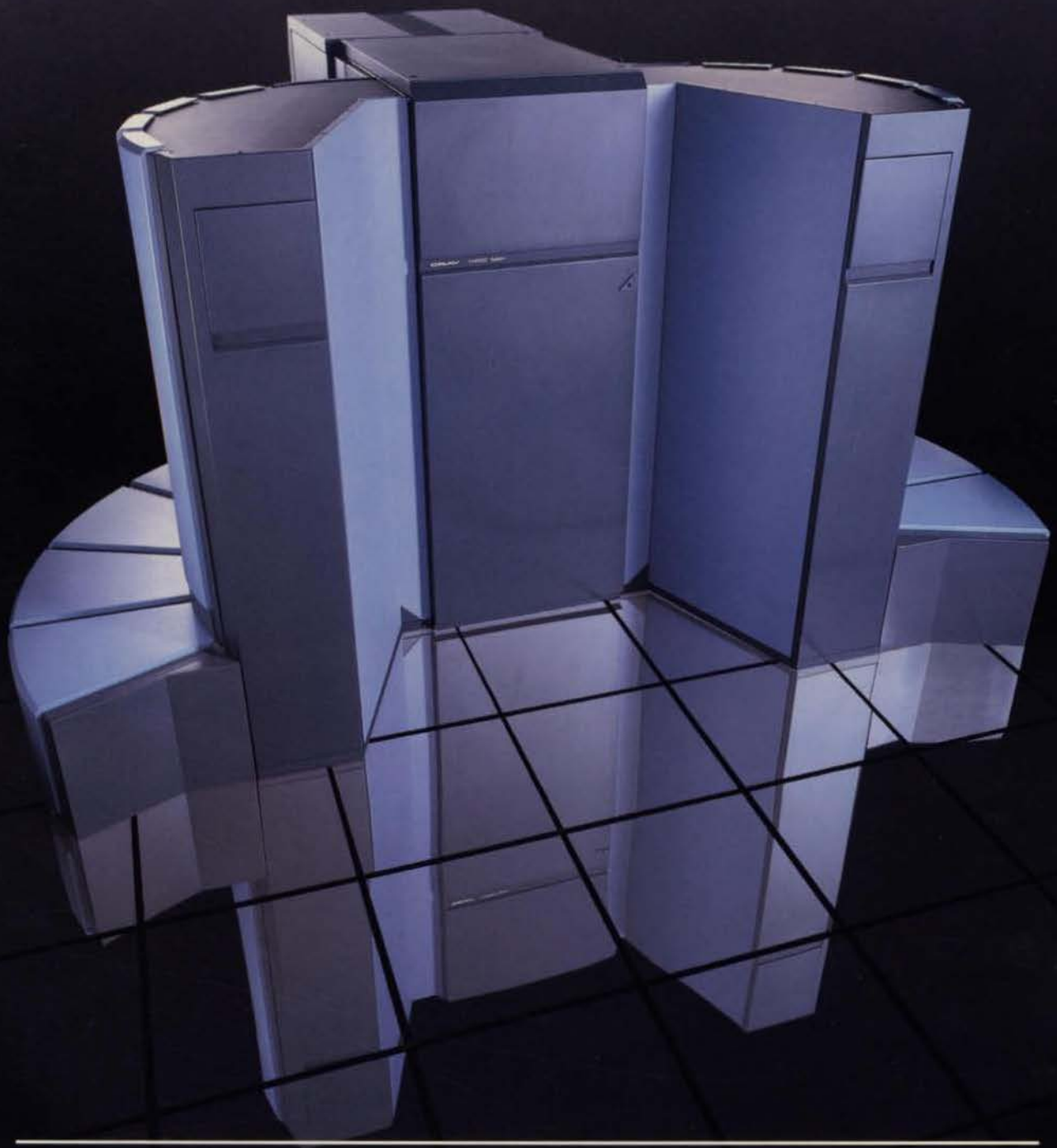
The CRAY Y-MP Computer System



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Cray Research's mission is to develop and market the most powerful computer systems. For more than a decade, Cray Research has been the industry leader in large-scale computer systems. The majority of supercomputers installed worldwide today are Cray systems. These systems are used in advanced research laboratories and have gained strong acceptance in diverse government and industrial environments. No other manufacturer has Cray Research's breadth of success and experience in supercomputer development.

The company's initial product, the CRAY-1 computer system, was first installed in 1976. The CRAY-1 computer quickly established itself as the standard for large-scale computer systems; it was the first commercially successful vector processor. Previously, the potential advantages of vector processing had been understood, but effective practical implementation had eluded computer architects. The CRAY-1 system broke that barrier, and today vectorization techniques are used commonly by scientists and engineers in a wide variety of disciplines.

