 milli-seconds	262 milli-seconds
Data Transfer Rate	1.98MB/sec.	61KB/sec.	512KB/sec.	61KB/sec.	1.2MB/sec.	1.2MB/sec.	61KB/sec.
Supported by System Models	DN420 DN600	DN420, DN600	DN420, DN600	DN300	DN300	DN300	DN300
COMMENTS							

DN300 while the DN600 offers the power and mainframe-like capabilities needed for high-level computation.

The restrictions on the Apollo Domain systems are, in many ways, apparent. They are up against the high-recognition, big name companies like DEC, Data General, and Wang who can provide a greater array of equipment, services and support to the potential 32-bit client. However, Apollo also suffers many of the same dilemmas as the big name companies, the most formidable being the lack of available 32-bit commercial application software packages for the business sector. Because of name recognition, however, third-party software houses are more likely to develop applications packages for the big-name systems first.

Also, in the area of throughput, the Domain systems fall short in overall capacity. The high-end VAX-11, MV/ Family, Wang VS, and Perkin-Elmer 3200 systems offer greater main memory capacities, cache memory capacities, number of instructions, and maximum disk storage than the Domain systems.

PHYSICAL SPECIFICATIONS: The Domain DN420 and DN600 nodes share a desk-side cabinet and free-standing display. Both displays are based on 19-inch diagonal monitors, and are designed for desktop placements. The DN300 is housed in a single enclosure with a five-slot backpanel and 17-inch diagonal monitor. Each Apollo node dissipates approximately 850 watts with a maximum of 1,450 watts at start-up. The ambient temperature should remain within the range of 60°F (15°C) to 90°F (32°C), with the optimal temperature being 68°F (20°C). The altitude of the installation site must be within the range of 0 to 7,000 ft. (2.1 Km). Electrical requirements on a per node basis is 120 VAC ± 10%, 15 Amps.

INPUT/OUTPUT CONTROL

Peripherals on the optional Multibus are mapped into the 22-bit Domain physical address bus by means of an I/O map. The I/O map consists of 256 page entries, each entry pointing to a particular physical page. A peripheral on the Multibus can generate a 16 bit word or byte address and have the high order bits indexed into the page map and low order bits indexed relative to the page. In this way, Multibus peripherals can directly address themselves into the virtual memory of a process.

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USER REACTION

Because the Apollo Domain Systems have been on the market for a relatively short time, Datapro has received only one response on its 1983 User Survey for the Apollo systems. That system, a DN420, had been installed since January 1983 and was leased from a 3rd party. The principal applications performed on the system included construction/architecture, engineering/scientific, manufacturing, mathematics/statistics, and petroleum/fuel analysis. The memory capacity was 2MB and the disk storage capacity over 1200 megabytes. The programming language used most on the system was Pascal. The user also employed both a data base management system and integrated word processing functions. In a rating of the system, this user rated as excellent: ease of operation, reliability of the mainframe, responsiveness, effectiveness, trouble-shooting, education, compilers and assemblers, ease of conversion, and overall satisfaction. The user rated as good: the reliability of peripherals, documentation, the operating system, applications programs, and ease of programming. There were no "fair" or "poor" ratings listed.

When contacted, this user (from a New York engineering firm) expressed a great deal of satisfaction with the Apollo system stating, "A high scale of features integration at a low cost relative to the full utility of the Domain system has made a real difference to the success of our firm." □

There are four levels in the I/O system of the Domain nodes: the language level, the stream level, mapped primitives, and the page level. The language level is supported by language constructs such as Fortran's Read and Write. The stream level is object type-independent and can talk to files, peripheral devices, or to other processes. Map primitives are object location-independent and allow streams to operate across the network. All data transferred in the entire system occurs at the page level. The page level is the physical I/O to local and remote disks across the network. This data is transferred on demand, resulting exclusively from a CPU page fault.

The *Peripheral-to-Node Adapter (PNA)* and *General-Purpose Input/Output (GPIO)* software are two Apollo products used for connecting peripheral devices to the DOMAIN Computational Node. The PNA is required to support peripherals supplied by Apollo Computer such as storage module disk subsystems, magnetic tape subsystems, and high speed line printers. In addition, DOMAIN users may write their own device control software and use the GPIO package to support other available IEEE-P796-compatible peripherals. Bus specifications, a guide to the use of GPIO software, and a sample device driver are included with the GPIO package.

