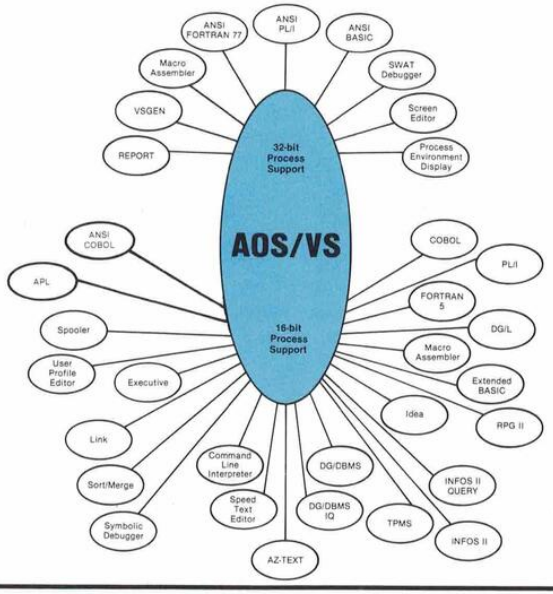
PRODUCT BRIEF

ROLM MIL-SPEC Computer Systems

ADVANCED OPERATING SYSTEM/ VIRTUAL STORAGE AOS/VS



FEATURES

- Intelligent multiprogramming operating system for ROLM® MSE/800 and Data General ECLIPSE® MV/8000 32-bit computer systems that dynamically adapts to simultaneously control the three most common computer environments:
  - Timesharing
  - Multiple batch job stream
  - Real-time
- Supports simultaneous development and execution for programs utilizing 64k-byte or 512M-byte addressing range
- Supports high-level languages for large address space processing:
  - ANSI FORTRAN 77
  - ANSI PL/I
  - ANSI BASIC
  - ANSI COBOL
  - APL
- Upward-compatible with 16-bit ECLIPSE-based AOS environments
  - COBOL
  - FORTRAN 5 and FORTRAN 77
  - PL/I
  - Extended BASIC
  - DG/L™ Systems Programming Language
  - Macroassembler
  - INFOS® II File Management software
  - DG/DBMS
  - TPMS
  - AZ-TEXT™ Word Processing software
  - Idea (Interactive data entry/access)
- Utilizes the advanced architectural features of the MSE/800 system
- Provides easy-to-use modules for program development and execution
- Supports up to 128 users and 255 processes, with up to 32 tasks per process
- Dynamically manages all system resources based on user-established priorities
- Dynamically handles virtual-to-physical address translations
- Sophisticated multiprogramming techniques include:
  - Concurrent control of multiple system and user processes
  - Multitasking within processes
  - Intertask and interprocess communications
- Permits generalized sharing of both code and data
- Permits user programs and operating system resources to reside in same process space
  - Eliminates user-to-system context switching overhead
  - More secure and reliable operating system
- Supports hardware-assisted memory protection
  - Utilizes eight-level ring-structured processing-privilege hierarchy
  - Resides in innermost, highest-privilege rings
  - Uses MSE/800 gate structure to vector user system calls to proper entry points
- Secure data management facilities include:
  - Multiple file access levels controlled by user privileges defined in user profile
  - Hierarchical file directory structures
  - Extensive communications facilities
  - Extensive controlled-sharing facilities

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- **Powerful system management and operator modules include:**
  - **Log-on Executive with password protection**
  - **Batch facility with multiple job streams and operator queue management**
  - **Hardware error logging and on-line reporting with soft error retry and recovery**
- **User-oriented Command Line Interpreter**
- **SWAT™ Native Language Debugger for simple, source-code level program debugging**
- **REPORT utility for resource utilization accounting**
- **Global and local optimization for AOS/VS FORTRAN 77, PL/I, and COBOL**
- **Interactive system generation**
- **Provides sophisticated support for ROLM MSE/800 computers, associated peripherals, communications facilities, and distributed data processing capabilities**

DESCRIPTION

The Advanced Operating System/ Virtual Storage (AOS/VS) (developed by Data General Corporation) provides the multiprogramming features of mainframe-oriented virtual storage operating system software on powerful, 32-bit MSE/800 computers. AOS/VS efficiently manages the MSE/800's vast 4-gigabtye logical address space. It implements a sophisticated demand paging, virtual memory management system that is totally transparent to users.

