

PRIME

PRIMOS[®] Operating System (Rev. 19)

Features

- Efficient multipurpose, multiprogramming operating system.
- Fully compatible across all Prime 50 Series systems.
- Utilizes the advanced architectural features of Prime 50 Series systems.
- Sophisticated virtual memory mechanism employing both segmentation and paging.
- 32Mb maximum program size.
- Embedded re-entrant operating system.
- Hardware memory protection system.
- Shared translators, utilities and libraries.
- Program development support and shared, re-entrant, recursive program execution.
- Dynamic linking to operating system and shared libraries.
- Up to 128 asynchronous terminals and 255 processes supported.
- Up to 8 synchronous lines supported.
- 16Mb maximum physical memory.
- Over 10Gb maximum mass storage.
- Multilevel hierarchical file structure with access control list protection.
- Sequential and direct file access methods.

■ Dynamic file and paging disk space allocation with optional usage quotas.

■ Comprehensive, easy-to-use command line processor and procedure language.

■ Exception handling via an ANSI PL/I standard condition mechanism.

■ Per-user abbreviation facility.

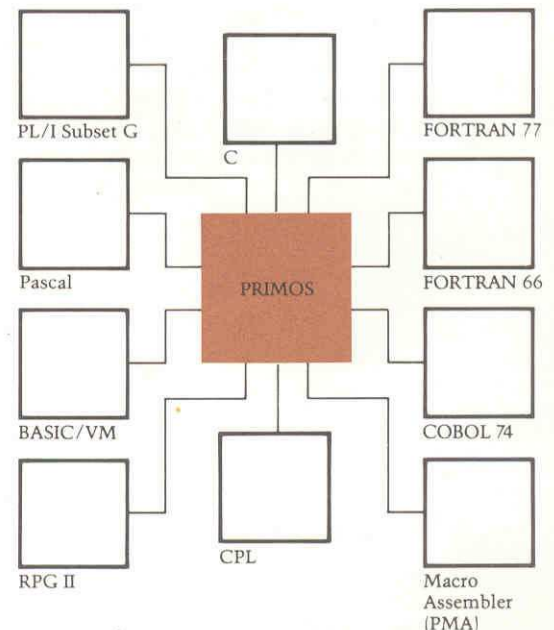
■ Inter-user message facility.

■ Online HELP facility.

■ Advanced communications support.

■ Indexed sequential access method and CODASYL-compliant DBMS.

■ Full complement of utilities for disk maintenance, system backup and program development.



Description

All Prime computer systems – from the small virtual memory Prime 2250 to the large virtual memory Prime 9950 that supports dozens of concurrent timeshared and queued tasks – use the multifunction PRIMOS operating system. Since each central processor provides a different level of performance and functionality within the Prime systems family, the PRIMOS operating system is designed to maximize the effectiveness of a processor's resources while minimizing operating system overhead.

The PRIMOS operating system further optimizes the high-speed computational ability and exceptionally large memory capacity of Prime central processors by integrating both interactive and batch supervisory services into a single operating system.

It is structured to take advantage of the advanced architectural features of Prime 50 Series systems such as virtual memory, process exchange, dynamic linking and hardware memory protection. This means the PRIMOS operating system provides a productive and easy-to-use environment for program development and an efficient, secure, reliable environment for program execution. Furthermore, as the same operating system runs on all Prime 50 Series systems, this environment is fully compatible across the product line.

The PRIMOS operating system supports a wide range of communication facilities including seven Remote Job Entry (RJE) products; Prime's Distributed Processing Terminal Executive (DPTX) for IBM connectibility; and PRIMENET™ networking software. Also supported are MIDASPLUS™, an indexed sequential file access method; DBMS, a CODASYL-compliant database management system; and a variety of industry-standard languages. The PRIMOS operating system supports a wide range of peripherals including over 10Gb of mass storage, eight tape drives, four parallel line printers and multiple serial printers, card readers, paper tape and graphics devices.

Compatibility

The PRIMOS operating system runs on all Prime 50 Series systems. This means that programs and data files created on one Prime system can be used on any other Prime system without modification. This compatibility holds true at both the source language level and at the object code and memory-image levels. Programs running on a small Prime system can run unchanged on larger Prime systems with substantial speed improvement. This preserves software investments and provides an attractive upgrade and growth potential. Large Prime systems can be used for efficient software development, creating programs and databases that are easily transferred to smaller distributed processing systems.