The *DOMAIN Server Processor DSP80* lets users connect a wide variety of shared peripheral devices to a DOMAIN system. DSP80 is compatible with the DN300, DN420, and DN600 series of computational nodes.

The DSP80 can control peripherals such as storage module disks, communication gateways, magnetic tape devices, line printers and plotters, as well as a range of low speed serial devices. By effectively managing peripherals and communications lines in the network, DSP80 frees user nodes to handle specific application-related processing.

DSP80 can serve as a communications gateway that supports X.25, Hasp, and Ethernet. It can also be used as a backend file server that supports large disk subsystems with a magnetic tape backup facility. The user controls whether devices are connected to a single DSP80 or to multiple DSP80s in a DOMAIN network.

DOMAIN users also have the option of connecting their own specialized devices or peripherals through either the IEEE-P796 Multibus or one of the two RS232C serial I/O ports. This feature—along with the optional GPIC (general purpose I/O) software—lets users write their own transparent device drivers in a high level language without concern for the underlying bus structure, assembly language or other hardware specifics.

The DSP80 fits in a standard 19″ rack or, with cabinet covers, can be placed on a table top or as a freestanding floor unit.

CONFIGURATION RULES

All DOMAIN computational nodes include a high performance 32-bit VLSI processor, memory management unit, interface to the local area DOMAIN network, integrated high-resolution bit mapped graphics display with detachable keyboard, and license to use Aegis network-wide virtual memory operating systems with display manager software, font editor, graphics primitives, high-level language debugger, software support for IBM 3270 and Hasp communications (requires external hardware devices), and network management utilities.

WORKSTATIONS: The Domain Node workstation configuration can support over 200 terminals. Each Domain mode is an autonomous single user workstation that shares access to peripherals and files via the Domain Local Area Network.

DISK STORAGE: A 34MB Winchester Disk subsystem is available for the DN300 computational node (maximum of one per DN300 node). An 8-inch, double-sided/double-density 1.2MB diskette drive is available for the DN420 and DN600 computational nodes (maximum of one per node). A 34MB, 68MB, or 158MB WInchester Disk is available for the DN420 or DN600 (maximum of one per node). Up to two 300MB, removable media, storage module disk drives may be connected to a computational node for shared storage service.

MAGNETIC TAPE UNITS: A 1600bpi, 25ips magnetic tape subsystem is available for DOMAIN computational nodes.

PRINTERS: A 300lpm or 600lpm printer with controller, and a 60cps letter-quality printer is available for DOMAIN nodes.

MASS STORAGE

For a look at the mass storage devices available for Apollo's DOMAIN computational nodes, refer to the Mass Storage Chart on page M11-075-104.

INPUT/OUTPUT UNITS

See the Peripherals/Terminals table on page M11-075-106.

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PERIPHERALS/TERMINALS

DEVICE	DESCRIPTION
Magnetic Tape	
MSD-1600	Magnetic tape drive and controller; 1600 bpi, 25 ips, 9-track tape drive mounted in cabinet; requires PNA or DSP80
Printers	
HCD-MMP	Multi-node printer includes near letter quality, draft, graphics (plot); and uses one asynchronous RS232 I/O port on any computational node or DOMAIN server processor; requires a DN300, DN420, DN600, or DSP80

COMMUNICATIONS CONTROL

Communications support capabilities provided by Apollo's DOMAIN nodes include X.25 and IBM Hasp, and 3270, BSC emulation.

DOMAIN X.25 provides DOMAIN users with shared access to long-distance communications via international public packet switching networks or private X.25 networks. DOMAIN X.25 conforms to CCITT recommendations for communications protocols and is compatible with the ISO Open Systems Interconnection Reference Model. In addition, it includes a file transfer service for use between remote DOMAIN computing systems. DOMAIN X.25 operates under the Aegis virtual memory operating system.

SOFTWARE

OPERATING SYSTEMS: There are two operating systems available for the Domain systems: Aegis and AUX.