AOS/VS enables the MSE/800 to achieve an extremely high degree of compatibility with other ECLIPSE systems. AOS/VS supports simultaneous program development and execution utilizing address spaces ranging from 64 kilobytes to 512 megabytes. This lets the MSE/800 be used as an expansion system for existing AOS-based ECLIPSE system applications software—with virtually no conversion effort; as a development system for AOS-based ECLIPSE systems in a distributed network (with the simple restriction that address ranges and instructions be limited to the smaller 16-bit machine specifications); and as a development and production system for programs that exploit the system's full 32-bit power. Up to 128 users can run 32-bit range applications programs, each using up to 512 megabytes of logical address space.

AOS/VS supports ANSI FORTRAN 77, ANSI General-Purpose Subset PL/I, ANSI BASIC, ANSI COBOL, and APL for 32-bit address space programming. Three-level global optimization enhances FORTRAN 77, PL/I, and ANSI COBOL program performance. Local optimization selects the machine's most efficient code sequences for extended performance improvements.

Most 16-bit AOS languages and utilities are supported under AOS/VS. AOS/VS gives programmers the same user interface as AOS. For example, AOS/VS supports the same Executive Interface and the same Command Line Interpreter commands.

AOS/VS dynamically controls the three most common computer environments, including timesharing, multiple batch job stream, and real-time operations. It intelligently performs program control, I/O, and file management functions commonly relegated to user programming on other computers. AOS/VS handles a wide variety of user environments. An MSE/800 system can simultaneously perform as a responsive multiuser timesharing system, a multiprogramming batch system, and an on-line real-time application system.

AOS/VS reinforces the extensive system security features incorporated in the MSE/800 architecture. The 32-bit design of the MSE/800 segments the system's 4 gigabytes of logical address space into an 8-level, ring-structured process protection privilege hierarchy. The AOS/VS kernel resides in the highest-privilege ring (ring 0), and user programs reside in the lowest-privilege ring (ring 7). A firmware-implemented gate structure at every ring boundary automatically checks cross-ring calls for proper entry points. Requests that do not receive privilege authorization are transferred to AOS/VS control. AOS/VS can then identify the user, the terminal, the time of the request, and the data requested, and can notify the system manager for intervention.

AOS/VS also gives the system manager an extensive set of user- and data-specific security features to protect AOS/VS data and resources from unauthorized access or inadvertent error. The system manager uniquely assigns execution priority and file access rights to each AOS/VS user. Restrictions that can be assigned within AOS/VS include specific file access and the ability to share programs and data (the system manager can grant users the ability to examine and modify other users' programs and data files).

AOS/VS is a heuristic operating system. At installation, the system manager generates an operating system tailored to the specific hardware configuration. From then on, AOS/VS dynamically adapts itself and its modules to user demands. The type and behavior of the system's collective workload determine the system's environment.

Multiprogramming

AOS/VS is a process-oriented multiprogramming operating system. A process in AOS/VS is a collection of program tasks (a sequence of instructions), sharing up to 4 gigabytes of logical address space. Each process is assigned a set of resources and privileges that determine how much time and memory the process can use. AOS/VS controls up to 255 user and system processes independently and concurrently, and protects processes from one another's activities.

AOS/VS, by residing in the same process-wide logical address space as the user, eliminates the overhead associated with saving information due to user program actions. That is, AOS/VS is treated as a group of system-provided subroutines. These subroutines, or system services, are simply invoked by the normal subroutine mechanism.

Users determine whether processes should be permanently memory-resident, preemptible (usually resident in memory but suitable for swapping), or swappable. The three types have specific applicability: resident processes can be used for real-time applications; preemptible processes suit less time-critical, event-driven applications; and swappable processes are ideal for timesharing and batch operations.

Initially, users assign resident and preemptible processes a priority ranging from 1 to 255 and swappable processes a priority of 1 to 3. More than one process can have the same priority. In addition, AOS/VS imposes a hierarchy on processes to allow interprocess control. All processes existing at any one time are related in a "family-tree" structure and parent processes can block and unblock offspring. Processes can also assign offspring

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privileges (such as what data they can access).

In operation, AOS/VS allocates CPU time to processes dynamically, depending on their eligibility state. Processes are eligible if they have been allocated memory and are not waiting for some external event, such as user console input/output or a message from another process. Among eligible processes, AOS/VS executes the highest priority resident or preemptible process first. If none is eligible, it gives control to the highest priority swappable process.

In timesharing operations, it is the swappable processes that are usually competing for system resources. AOS/VS completely controls the swapping of these processes, based on past behavior and process priority. For example, it grants more time to swappable processes that fully utilize their time slice but may assign them a lower priority.

Multitasking

AOS/VS supports as many as 32 tasks within any process. Under AOS/VS, tasks are logically complete instruction sequences. AOS/VS multitasking controls the concurrent execution of multiple tasks through a single process. Multitasking provides efficient handling of multiple asynchronous events within a single user program.