The CRAY X-MP series of computer systems was Cray Research's first product line featuring a multiprocessor architecture. The multiple CPUs of the larger CRAY X-MP systems can operate independently and simultaneously on separate jobs for greater system throughput or can be applied in combination to operate jointly on a single job for better program turnaround time. For the first time, multiprocessing and vector processing combined to provide a geometric increase in computational performance over conventional scalar processing techniques.

Now, Cray Research is pleased to introduce a powerful extension to the CRAY X-MP series of computer systems. Continuing Cray's tradition of leadership in supercomputing — the CRAY Y-MP computer system.

Introducing the CRAY Y-MP computer system

Building on the foundation established by the field-proven CRAY-1 and CRAY X-MP computer systems, the CRAY Y-MP system offers significantly more power to solve new and larger problems. The unique architecture of the CRAY Y-MP system allows more efficient multiprocessing and vector processing, and the fast clock cycle time and very high I/O bandwidth yield unequaled gains in throughput. Once again, Cray Research has moved supercomputing forward, offering new levels of hardware performance and software techniques to meet the expanding needs of industry, science, and education.

The CRAY Y-MP computer system is approximately 30 times more powerful than the CRAY-1 computer system; the ECL bipolar memory offers a maximum memory bandwidth more than 50 times greater.

The CRAY Y-MP system incorporates 2500-gate array ECL (emitter-coupled logic) technology in its eight central processing units (CPUs). The 6-nanosecond clock cycle time resulting from this technology enables faster and more efficient use of the multiprocessing and vector processing capabilities available in all Cray computer systems.

With 32 million 64-bit words of directly addressable central memory, the CRAY Y-MP system enables users to solve more complicated problems without the need for out-of-memory programming techniques. This means that an engineer or scientist can confidently tackle applications requiring large memories. The CRAY Y-MP system also includes a 128-million-word (1-Gbyte) SSD solid-state storage device as a standard feature to aid in solving larger problems requiring extensive I/O and out-of-memory solution techniques.

As with its predecessors, the CRAY Y-MP system design is carefully balanced to deliver optimum overall performance and high system throughput. Fast long and short vector processing is balanced with high-speed scalar processing, and both are supported by powerful input/output capabilities.

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All of the best features of the CRAY X-MP series of computers — such as gather/scatter and compressed index vector instructions, flexible hardware chaining, and dedicated registers for interprocessor communication and control — have been retained and enhanced in the CRAY Y-MP computer system.

The input/output capabilities of the standard I/O Subsystem (IOS) complement the CRAY Y-MP CPUs and enable fast, efficient data access and processing. A second IOS can be added for increased I/O capability. Each IOS can be connected to as many as 24 Cray Research disk drives.

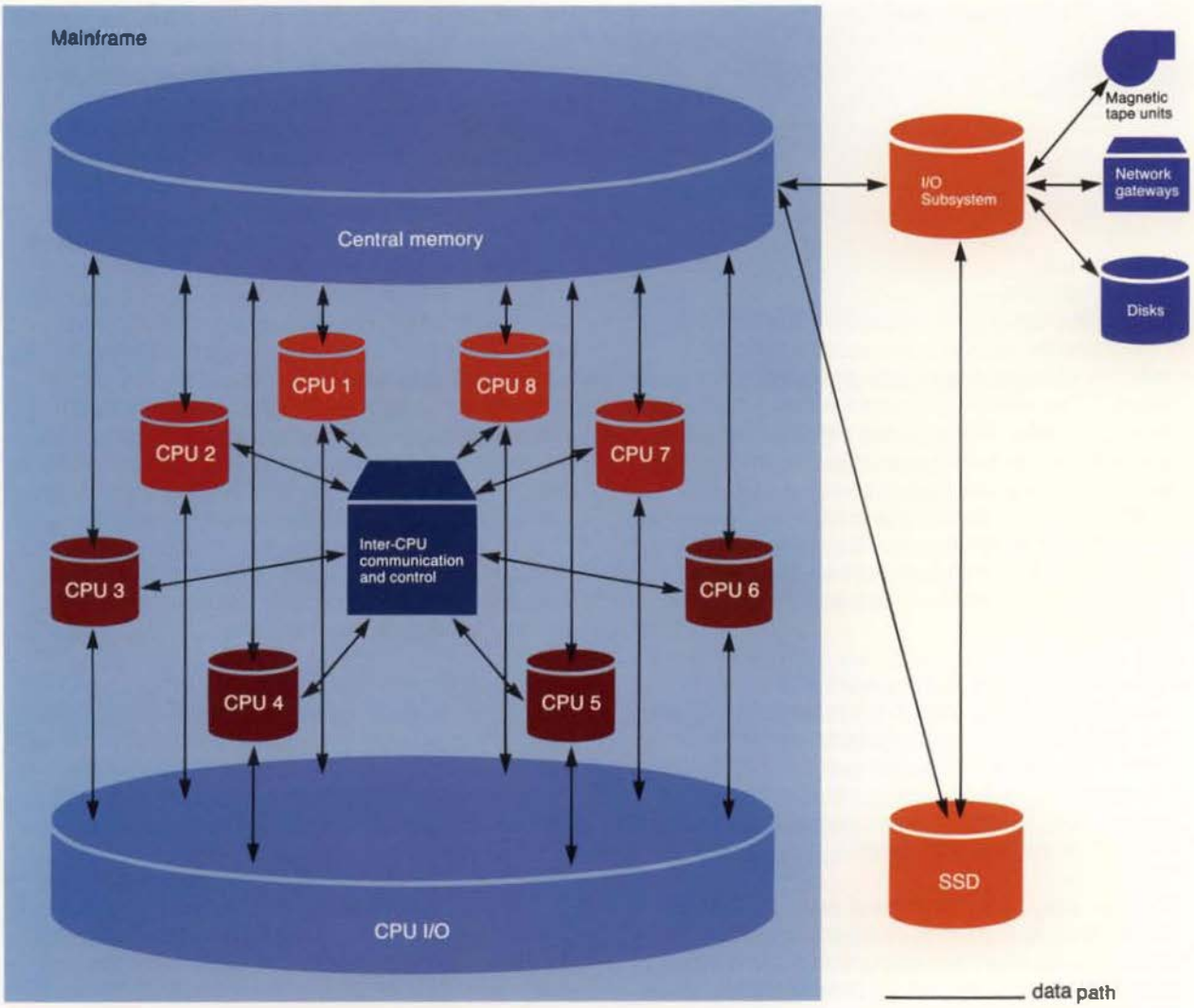
The CRAY Y-MP computer system can be integrated easily into new or existing computing environments. Cray Research offers hardware and software interfaces for many other manufacturers' equipment and networks. The instruction set of the CRAY Y-MP system has the built-in ability to run software developed for the CRAY X-MP and CRAY-2 computer systems under the UNICOS operating system, thus protecting user software investments in application programs that require rigorous certification. Also, software developed for CRAY X-MP systems under the COS operating system can be transported to the CRAY Y-MP system and run on up to four processors and 16 million words of memory.