The *Aegis Operating System* provides an integrated computing environment designed to enhance technical professionals' individual and teamwork productivities. Aegis combines virtual memory management with access to the DOMAIN system's graphic displays and local-area nework. It offers a multiuser system environment for applications that include computer-aided design, engineering, and scientific computation, computer-aided software engineering, artificial intelligence research, electronic publishing, and financial modeling.

The Aegis operating system features:

- Virtual memory for direct execution of large programs
- Network-distributed file system with access control list security and protection facility
- Concurrent, multi-window Display Manager Environment provides "virtual terminals" to programs, text, and graphics; includes screen-oriented editing.
- Interprocess communication, process creation, and event synchronization to coordinate execution of separate programs
- Extensive online HELP facility, including documentation of access to system services
- Shell command line interpreter for application control
- Support for a variety of programming languages and data management techniques

Aegis also supports a wide selection of options for communications beyond the DOMAIN network that include file transfer, remote virtual terminal, and virtual circuit services based on X.25 and related protocols; mainframe file transfer and remote job entry using the Hasp protocol; 3270 interactive terminal emulation using either bisync or SDLC data links; Ethernet interface at the data link level; asynchronous ASCII file and interactive terminal emulation; and the ability to read and write both EBCDIC and ANSI-labelled tapes.

Apollo's *AUX* is an interactive software environment based on the Bell Labs UNIX System III operating system with Berkeley enhancements. AUX provides an integrated multiprocessing computing environment designed to enhance technical professionals' individual and teamwork productivities. AUX uses Apollo's proprietary operating system kernel, which provides virtual memory management with access to DOMAIN System's graphic displays and local-area network. The system supports individual users DN300, DN420, and DN600 computational nodes as well as the shared DOMAIN Server Processor, DSP80. It supports a variety of optional high-level languages, standard graphics subsystems, facilities for data management, and a wide range of end-user application software.

Among its many features, AUX offers: virtual memory for direct execution of large programs; a network-distributed file system with access control list security and protection facility; support for I/O redirection, pipes, and forks; extensive online HELP facility, including documentation of system services; and support for both the Bourne and Berkeley C shell.

PROGRAMMING LANGUAGES: Pascal, Fortran 77, and C are members of the DOMAIN Language System. The Language System is a software development environment that includes Pascal, Fortran 77, and C language compilers; a common code generator, binder, and runtime package; and a high-level language debugging system. The Language System runs under the Aegis operating system on any DOMAIN computational node.

DOMAIN's Fortran 77 is a compatible superset of the ANSI X3.9-1978 Fortran language standard. DOMAIN's Fortran 77 simplifies conversion of existing Fortran programs to the DOMAIN processing system.

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The latest ANSI Fortran standard includes new features that increase the languages functionality. The character data type and related operators improve Fortran's text-handling capabilities. Multiple entry points, alternate RETURNs, and the IF/THEN/ELSE construct contribute to structured programming. The OPEN/CLOSE and INQUIRE auxiliary statements increase the flexibility of file-oriented input/output, while providing standards that increase program portability.

DOMAIN Fortran 77 exceeds the requirements of the ANSI standard. Extensions include: subprogram and variable names of length up to 32 characters, with lowercase allowed; insertion of global declarations from common source files using the %INCLUDE directive; predefined calls and declarations to simplify use of system services; 32-bit pointer data type that permits direct reference to any portion of a DOMAIN file of any size up to four gigabytes; and 16-bit and 32-bit integer, plus 32-bit and 64-bit real data types.

DOMAIN's C Programming Language is a compatible superset of the language defined in the C Programming Language by Kernighan and Ritchie. DOMAIN C simplifies conversion of existing C programs to the DOMAIN processing system. In addition, 32-bit DOMAIN C includes extensions to facilitate significant engineering/scientific application and systems projects.

Domain C features command line interpreters; a language-independent variable formatting package; a mailbox facility for network-wide interprocesses; display manager services; use of device-independent files via the graphics metafile manager; an optional library of Domain Distributed Data Management (D3M) routines; dynamic memory allocation routines; and extended error code processing for enhanced software debugging.