Performance

Prime's system architecture was developed in a rather unique way – the software was designed first. The hardware was designed to support the software with many of the traditional operating system functions implemented in microcode and hardware. Examples include the process exchange mechanism, the hardware procedure call mechanism and support for dynamic linking. This 'software first' design philosophy manifests itself in terms of performance. The microcode and hardware assist allows the PRIMOS operating system to maximize system performance, particularly in a multiuser environment.

Ease-of-Use

The PRIMOS operating system provides a productive, easy-to-use environment for the application developer. Advanced features such as command iteration, wildcarding, treewalking, name generation, Command Procedure Language and the abbreviation processor let users customize command environments. The condition mechanism allows an application designer to ensure that users remain within the application. The PRIMOS operating system provides an extensive HELP facility for user assistance on all system commands.

The PRIMOS operating system is designed to be easy to configure and bring up. At start-up time, it automatically configures itself according to the hardware installed on the system. Simple commands, in a configuration file used at system start-up, control additional configurable options within the PRIMOS operating system.

Security and Integrity

Hardware, firmware (microprogrammed logic) and software components within the PRIMOS operating system monitor the complete hardware/software system to ensure reliable hardware operation and secure process execution. System integrity is maintained by single-bit main memory error correction and microverification routines that test the central processor's logic and help determine the cause of any faulty operation. A hardware-implemented ring protection mechanism protects memory from accidental or unauthorized access, preserving the integrity of the operating system, its databases and shared code. File systems security is based on access control lists. These allow access rights to any directory or file to be specified on a per user basis. User access to the system is controlled through a secure log-in mechanism. The operating system also includes file access integrity features such as forward and backward pointers, and utilities to repair damage or inconsistencies.

A Source-Level Debugger is available for most Prime languages, allowing users to step through their source-level code and exert interactive control over all aspects of program execution. They can set or clear breakpoints on any statement, examine or modify variables, evaluate expressions, execute single statements and trace execution at will. The generic capabilities of the Source-Level Debugger are unique and promote user convenience in a multilanguage environment.

Virtual Memory

The advanced virtual memory management in the PRIMOS operating system supports multiple concurrent processes, each with its own private virtual memory space. Additional virtual memory space is shared among all processes. This mechanism takes advantage of both segmentation and paging to provide users an extremely large address space, eliminating concern over program size limitations. (A 32Mb program can be run in a user's private address space.) Virtual memory resources are available on systems with as little as 512Kb of main memory. The size of the user's virtual address space is independent of physical memory size. The PRIMOS operating system automatically takes advantage of additional increments of main memory (up to 16Mb) to reduce paging as system load increases.

Embedded Operating System

The PRIMOS operating system is exceptionally responsive and provides direct and immediate control because it is effectively embedded in the virtual address space shared by all users. It is an integral part of each user's process, and executes for all users at the same time. The shared, re-entrant embedded design of the PRIMOS operating system allows it to service user requests with minimum overhead and delay. Users can access an operating system resource in no more time than it takes a user program to call a subroutine.

Procedure Sharing

Memory utilization is greatly improved with the PRIMOS operating system because one user can write procedures that others can share. Prime systems make maximum use of procedure sharing. That means a shared procedure exists no more than once on disk and once in memory regardless of the number of users accessing it. Prime's system architecture provides for separation of "pure" re-entrant code, static storage and dynamic storage. A stack architecture provides a re-entrant recursive environment for program execution. Prime's shared high-level language translators generate re-entrant code. All high-level language libraries are also shared. Programs are dynamically linked to shared libraries and PRIMOS operating system services at runtime.

Data Communication/Networking

The PRIMOS operating system handles all data communication between a Prime system and interactive terminals, other Prime central processors and other mainframes. The PRIMOS operating system communicates directly with most currently available asynchronous ASCII terminals operating at speeds up to 9600 baud. Communication between Prime systems is handled via PRIMENET Node Controllers (PNC's) for locally connected processors, or through high-speed synchronous lines or public data networks, using the CCITT X.25 standard packet switching protocol.