The CRAY Y-MP computer system offers the most powerful and cost-effective computing solution available for large-scale applications.

CRAY Y-MP highlights

- Eight processors
- 6-nanosecond clock cycle
- Flexible hardware chaining for vector operations
- Gather/scatter and compressed index vector support
- Flexible processor clustering for multitasking applications
- CRAY X-MP compatible instruction capability
- Four parallel memory ports per processor
- Dedicated registers for efficient interprocessor communication and control
- 32 million words of memory
- 32-bit addressing capability
- 256 memory banks
- SECDED memory protection
- One or two I/O Subsystems

CRAY Y-MP system configuration



CRAY Y-MP design

The CRAY Y-MP system design combines high-speed scalar, vector, and address processing capabilities, a very large and fast memory, and high-performance I/O. The system's eight CPUs may operate independently on separate jobs or may be organized in any combination of up to eight processors to operate jointly on a single job. The result is exceptional speed and high overall system throughput.

Processors

Each of the CRAY Y-MP system's eight CPUs has a computation section composed of operating registers, functional units, and an instruction control network. The instruction control network makes all decisions related to instruction issue as well as coordinating the three types of processing available on all Cray computer systems (vector, scalar, and address). Each of these processing modes has its associated registers and functional units. An interprocessor communications section coordinates processing between the CPUs and the shared central memory.

The CRAY Y-MP computer system offers very fast scalar processing with high-speed processing of long and short vectors. The eight processors of the CRAY Y-MP system, twice the number available on the largest CRAY X-MP computer system, enable users to apply the extra dimension of multitasking in new and more productive ways.

The high scalar performance of each processor derives from its fast clock cycle, short memory access times, and large instruction buffers. Vector performance is supported by the fast clock, parallel memory ports, and flexible hardware chaining. These features allow simultaneous execution of memory fetches, arithmetic operations, and memory stores in a series of linked vector operations. As a result, the processor design provides high-speed and balanced vector processing capabilities for short and long vectors characterized by heavy register-to-register or memory-to-memory vector operations.

The effective overall performance of each processor executing typical user programs with interspersed scalar and vector operands (usually short vectors) is ensured through fast data flow between scalar and vector functional units, short memory access time for vector and scalar references, and short start-up times for scalar and vector operations. As a result, the CRAY Y-MP computer system provides high performance using ANSI standard Fortran without the need for hand-coding or algorithm restructuring.

The CRAY Y-MP computer system also includes instructions for the efficient manipulation of randomly distributed data elements and conditional vector operations. Gather/scatter instructions allow for the vectorization of randomly organized data, and the compressed index instruction allows for the vectorization of unpredictable conditional operations. With these features, CPU performance for program segments that depend on the manipulation of sparse matrices can be improved by a factor of five over the performance of a system without gather/scatter or compressed index instructions.