The performance of Domain C programs is enhanced by two compiler options. One option makes maximum use of the floating point hardware on the Domain Performance Enhancement Board. The other causes the compiler to perform several global performance and storage optimizations.

The Domain C user can enable compiler switches to control the generation of traceback information, program listings, cross reference listings, expanded machine code listings, and debugging tables for added ease in software development.

DOMAIN's Pascal is based in the ISO's proposed DIS 7185 standard. Pascal simplifies conversion of existing Pascal programs to the DOMAIN processing system and includes extensions for engineering/scientific applications and systems programming projects.

Extensions to DOMAIN's Pascal beyond that of the proposed ISO standard include: full support for separately compiled external routines; insertion of global declarations from common source files using the %INCLUDE directive; predefined calls and declarations to simplify use of system services; 32-bit pointer data type that permits direct reference to any portion of a DOMAIN file of any size up to four gigabytes; 16-bit and 32-bit integer, plus 32-bit and 64-bit real data types; static data initialization to improve maintainability and reduce the size of programs; and conditional compilation using the %DEBUG directive.

DATA MANAGEMENT: *DOMAIN Distributed Data Management, D3M* 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. D3M integrates the runtime efficiency of a CODASYL-compliant design with the personal productivity advantages of a relational interface to span a spectrum of data management applications from simple, file drawer chores to CAD/CAM, engineering, scientific and software development applications.

Features of DOMAIN's Distributed Database Management System include CODASYL-compliance with relational access functions; distributed database 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, as a family of software components, provides users with all the necessary database tools needed to create, maintain, and update both small and large databases. These components include:

- D3M/Dataview—a query/update language that provides easy-to-use, relational capabilities for both queries and forms-oriented updates.
- D3M/Describe—a fully interactive database description tool that can be driven using either forms or commands.
- D3M/Unite—an aggregate schema compiler to create logical combinations of multiple databases located anywhere in a DOMAIN local-area network.
- D3M/Formatter—a complete report writing package specifically tailored for the non-programmer.
- D3M/Runtime Library—resides in the shared virtual memory with the rest of the DOMAIN distributed operating system. It is bound to user programs at execution time to provide D3M services.
- Schema and Subschema Compilers—process the CODASYL-standard data description language to generate database descriptions.
- Database maintenance utilities—such as Index, Collect Freespace, and Initialize Diskspace, which work on an ongoing basis with the shared routine library.

D3M is supported by any DN300, DN420, or DN600 computational node equipped with a minimum of one megabyte of main memory. One node in the DOMAIN network supporting D3M must also be equipped with Winchester and floppy disks.

GRAPHICS: *The 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 System provides high-level graphics functionality which allows the user to concentrate on developing applications rather than developing graphics system software. The DOMAIN Core System adheres to the GSPC Proposal and supports the full range of 2D and 3D viewing and image tranformations. It supports all DOMAIN computational nodes and allows applications to be device independent and imput devices such as the touchpad, mouse, data-tablet, and keyboard. Device independence insures application transportability and helps protect the users application software investments.

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PRICING

POLICY: Apollo Computer takes a system level view toward the maintenance of its computer hardware and software products. Each system Support Representative is qualified to support both Apollo hardware and software products thereby reducing the time for service resolution.

Service and information requests for customers with system maintenance agreements are conducted through the Apollo Response Center's toll free line. The first point of contact is a qualified System Support Specialist who performs diagnostic and resolution activities. If it is necessary for on-site remedial support, a System Support Representative is dispatched with the appropriate replacement modules and software expertise to effect resolution.

The System Maintenance Agreement features the following:

- **Complete support of the Apollo operating system, software and hardware products.**
- **Telephone assistance via the Apollo Response Center's toll free line from 8:30 a.m. to 8:00 p.m. (EST), excluding Apollo observed holidays.**
- **On-site remedial support from 8:30 a.m. to 5:30 p.m. Monday through Friday, excluding Apollo observed holidays.**
- **Planned preventative maintenance program.**
- **All labor and materials required to complete remedial and preventative maintenance.**
- **Updates of all maintained products (hardware/software).**

In addition, Apollo offers a variety of "custom" support and training programs to meet unique customer requirements.

EQUIPMENT: The following are typical system purchase and maintenance prices.