When a process executes, AOS/VS gives control to the task designated as first by the user. In a multitasking program, the first task initiates the other tasks. They all can run in parallel or interact using task calls designed for execution control, communication and synchronization, and timing.

Execution control calls can define, suspend, make ready, or terminate tasks based on the user-assigned priority or identification. Communication and synchronization calls can be used to send messages to other tasks, lock a process-wide resource, form "mailboxes" and queues, and distribute work among tasks. Task timing calls let users start tasks based on time-of-day or specific time intervals.

Intertask and Interprocess Communication

AOS/VS lets processes intercommunicate with multiple, point-to-point, free-format messages of variable length. Processes send and receive messages using full-duplex communications ports.

Processes sending messages can continue activity without delay. If no receiver is waiting for the message, AOS/VS can spool the message. Conversely, AOS/VS can suspend a task that wishes to receive a message until another process sends the requested message.

Demand Paging

AOS/VS is optimized for the MSE/800 architecture to take advantage of its virtual storage design. Depending on the application, it enables the MSE/800 to efficiently support up to 128 users, giving each up to 512 megabytes of logical address space by implementing sophisticated demand paging. Demand paging logically separates a user's logical program addresses and the MSE/800's physical memory locations into 2k-byte pages. Not all pages of a program's logical addresses need to be active in memory at the same time. As program execution flow changes over time, AOS/VS demand paging keeps only the active pages that make up a program's working set in memory. Nonactive pages are kept on disk, ready to be moved into memory when required.

AOS/VS contains the logic to locate required pages kept on disk and transfer them to physical storage. Further, AOS/VS works to anticipate the need for program pages to speed system performance. It uses the MSE/800 Address Translation Unit (ATU) to accelerate logical-to-physical address translations. Since certain pages are commonly referenced, the ATU keeps a table of 256 recently referenced page addresses to reduce the number of memory-based page address translations the ATU must perform. AOS/VS uses a page-fault-frequency page replacement algorithm to constantly monitor and adapt the user's working set.

AOS/VS demand paging makes optimal use of MSE/800 resources because it does not require logically sequential program addresses to be physically contiguous in MSE/800 memory. It generates a map of all memory locations, protecting the logical integrity of program addresses, and uses memory locations as they become available. This enables the MSE/800 to support extremely high multiprogramming levels. Demand paging also results in greater programming productivity because programmers do not need to concern themselves with overlay techniques. AOS/VS builds the necessary virtual-to-physical translation tables. The MSE/800 ATU performs this translation when a user program is running.

File Management

AOS/VS provides data management capabilities, including complete file protection by user access, device-independent I/O access, and hierarchical file directories to catalog programs and data.

Like processes, all file directories are related in a "family-tree" structure. The initial parent is termed the system root. The system root directory contains entries for other directories and certain files used by AOS/VS.

AOS/VS has a number of predefined directory entry types, such as program file, peripheral device, interprocessor communication file, and other system types. Users can define up to 128 additional directory entry types. Each entry contains a name and other information unique to that type of entry.

Every process has a working directory and a search list of other directories to consult if a process cannot find a named entry in the working directory.

File Access Control

AOS/VS provides a secure protection scheme that prevents unauthorized or accidental use or alteration of data accessed through the directory structure. Privileges include owner, write, append, read, and execute access. These privileges differ slightly, depending on whether an entry is in fact another directory or a data file. The owner can change privileges during the life of an entry. AOS/VS maintains an access control list for each directory and data file. It includes the users that can access the files, as well as the privileges that access allows.

This access control mechanism provides sophisticated protection of code and data in the system while simultaneously simplifying procedures for the individual user.

Device-Independent Input/Output

AOS/VS provides a flexible system for accessing files on ECLIPSE-line peripheral devices. To execute an I/O

transfer to any device, users simply open the file, read or write file data, and close the file. Users can read/write data by blocks or by logical groupings called records. This method is used to transfer data to and from all devices, including remote devices.

Various disk units can be mixed on any system. At installation, the user can specify one or more physical disk drives as a logical disk unit.

User can access magnetic tape using block or record I/O methods. Access control applies to the entire tape. AOS/VS implements ANSI standard levels 1, 2, and 3 and IBM levels 1 and 2 for labeled magnetic tape. User programs can read and write tapes with these labels for convenient data interchange. The Multiprocessor Communications Adapter (MCA) is treated as a multifile device. AOS/VS MCA block transfers use a protocol compatible with Data General's Advanced Operating System (AOS), Real-time Disk Operating System (RDOS), and Real-Time Operating System (RTOS).