The 2500-gate array ECL chip is the building block for the CRAY Y-MP CPU. A single CRAY Y-MP CPU module contains an entire CPU plus logic for memory conflict resolution, I/O channels, and semaphore registers. Each of the eight identical processors has a clock cycle time of 6 nanoseconds.

Each CPU has its own 32-bit programmable clock with a frequency equal to the reciprocal of the clock cycle time. These clocks allow the operating system to force interrupts to occur at a particular time or frequency, thus facilitating the time-sharing of jobs.

Data structure

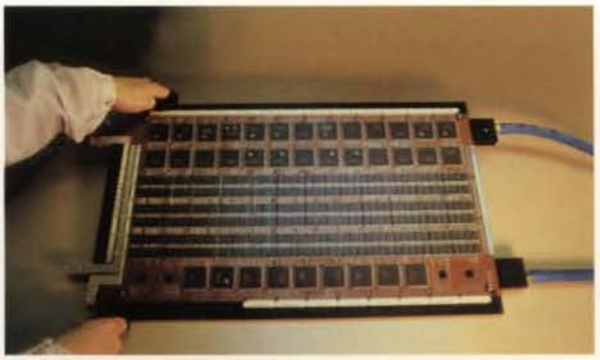
CRAY Y-MP system internal character representation is in ASCII, with each 64-bit word able to accommodate eight characters. All integer arithmetic is performed in 32-bit or 64-bit 2's complement mode. Floating point numbers (64-bit quantities) consist of a signed magnitude binary coefficient and a biased exponent. The CRAY Y-MP system also runs in CRAY X-MP compatible mode. This mode limits address processing to the 24 bits used in the CRAY X-MP systems.

Central memory

The CRAY Y-MP computer system has 32 million 64-bit words of directly addressable central memory in 256 banks. Single-bit error correction/double-bit error detection (SECDED) logic is implemented. The interleaved multiport memory design, coupled with the short memory cycle time, provides high-performance memory organization with sufficient bandwidth to support high-speed parallel CPU and I/O operation.

The eight processors of the CRAY Y-MP system share the central memory, which is organized into interleaved sections, subsections, and banks that can be accessed independently and in parallel during each machine clock period. The large number of memory banks greatly reduces memory contention. Each CRAY Y-MP processor has four parallel memory ports connected to central memory: two for vector and scalar fetches, one for result store, and one for independent bi-directional I/O operations. The multiport memory has built-in conflict resolution hardware to minimize delays and maintain the integrity of simultaneous memory bank conflicts.

The memory modules in the CRAY Y-MP computer system use bipolar random access memory (RAM) chips. Each of the 32 memory modules contains one million 64-bit words, about 16 times the memory of a CRAY X-MP memory module. Central memory has a bank cycle time of 30 nanoseconds.



Multiprocessors and multitasking

The multiprocessor environment of the CRAY Y-MP computer system enables the user to improve turn-around time using multiprocessing and multitasking techniques. Multiprocessed applications that are run on the CRAY Y-MP system can realize speed increases of two to three times over the CRAY X-MP four-processor systems.

Multiprocessing allows several programs to be executed concurrently on multiple CPUs of a single mainframe. Multitasking is a feature that allows two or more parallel execution segments of a program (tasks) to be executed while sharing a common memory space, potentially resulting in substantial throughput improvements over programs serially executed on a single CPU.

Performance improvements are in proportion to the number of parallel tasks in a program and the number of CPUs that can be applied to the separate tasks over a given unit of time.

All processors are identical and symmetrical in their programming function. When executing in multitasking mode, any number of processors (a cluster) can be

dynamically assigned to perform multiple tasks of a single job. To provide flexible and efficient multitasking capabilities, special hardware and software features have been built into the system. These features allow one or more processors to access shared memory or high-speed registers for rapid communication and data transmission between CPUs. All of these capabilities are made available through library routines accessible from Fortran. In addition, the hardware provides built-in detection of deadlocks within a cluster of processors.

Input/output processing

Cray Research's new Model D I/O Subsystem (IOS) is an integral part of the CRAY Y-MP design, acting as a data distribution point for the mainframe. The IOS gathers and distributes data for a variety of network gateways and peripherals such as disk units and plug-compatible IBM Series 3420 and 3480 tape subsystems. The architecture of the IOS, with its parallel data paths and direct access to main memory, results in a very high I/O bandwidth with a minimum of interference to computation.

Either one or two I/O Subsystems can be configured on the CRAY Y-MP system. Each IOS contains a maximum of four interconnected I/O processors (IOPs), each with its own local memory, and a common buffer memory. In a single-IOS configuration, four IOPs are standard; in a dual-IOS configuration, seven or eight IOPs can be configured.