DOMAIN DN300 Computational Node: Includes a high resolution, 1024 x 800 bit-mapped black and white display, 17″ landscape orientation; 512KB of main memory; 2 asynchronous RS-232-C I/O ports; and up to 1.5MB of main memory. The purchase price is $12,900. Monthly maintenance is $130.

DOMAIN DN420 Computational Node: Includes a high-resolution, 800 x 1024 bit-mapped black and white graphics display, 19″ landscape orientation; 512KB main memory with ECC; touchpad locating device; f-slot chassis; 3 asynchronous RS-232-C I/O ports; and supports up to 3.5MB of main memory. Purchase price is $27,000 and monthly maintenance is $295.

DOMAIN DN600 Computational Node: Includes a high-resolution, 1024 x 1024 bit-mapped color graphics display, 19″ landscape orientation; 1MB main memory with ECC; 1MB dedicated display memory; touchpad locating device; 10-slot chassis; and supports up to 3.5MB of main memory. The purchase price is $49,000 with monthly maintenance at $535.

EQUIPMENT PRICES

SYSTEMS

All DOMAIN Computational Nodes include a high performance 32-bit VLSI processor, memory management unit, interface to the token-passing local area DOMAIN network, integrated high resolution bit-mapped graphics display with detachable keyboard, and license to use Aegis network-wide virtual memory operating system with display manager software, font editor, graphics primitives, high-level language debugger, software support for IBM 3270 and Hasp communications (requires external hardware devices), and network management utilities.

		Purchase Price	Monthly Maint.
DN300-HMB	DOMAIN DN300 Desktop Computation Node includes a high-resolution 1024 x 800 bit-mapped black and white display, 17" landscape orientation; 512KB main memory; 2 asynchronous RS232-C I/O ports; and supports up to 1.5MB of main memory	$12,900	$130
DN300-1MB	DOMAIN DN300 Desktop Computation Node; a DN300 with 1MB of main memory	15,900	160
DN300-1.5MB	DOMAIN DN300 Desktop Computational Node; a DN300 with 1.5MB of main memory	18,900	190
TPAD	Optional touchpad locating device for DN300 Desktop Computation Node (must be ordered with node)	350	5
MSE	Optional mouse pointing device for DN300 Desktop Computational Node; requires DN300	400	5
DN420-HMB	DOMAIN DN420 Computational Node includes high-resolution 800 x 1024 bit-mapped black and white graphics display, 19" landscape orientation; 512KB main memory with ECC: touchpad locating device; 8-slot chassis; 3 asynchronous RS232-C I/O ports; and supports up to 3.5MB of main memory	27,000	295
DN420-1MB	DOMAIN DN420 Computational Node; a DN420 with 1MB of main memory	30,000	325
DN420-2MB	DOMAIN DN420 Computational Node; a DN420 with 2MB of main memory	36,000	385
DN600-1MB	DOMAIN DN600 Computational Node includes high-resolution 1024 x 1024 bit-mapped color graphics display, 19" landscape orientation; 1MB main memory with ECC; 1MB dedicated display memory; touchpad locating device; 10-slot chassis; and supports up to 3.5MB of main memory	49,000	535
DN600-2MB	DOMAIN DN600 Computational Node; a DN600 with 2MB main memory	55,000	595
DN600-E-1MB	DOMAIN DN600 Computational Node; a DN600 with 1MB of main memory and 2MB dedicated display memory	56,000	620
DN600-E-2MB	DOMAIN DN600 Computational Node; a DN600 with 2MB of main memory and 2MB dedicated display memory	62,000	680
TPAD-NC	Touchpad option for DN420 or DN600 Computational Node (must be ordered with node)	NC	NA
MSE-NC	Mouse option for DN420 or DN600 Nodes (must be ordered with node)	NC	NA

Apollo Domain Systems

ADD-ON MEMORY

ADM-HMB	512KB main memory expansion with ECC for DN420 and DN600 Computational Nodes	5,000	30
ADM-1MB	1MB main memory expansion with ECC for DN420 and DN600 Computational Nodes	8,000	60
DDM-1MB	1MB dedicated display memory upgrade for DN600 Computational Node (converts DN600 to DN600-E)	8,500	85
SSADM-HMB	512KB main memory expansion for DN300 Computational Nodes; allows expansion from HMB to 1MB	5,000	30
SADM-1MB	1MB main memory expansion for DN300 Computational Nodes; allows expansion from HMB to 1.5MB	8,000	60