For all file I/O, dynamic, fixed-length, data-sensitive, and variable-length records are supported. Users can specify the record type when creating a file or when performing the input/output.

Block data transfers are supported on disk units, magnetic tape units, and multiprocessor communications adapters. Disk unit blocks are 512 bytes long; magnetic tape unit blocks vary in size and are separated by interrecord gaps; multiprocessor communications blocks can vary in length up to 8192 bytes.

Command Line Interpreter

The AOS/VS Command Line Interpreter (CLI) lets users perform file and process maintenance at the console. CLI is also used to invoke execution of other AOS/VS modules or user programs. CLI commands are used to execute programs, execute functions built into the CLI itself, and expand user- or system-defined macros.

Specifically, some of the operations CLI performs are: file creation, maintenance and backup; directory creation and maintenance; spooling control; and batch job submission.

One of CLI's great advantages is its flexibility and ease of use. Some CLI functions do little more than execute one system call (such as DELETE "filename"), while others (such as DUMP) perform very complex operations. Depending on their specific needs, users can learn CLI commands ranging from a few simple ones to the large number available for more complex processing.

All CLI commands can be abbreviated to their minimally unique form. For example, the full name of DIRECTORY can be shortened to DIRECT or DIR or to any letters that don't conflict with another command.

A HELP capability is available to supply users more information on any CLI command. For example, users can type "HELP DIRECTORY" to receive a full description of the DIRECTORY command.

A macrofacility enables users to combine and execute a series of commands with a single name while passing variable parameters.

CLI macrofeatures include conditional command execution, compound commands, template expansion, variables, and error handling. CLI macros can call themselves or other CLI macros.

Language Compilers and Libraries

The AOS/VS compilers for ANSI FORTRAN 77, ANSI PL/I, and ANSI COBOL have a common code generator and share the same optimizer. This commonality reinforces the MSE/800's reliability and performance advantages. System reliability is enhanced because sharing language system components between the two languages reduces the number of system modules that must be supported and maintained. System performance is increased because the common optimizer offers three-level optimization, and both languages can fully exploit this inherent operation efficiency.

AOS/VS also provides common libraries to support the FORTRAN 77, PLI, and ANSI COBOL runtime environments. A math library and a transcendental function library are included in the AOS/VS common runtime libraries. This commonality in runtime libraries provides greater uniformity between identical functions performed in different languages, and because the system need support only one routine for each high-level language function, system reliability is further increased.

System Generation

The person designated as system manager can generate an AOS/VS system tailored to the hardware. Very flexible device specification (baud rate, cursor controls, tab simulation, etc.) is permitted. These specifications may be dynamically changed during system operation. In addition, multiple operating systems can be generated and stored on disk for easy access. AOS/VS offers the system manager considerable flexibility in specifying these systems. The entire generation process is interactive.

Hardware Requirements

AOS/VS operates on ROLM MSE/800 computers with at least 1 megabyte of memory, at least 36 megabytes of disk storage, magnetic tape, and a console device.

AOS/VS supports a wide variety of peripherals, including disks, magnetic tape units, terminal printers, video displays, card readers, line printers, a variety of communication interfaces, and the Multiprocessor Communications Adapter.

Utilities

AOS/VS provides a wide variety of system utilities to simplify 32-bit address space program development and system management. They include:

—**SWAT Native Language Debugger**–A high-level interactive symbolic debugger that lets AOS/VS FORTRAN 77, PL/I, and ANSI COBOL programmers debug their programs with their development language, instead of having to switch to assembler language for machine-level code revisions. The SWAT utility includes many user-oriented features, such as a HELP facility. It lets users examine memory, set program break points, and test program execution interactively.

—**LINK**–A facility that lets AOS/VS rebind files from other systems for use with the MSE/800. It links object files to produce an executable program file.

—**Macroassembler**–A tool for producing assembly language programs that utilize the full addressing capabilities of the MSE/800 computer. Macroassembler is designed for use in developing user-specified device-drivers, as well as specialized subroutines for high-level languages.

—**REPORT**–A utility that gives the system manager effective management information on MSE/800 system

resource utilization. Report can analyze system use by CPU time, connect time, and data file access. It identifies users, terminals, the types of operations performed, and the time services were used.

—**Symbolic Text Editors**–Utilities that let users conveniently edit program source and data files.

—**Symbolic File Editor**–A utility that lets users modify program files.