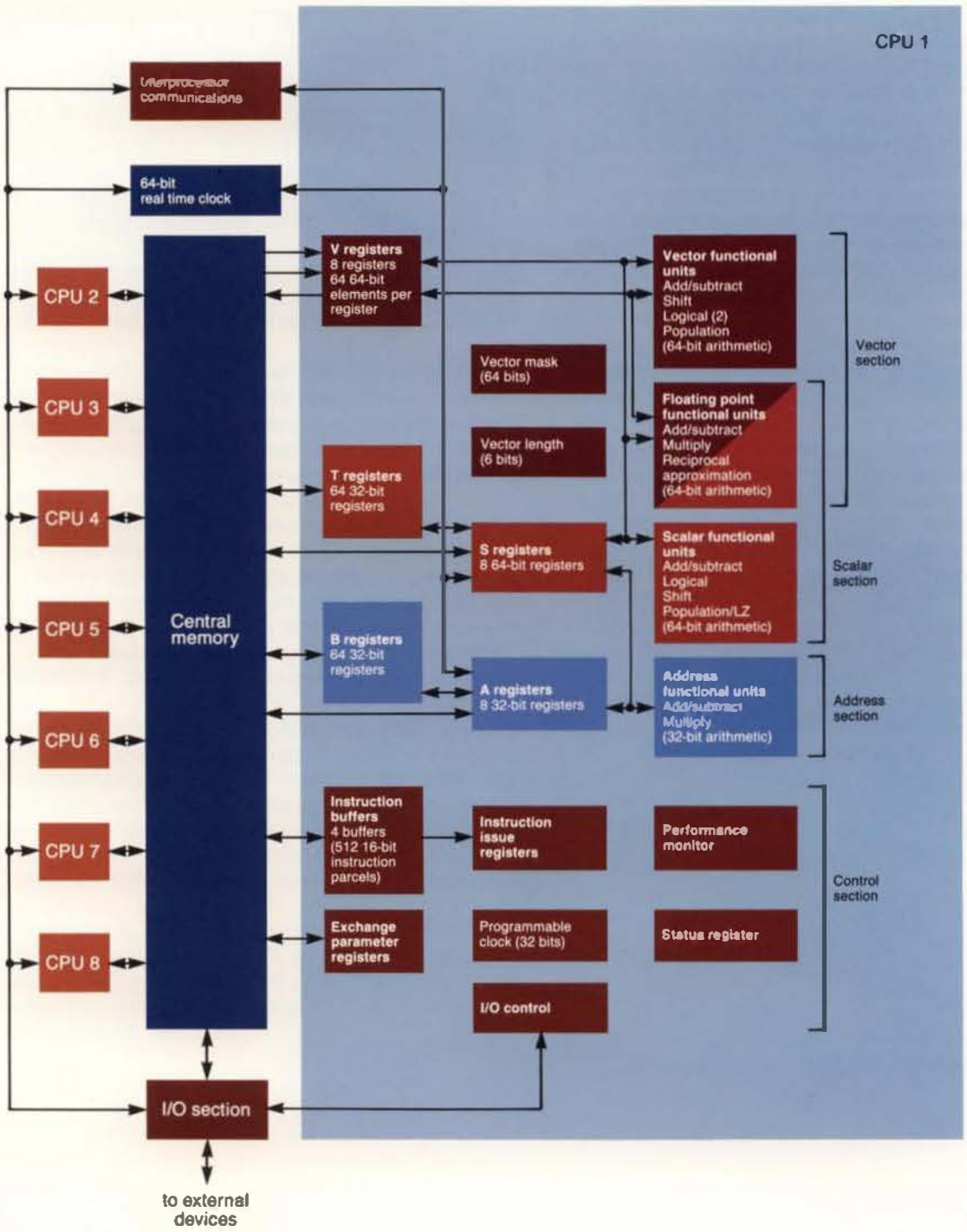
Buffer memory is solid-state secondary storage accessible by all of the IOPs in each of the IOS units. The CRAY Y-MP system comes with a 4-million-word (32-million-byte) dynamic MOS buffer memory; an additional 4 million words may be added. Buffer memory provides extremely efficient transfers of data to and from peripheral devices. It also can be used to store user datasets, thus contributing to faster and more efficient data access by the CPUs.

The CRAY Y-MP computer system supports three different channel types, identified by their maximum transfer rates of 6 Mbytes/sec, 100 Mbytes/sec, and 1000 Mbytes/sec. Eight 6-Mbyte/sec, eight 100-Mbyte/sec, and four 1000-Mbyte/sec channels are available on the CRAY Y-MP computer system. The 6-Mbyte/sec channels pass control information between central memory and the IOS or between central memory and network gateways. The 100-Mbyte/sec channels transfer data between central memory and the IOS, between central memory and the SSD, or between the IOS and the SSD. One 1000-Mbyte/sec channel transfers data between central memory and the standard SSD; two 1000-Mbyte/sec channels are available on larger SSD models.