SYSTEM OPTIONS

PEB	Performance Enhancement Board; includes hardware floating point and 4KB cache memory	4,500	45
PNA	Peripheral-to-Node Adapter including a 5-slot IEEE-796 (MULTIBUS) card cage and power supply	3,000	30
PWR-CNV-1	Power Converter Subsystem; 100 VAC to 120 VAC, 50 Hz or 60 Hz	900	15
DSP80-HMB	DOMAIN Server Processor including dedicated 32-bit VLSI CPU; 512KB main memory; 5 IEEE-796 (MULTIBUS) slots; 2 asynchronous RS232-C I/O ports; tabletop package; power supply; license to use Aegis Operating System Subset; and DOMAIN network interface	7,000	70
DSP80-1MB	DOMAIN Server Processor; DSP80 with 1MB main memory	10,000	100
DSP80R-HMB	DOMAIN Server Processor; 19" rack-mountable DSP80-HMB	7,000	70
DSP80R-1MB	DOMAIN Server Processor; 19" rack-mountable DSP80-1MB	10,000	100
NET-SWT-1	Manual Switch used to partition DOMAIN networks into multiple Subnetworks	250	NA

MASS STORAGE

SMSD-34M	Winchester Disk Subsystem; 34MB, tabletop package, maximum of one per DN300 Node; requires a DN300 node	10,500	105
SMSD-34M-1.2M	Winchester Disk and Diskette Subsystem; 34MB Winchester, 1.2MB diskette, tabletop package, maximum of one per DN300 node; requires a DN300 node	12,000	120
MSD-1.2M	1.2MB diskette drive; maximum of one per node; requires DN420, DN600	2,500	25
MSD-34M	34MB Winchester Disk; maximum of one per node; requires DN420, DN600	8,400	85
MSD-68M	68MB Winchester Disk; maximum of one per node; requires DN420, DN600	12,500	125
MSD-158M	158MB Winchester Disk; maximum of one per node; requires DN420, DN600	16,800	170
MSD-300M	300MB storage module disk drive with removable pack; first drive with controller; requires PNA or DSP80	21,000	230
MSD-300MA	300MB storage module disk drive with removable pack; second drive; up to two drives per node; requires MSD-300M	19,000	205

MAGNETIC TAPE

MSD-1600	Magnetic tape drive and controller; 1600 bpi, 25 ips, 9-track tape drive mounted in cabinet; requires PNA or DSP80	12,500	160

PRINTERS

HCD-MMP	Multi-mode printer includes near letter quality, draft, graphics (plot); and uses one asynchronous RS232 I/O port on any computational node or DOMAIN server processor; requires a DN300, DN420, DN600 or DSP80	3,800	40

SOFTWARE PRICES

		Purchase Price	Monthly Maint.
Software Licenses (per node basis unless otherwise specified) includes documentation and distribution media (diskette or mag tape).			
SFW-FTN	Fortran-77	$1,250	15
SFW-PAS	Pascal	1,250	15
SFW-C	C	1,250	15
SFW-D3M	DOMAIN Distributed Data Management System (D3M)	2,500	25
SFW-CORE	SIGGRAPH Core Graphics Software Package	1,000	15
SFW-AUX	AUX; Subsystem based on UNIX System III; requires C license	1,000	15
SFW-VERS	Versatec V80 Software Driver Support (license per Versatec device)	200	NC
SFW-GPIO	General Purpose I/O Software (only a single GPIO license is required at a single site, regardless of the number of nodes at that site); used for interfacing IEEE-796 Multibus Peripheral-to-Node Adapter or DOMAIN Server Processor (DSP80); requires PNA or DSP80	3,500	35

COMMUNICATIONS

COM-X25	DOMAIN X.25 GATEWAY including an intelligent hardware controller that mounts in either DSP80 or PNA; dual synchronous lines; full X.25 software protocol with extensions; and two modem cables; requires PNA or DSP80	15,600	150

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