DPTX

The Prime Distributed Processing Terminal Executive (DPTX) software product allows users to construct interactive communication networks with equipment provided by Prime and IBM. DPTX products conform to IBM 3271/3277 Display System protocols, and can be integrated into new or existing networks containing IBM or IBM-compatible mainframes and terminal controllers without changing application code or access methods.

Remote Job Entry (RJE)

A Prime system can act as an RJE system by emulating the protocols used by the IBM 2780/3780, IBM HASP II Workstation, CDC UT200, ICL 7020 and XBM, Univac 1004 and Honeywell GRTS. When used as an RJE system, programs and data files can be created interactively and then queued on a disk for direct transmission to a host mainframe.

PRIMENET

PRIMENET networking software lets a user or process on one Prime system communicate with any other Prime system in a network, without concern for any of the protocol details. A user can log in to any computer in a network from any terminal in the network. With PRIMENET software, networking processes running concurrently on different systems can communicate interactively with one another via X.25 virtual circuits. It allows transparent access to any system in the network without burdening the user with extra commands.

Languages

The Prime family of interactive systems provides a productive, easy-to-use environment for program development in a wide variety of languages. COBOL 74, BASIC/VM, FORTRAN 66, FORTRAN 77, PL/I Subset G, RPG II V-Mode Compiler, Pascal, C and Prime Macro Assembler (PMA) are supported on all Prime 50 Series systems.

Prime languages employ common call conventions. That means programs written in one Prime language can call routines written in another, allowing program development time to be saved by utilizing existing routines written in other Prime languages.

Data Management

Database Management System

Prime DBMS, Database Management System, conforms to CODASYL standards and provides all processes concurrent access to integrated data. This capability is required by multiple users at interactive terminals who are simultaneously updating and retrieving common files.

Prime DBMS means reduced application programming expenses and shorter development times. Programmers concentrate on the logic of the application, not the details of data manipulation and file design.

Multikeyed Isam

Prime MIDASPLUS, Multiple-Indexed Direct Access System, is a data management facility that allows PRIMOS operating system users to interactively create and maintain data files. Data can be accessed through 18 different key paths via any standard Prime programming language. The multikeyed structure of MIDASPLUS and its availability through all programming languages provides users maximum flexibility in data retrieval with minimum redundancy of data storage and coding.

Query and Report Writer

PRIME/POWER, based on an English-language command system, is a user-oriented data query and reporting language that runs on all Prime 50 Series systems and is designed for both data processing and non-data processing personnel. PRIME/POWER supports standard data files – MIDASPLUS, ASCII, Direct Access and Binary – which are also accessible by programs written in standard Prime languages.

Forms Management

Prime FORMS, Forms Management System, is a set of software functions used to develop systems for interactive, multiterminal and on-line processing. It permits forms to be designed for a variety of CRT and hardcopy terminals using the FORMS Description Language (FDL) with easy-to-use statements, or FED, the FORMS screen painter. Application programs are created using the standard READ/WRITE statements.

Prime's Office Automation System software combines Word Processing, Management Communication and Support, and Data Processing on one totally compatible system. All of these components work to improve information handling and productivity for the manager and professional, as well as administrative personnel.

The Word Processing module includes functions like text creation and editing, list processing and a boilerplate library. The Management Communications and Support module combines electronic mail; correspondence management, including filing and retrieval capabilities; and management support, providing electronic scheduling.

The software matches complete office automation and communication functionality with the full data processing capabilities of a Prime system.

Utilities

A very capable batch processing subsystem, which is completely compatible with the interactive environment, is supplied as standard software. Command and CPL files created for execution in the interactive environment may be run without modification as batch jobs.

Prime provides, as a part of standard system software, a set of disk-to-disk or disk-to-tape utilities which are among the best in the industry. For system backup, a special feature allows very fast disk-to-disk or disk-to-tape backup of complete disk volumes.

Utilities to transfer or copy files to tape or disk are supplied as standard software.

A very powerful print spooling package enables users to share both parallel and remote serial printers. With the versatile administrator and operator controls provided, individual print jobs may be automatically routed either to any printer on the system or to any printer on any network node. This package is supplied as standard software.

Memory Management

The PRIMOS operating system is optimized to make efficient use of the sophisticated virtual memory mechanism available on Prime 50 Series systems. The mechanism takes advantage of both paging and segmentation techniques. Demand paging is used to achieve efficient memory utilization. Segmentation allows easy sharing and access control. These procedures are user-transparent.