Input/output highlights

- Standard I/O Subsystem with four I/O processors
- Optional second I/O Subsystem with three or four I/O processors
- Standard features:
  - —Local memory in each I/O processor
  - —Up to four parallel streams per disk control unit
  - —I/O buffering for disk-resident and tape-resident datasets
  - —Software support for parallel disk striping
  - —Buffer-memory-resident datasets
- Options:
  - —High-performance disk drives
  - —High-performance on-line tapes
  - —Network communication
  - —Linkage to workstations
  - —Fiber optic link
  - —100-Mbyte/sec external channel (HSX-1)

CRAY Y-MP system organization



The SSD storage device

Cray Research's SSD solid-state storage device is a very fast random-access device suited for use with the CRAY Y-MP computer system. The SSD allows the development of algorithms to support I/O-intensive applications such as out-of-memory solution techniques. It is used for large prestaged or intermediate files generated and manipulated repeatedly by user programs. Datasets may be assigned to the SSD by a single control statement without modification of the user program. Additionally, the SSD can be used as a disk cache, which keeps the most recently used data in the SSD. This operating system feature automatically provides SSD access for the most I/O-intensive processes.

System performance is significantly enhanced by the SSD's exceptionally high transfer rates and short data access times. A 128-million-word (1-Gbyte) SSD is standard with the CRAY Y-MP computer system. Larger sizes of 256 million words (2 Gbytes) or 512 million words (4 Gbytes) are offered as options. Transfer rates of 100 to 1000 Mbytes/sec per channel and access times of less than 25 msec can be achieved between the SSD and the CRAY Y-MP mainframe.

SSD highlights

- 128-million-word (1-Gbyte) memory standard; 256-million-word (2-Gbyte) or 512-million-word (4-Gbyte) memory optional
- MOS memory technology
- One or two 1000-Mbyte/sec channel linkages to CPUs
- SECDED memory protection
- Software support
- Four 100-Mbyte/sec channel linkages to each IOS

The SSD is housed in a four-column cabinet integrated with the CRAY Y-MP mainframe and communicates with the mainframe via one or two 1000-Mbyte/sec channels, which provide a maximum aggregate transfer rate of 2000 Mbytes/sec. Thus, the SSD offers significant performance improvements on I/O-intensive applications.

As a standard feature of the CRAY Y-MP system, the SSD also is connected to each IOS via one to four 100-Mbyte/sec channels. This connection enables data to be transferred directly between an IOS and the SSD without passing through central memory.

Disk drives

Complementing and balancing CRAY Y-MP computing speeds are the DS-40 disk subsystem and DD-49 disk drives. These magnetic storage devices can sustain transfer rates of 9.6 Mbytes/sec at the user job level with an average seek time of 16 msec. The DS-40 disk subsystem is comprised of four DD-40 disk storage units, with a total storage capacity of 20.8 Gbytes. The DD-49 disk drives have a capacity of 1.2 Gbytes. When combined with the data handling and buffering capability of the IOS, these disks provide superior I/O performance.

Effective disk transfer rates can be increased further by the use of optional disk striping, a technique available through Cray system software that distributes a single user dataset across two or three disk drives, depending on the device type. Successive disk blocks are allocated cyclically across the drives, and consecutive blocks can thus be accessed in parallel. The resultant I/O performance improvements are in proportion to the number and types of disk drives used.

Network gateways

The CRAY Y-MP system connects easily to existing computer environments. A major benefit of this networking capability is that the end user has access to a considerably greater computational resource while continuing to work in a familiar environment. Several hardware interfaces are available to integrate the CRAY Y-MP system into customer environments.

The Network Systems Corporation (NSC) HYPERchannel, Computer Network Technology LANlord, and similar network adapters enable the CRAY Y-MP supercomputer to communicate with multiple front-end computer systems.

Digital Equipment Corporation offers a VAX Supercomputer Gateway that provides a high-performance direct connection between the Digital VAXcluster environment and the CRAY Y-MP system.

The Cray Research HSX-1, a special high-speed external communication channel, provides full duplex point-to-point communication (up to 100 Mbytes/sec) with very fast devices over distances of up to 70 feet (22 meters).

Cray Research front-end interfaces (FEIs) compensate for differences in channel widths, word size, logic levels, and control protocols between front-end systems supplied by other manufacturers and the CRAY Y-MP system. Up to fourteen front-end interfaces can be accommodated on a dual-IOS CRAY Y-MP system.

- The Cray Research FEI-1 provides a point-to-point interface at the I/O channel level to a wide variety of computers and workstations, including IBM, CDC, DEC, Data General, Unisys, and Honeywell Bull.
- The Cray Research fiber optic link allows an FEI-1 to be separated from a CRAY Y-MP system by distances of up to 1 kilometer (about .6 miles).
- The Cray Research FEI-3 used in conjunction with an Apollo, Sun, or IRIS intelligent workstation provides a gateway interface between the CRAY Y-MP system and an Ethernet local area network or other VME device.