—**Spooler**–A utility that ensures that AOS/VS services will be provided to multiple users, sending output to line printers directly or via asynchronous communications lines in an orderly manner. The Spooler provides forms control, flush, print, and restart capabilities. The Spooling mechanism uses a temporary disk file to queue output. It identifies each printer on the system in the spool queue with the names of the files that will be printed.

—**User Profile Editor**–A utility that allows the system manager to specify user privileges. AOS/VS checks the User Profile for access privileges and process restrictions every time a user logs-on the system.

—**Executive**–A utility that validates a log-on user or batch job against the user profile. It creates processes for each according to assigned privileges, and monitors user activities.

—**Sort/Merge**–An efficient Sort/Merge utility for program production included with AOS/VS.

User Programming Languages

AOS/VS provides a full complement of high-level languages. For 32-bit address space program development and execution, AOS/VS supports ANSI FORTRAN 77, ANSI PL/I, ANSI BASIC, ANSI COBOL, and APL.

AOS/VS FORTRAN 77 is a fully compatible implementation of the ANSI FORTRAN X3.9-78 standard which provides structured programming, expanded I/O and character processing, and manipulation features. Extensions such as greater syntax complexity and IF THEN ELSE statements support ease of use and enhance industry compatibility. AOS/VS PL/I adheres closely to the ANSI General-Purpose Subset standard PL/I language (ANSI PL/I X3.74), with extensions. AOS/VS BASIC is a substantial superset of the ANSI BASIC standard (ANSI BASIC X3.60-1978). It adds many powerful features like decimal arithmetic, source-level debugging, and user-friendly diagnostics to make it a useful development system for engineers and others who want programming simplicity with comprehensive 32-bit computational power.

AOS/VS COBOL provides users with high-level language capabilities, powerful data management facilities, and extensive program development aids. Making use of the full 32-bit features of AOS/VS, and conforming to ANSI '74 COBOL specifications, this implementation ensures language compatibility with industry standards. AOS/VS COBOL's integration with the INFOS data managment facilities permits easy access to sophisticated file management capabilities. These capabilities let COBOL programs generate, manipulate, and access data by using sequential, random, index-sequential, and multilevel-keyed access methods. COBOL programs can be easily developed and debugged using the SWAT Native Language Debugger.

APL (A PROGRAMMING LANGUAGE) is a sophisticated, powerful, and easy-to-use interpreter-based language. Supported under AOS/VS, this 32-bit language permits direct manipulation of scalar, N-dimensional arrays, and character strings with a powerful set of built-in operators. AOS/VS APL is a superset of APL.SV, with extensions provided for the quad format operator and direct manipulation of files within user language statements. Ease of use is further enhanced by permitting AOS/VS CLI commands to be executed within the APL workspace.

AOS/VS also supports a number of 16-bit AOS-standard programming languages for development and execution, including COBOL, FORTRAN 5, Extended BASIC, PL/I, RPG II, Idea, DG/L™ Systems Development Language, and Macroassembler. Globally optimizing FORTRAN 5 includes a series of ISA extensions. Extended BASIC supports both scientific and commercial applications. COBOL is ANSI 74-compatible, and supports sophisticated commercial processing applications. PL/I supports structured programming for all application types.

RPG II is an industry-standard implementation. Idea (Interactive data entry/access) software provides interactive screen-oriented program development. DG/L Systems Programming Language permits structured program development for ECLIPSE and NOVA® architecture computers. The Macroassembler provides machine-language-level program development capabilities with complete macroinstruction and symbolic facilities.

AOS/VS also supports the full complement of AOS-standard data management, transaction processing, and word processing software systems. INFOS II file management software supports interactive and batch-oriented data base applications with hierarchical data structures and extensive logging and recovery features. The Data General/Data Base Management System (DG/DBMS) is an interactive CODASYL-compatible data base implementation that supports network data structures and comprehensive reliability, integrity and system security features. An end-user-oriented Interactive Query (DG/DBMS IQ) facility lets users interrogate DG/DBMS data bases with English-like commands. Transaction Processing Management System (TPMS) supports multiuser transaction processing applications and conserves AOS/VS and MSE/800 resources by letting users share AOS/VS processes. AZ-TEXT word processing software supports complete text entering, editing, and store-and-forward capabilities with letter quality output.

SOFTWARE SERVICES

Software services available from ROLM include:

Software Subscription Service—The user is supplied with the latest revision of software and documentation on an as-required basis.

Software Trouble Report Service—Provides the user with service for reporting software difficulties.

Software Training—Training for AOS/VS and AOS/VS related software is provided by the Data General Corporation's Customer Training Department. ROLM training credits are honored by Data General.

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