When a program references a location in virtual memory not currently in physical memory, a "page fault" occurs and the PRIMOS operating system brings the referenced page (2Kb section of virtual memory) into physical memory. If a page has to be overwritten in order to do this, the least recently used page is chosen. Referenced and modified page bits are maintained by the hardware and used by the software to reduce disk accesses caused by paging.

Segmentation provides variable length segments of virtual memory up to 128K bytes. Code and data modules can be loaded into different segments thus providing an easy method for sharing of modules. Access to segments is controlled by per user segment access codes. It is therefore possible for different users to have different access rights to shared data.

Address translation is speeded up by use of a high-speed buffer called the Segment Translation Lookaside Buffer (STLB). This buffer holds recently used virtual-to-physical page translations. Prime processors include a cache memory with an access time as short as 40 nanoseconds. The cache is an integral part of the CPU and reduces memory access delays for data resident in the cache. Address translation is overlapped with cache access to further reduce total instruction execution time.

The combination of hardware and software in Prime 50 Series systems creates a secure multi-user environment.

Security is addressed at the memory, file system and user log-in levels. Segment Descriptor Words (SDWs) describe each segment of a user's virtual address space. Part of this description is per-ring access rights. Rings are levels of access privileges and are maintained by the hardware. Ring 0 is the most privileged with full access rights and the ability to execute all instructions. Ring 3 is the least privileged with no right to execute instructions that alter the system's mode of operation. The PRIMOS operating system enjoys ring 0 privileges, timeshared users run in ring 3. This ring privilege is used to validate all memory accesses. A hardware supported gate mechanism allows ring 3 users to temporarily gain ring 0 privileges as they execute with the operating system. In this way data can be protected so that it can be accessed only via a controlled gated call into a more privileged ring.

PRIMOS protects the system against unauthorized use. A user is identified with a 1- to 32-character user name and an optional password which is stored in encrypted form and verified by the PRIMOS operating system on log-in. Users are further registered as members of projects (an accounting designation) and groups (users with common access rights).

The system is designed to invoke an installation-supplied log-in procedure which cannot be defeated. This feature allows system administrators to add additional site-dependent log-in processing such as customized security checking or accounting.

File system security is provided by Access Control Lists (ACLs). ACLs are used to protect files and directories. An ACL is a list of access pairs. Each access pair specifies a user name or group name and the associated access rights. ACLs are a passive mechanism whereby a user's access to an object is determined solely by the access rights associated with the user or group name.

Only users with Protect rights to a directory can create ACLs for objects in that directory. Objects not explicitly protected by their own ACL are implicitly protected by the ACL protecting the directory in which they reside.

An alternative method of file system protection utilizing directory passwords is also available for compatibility with older versions of the PRIMOS operating system.

PRIMOS operating system automatically transfers the attention of the central processor from one user or process to another with minimum overhead and complete protection. The key is a central processor feature called Process Exchange, a firmware mechanism for context switching. It includes a hardware implemented priority mechanism and makes use of dual user register sets. A context switch takes as little as 9 microseconds. The combination of process exchange and demand paging means that directing the central processor to run a new user is a very low overhead operation. The scheduler takes full advantage of this and is able to maintain fast response for interactive users as machine load increases.

Command Line Processor

The PRIMOS command line processor provides facilities to improve the user's productivity by reducing the amount of typing necessary to accomplish common and repetitive functions.

The abbreviation facility (ABBREV) allows users to create their own synonyms for commands and arguments. Using abbreviations, users can reduce common or lengthy command lines to simple, possibly parameterized, abbreviations. The net result is less typing, fewer errors, and increased productivity.

Users can utilize global variables for passing strings between command lines and programs. Global variables are created by the user and are referenced by using their names in command lines or through subroutines in a program.

Command functions are available which return system data as strings for use in command lines. There are functions providing time and date in multiple formats, file system information, and arithmetic calculations.

The command processor also supports features which allow the application of single commands to multiple operands. Command iteration causes a single command to execute once for each of an explicit list of operands. Wildcarding allows a command to operate on a collection of file system objects selected via a mask. Treewalking executes a command over selected parts of a file system subtree. And name generation provides for the generation of file system names from a given (possibly wildcard) name and a pattern. In addition, qualifiers may be applied to selection criteria specifying for example file types or date selectors.