Physical characteristics

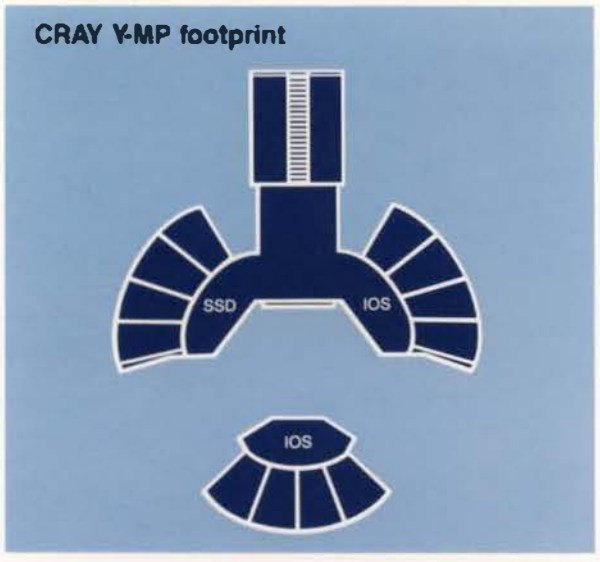
The CRAY Y-MP CPUs and memory, one I/O Subsystem, and the SSD are connected in a Y-shaped configuration.

The rectangular CRAY Y-MP mainframe chassis, which occupies 98 square feet (9.2 square meters) of floor space, contains the CPU and memory modules, power supplies, power distribution units, and coolant hoses.

Each IOS consists of four vertical columns arranged in a 90° arc occupying 15 square feet (1.4 square meters) of floor space. One IOS is attached directly to the mainframe chassis and forms one arm of the Y configuration. The optional second IOS can be up to 9.5 feet (2.9 meters) from the mainframe cabinet. The SSD cabinet also consists of four columns arranged in a 90° arc occupying 15 square feet (1.4 square meters) of floor space. It forms the other arm of the Y configuration.

The CRAY Y-MP CPUs use the 2500-gate array ECL chip. The 2500-gate array uses macrocells that allow Cray Research to custom-design the necessary logic components for the CRAY Y-MP computer system. The use of these chips, with typical 300- to 350-picosecond propagation delays, enables more efficient use of subcircuits (macros) and higher component density to yield a substantial improvement in performance over the CRAY X-MP systems. The CRAY Y-MP memory is composed of ECL bipolar circuits.

CRAY Y-MP footprint



Use of the 2500-gate array chip enables an entire CRAY Y-MP CPU to be contained on a single module. The resulting densely-packed modules and the power supplies are cooled by chilled liquid, thus maintaining the necessary internal system temperature, contributing to high system reliability, and minimizing the need for expensive room cooling equipment. The SSD and the IOS use high-speed 16-gate array integrated logic circuits, field proven on the CRAY X-MP series of computer systems. A liquid refrigerant maintains the necessary internal system temperature of the SSD and IOS.

CRAY Y-MP system specifications

Mainframe

Number of CPUs	8
Bipolar memory (Mwords)	32
Clock cycle (nsec)	6
6-Mbyte/sec channels	8
100-Mbyte/sec channels	8
1000-Mbyte/sec channels	4

Solid-state Storage Device

Memory size (Mwords)	128, 256, or 512

I/O Subsystem

Number of I/O Subsystems	1	2
I/O processors	4	7 or 8
Disk storage units	2 to 24	4 to 48
Magnetic tape channels	1 to 8	2 to 16
Network gateways	1 to 7	2 to 14
Buffer memory (Mwords)	4 or 8	8, 12, or 16

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Software

The CRAY Y-MP computer system comes with state-of-the-art software including UNICOS, an operating system based primarily on the AT&T UNIX System V Operating System and in part on the Fourth Berkeley Software Distribution (BSD). UNICOS offers a widely accepted program development environment joined with the advanced computational power of the CRAY Y-MP computer system. All UNICOS and Fortran software that has been developed for the CRAY X-MP computer systems and most of the software developed for the CRAY-2 systems runs on the CRAY Y-MP system, thus protecting user software investments.

The Cray operating system COS is also available, allowing COS programs developed in the CRAY X-MP environment to use up to four processors and 16 million words of memory on a CRAY Y-MP system.

Standard software also includes an automatic scalar optimizing and vectorizing Fortran compiler, automatic scalar optimizing and vectorizing C and Pascal compilers, extensive library routines, program-and file-management utilities, debugging aids, a Cray assembler (CAL), PSL LISP, and a wealth of third-party and public-domain applications.

Programs written in one language can call routines written in another language. In addition to the Fortran, C, and Pascal compilers, Ada, Common Lisp, and SIMSCRIPT compilers are under development.