Finally, all of these PRIMOS features — abbreviations, global variables, command functions, and command processing — may be used together yielding commands of extraordinary functionality.

Command Procedure Language

The Command Procedure Language (CPL) is a powerful programming language available at command level. It is a simple high-level language with PRIMOS operating system commands, as its primitive statements, making it very powerful. CPL allows sequences of operating system commands and CPL directives to be built into command procedure files for execution. CPL directives provide for parameter passing and validation, for error handling and for control of statement execution order within the command file. CPL has many unique features which bring the power of command level programming to the user. Some of these are the position-independent argument passing, the interface to the PRIMOS operating system condition mechanism, and the comprehensive set of flow of control directives. The use of CPL will significantly enhance user productivity and system ease-of-use.

Condition Mechanism

The PRIMOS operating system provides full support for the ANSI PL/I condition mechanism. A condition is an unexpected event that occurs during program execution. Examples are arithmetic overflow, a "break" from the user's terminal, or a hardware detected event such as access violation. The condition mechanism allows a specific software module called an on-unit to gain control when these events occur, irrespective of the execution state within the currently running program. On-units can be defined by users. When a condition is detected, the PRIMOS operating system "signals" that condition and searches the stack history of the running program backward in time for an on-unit for that condition. If a user-defined on-unit is found, it is invoked to perform a user-specified procedure. Users are thus able to trap system conditions and perform user specified actions. Users can also define, signal and trap their own conditions.

File Management System

The PRIMOS operating system file structure is a hierarchical tree structure with a Master File Directory (MFD) at the root of the structure. The file system creates and maintains an MFD for each disk or user-specified portion of a disk. The MFD contains the names and disk addresses of User File Directories (UFD), segment directories and files. UFDs contain named data files and lower level UFDs. UFDs can be nested to 16 levels. Segment directories contain pointers to files which are addressed by position in the directory rather than by name. They permit rapid access to large collections of data that have an established order but variable size.

File access is through sequential (SAM) or direct (DAM) access methods. In SAM files, each record contains a pointer to the next record in the file for efficient sequential access. In DAM files, pointers to all data records in the file are stored in index records— thus reducing the

search time required to retrieve any given data record. Both files types contain redundant pointers which can be used to repair the structure in the event of damage.

Security is ACL-based meaning user access rights to files and directories are a function of user identification. Also, file system usage quotas are available for limiting disk usage by directory.

All file I/O is buffered in memory. The PRIMOS operating system maintains the most recently accessed disk records in memory, reducing the effective time for repeated accesses to the same disk record.

The PRIMOS operating system automatically assigns logical files to physical disk records. This feature permits a user to create file structures without concern for the characteristics of the disk on which they are stored.

Batch Processing

Although it is primarily an interactive operating system, a very capable batch processing facility (BATCH) is provided. BATCH is designed for users who want the convenience of sequential job scheduling. With this facility, data processing or computational programs may be submitted for execution at a later time. Jobs submitted to the BATCH processing subsystem are comprised of standard PRIMOS operating system commands; so there is no need for the BATCH user to learn a complicated job control language. BATCH provides extensive operator control features which allow the operator to dynamically control the number of job queues and the characteristics of each queue; thus, the operator has the capability to optimize the workload balance. BATCH is provided as part of Prime's standard software.

System Backup and Recovery

The Backup/Recovery Management Service (BRMS) is a set of utilities for full and incremental backup and archiving. BRMS is comprised of the BACKUP, RECOVER, ARCHIVE and TRANSPORT utilities.

The BACKUP and RECOVER utilities help to ensure that the file system is restored to its state at the time of the last backup. To facilitate recovery of backed-up files, on-line catalogs record information about each file as it is saved.

In addition to backup and recovery, BRMS also provides archiving capabilities. Archiving is available to all users for saving files which will not be needed online for an extended period, or for performing backup of personal files. As with BACKUP, the ARCHIVE utility catalogs file information as each file is saved.

The TRANSPORT command is provided to transfer files between systems. TRANSPORT does not update catalogs nor does it save attributes that may be specific to the system from which the file is saved.

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