The CRAY Y-MP computer system is supported by communications software and hardware interfaces to meet a variety of customer connectivity needs. Included are the TCP/IP protocol, a widely accepted protocol for interconnecting UNIX systems, and Cray proprietary station products. These facilitate connections of Cray supercomputers to workstations and to other vendors' systems and operating software environments (for example IBM MVS and VM, CDC NOS/BE and NOS/VE, and AT&T and BSD UNIX).

UNICOS operating system

The UNICOS operating system delivers the full power of the CRAY Y-MP hardware in both an interactive and a batch environment. Significant features of UNICOS include support for asynchronous I/O, improved file system reliability, multiprocessing, and user multitasking. UNICOS efficiently manages high-speed data transfers between the CRAY Y-MP computer system and peripheral equipment. Standard system software interfaces the CRAY Y-MP computer system with other vendors' operating systems and with networks. UNICOS includes a variety of utility programs that assist in program development and maintenance. User programs can be ported easily between UNICOS and other UNIX systems.

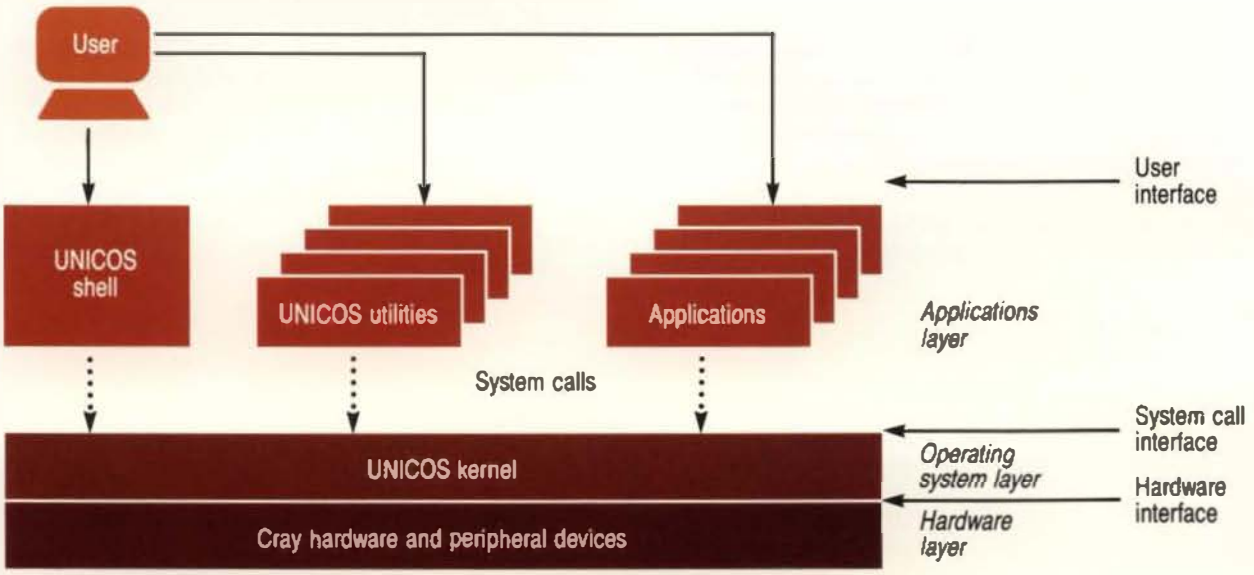
UNICOS is based on UNIX System V, an operating system developed by AT&T. In recent years, versions of UNIX have become available on many different computer systems. Like UNIX, UNICOS is written in the C programming language. It contains a small kernel that is accessed through system calls and a large, diverse set of utilities and library programs. Its file system is hierarchical, featuring directories for convenient organization of files.

The UNICOS kernel has been substantially enhanced in the areas of I/O processing and in the efficient use of very large data files.

The UNICOS system supports both an interactive environment and a batch processing capability to provide for efficient use of the system by large, long-running jobs. The standard UNIX process accounting features have been augmented with accounting features more appropriate for a supercomputer environment.

Users may initiate asynchronous processes that can communicate with one another. A variety of command-language interpreters (shells) are possible. UNICOS offers the standard AT&T UNIX Bourne

Overview of the UNICOS operating system



shell and the University of California Berkeley 4.3 BSD C shell. Other shells may be created to provide different command interfaces for users.

UNICOS provides the classic multiuser environment of UNIX in which information and resources are easily shared. UNICOS provides password protection and file access permissions. A system administrator can create a system profile to provide a customized initial environment for each user. To aid in controlling access to critical files, each user can be assigned to one or more logical groups. Associated with each file in the system is a set of access permissions. The system administrator may specify read, write, and execute restrictions for each file in the system. The current implementation represents initial security support; further enhancements are under development.

With the UNICOS tape subsystem, users can store extensive amounts of data while using the computational power of the CRAY Y-MP system for data analysis and large-scale problem solving. Tapes may be accessed by user programs as well as being used for both backing up and restoring user files on-line.

Cray Research has adopted an industry-standard operating system along with industry-standard communications protocols and proprietary software interfaces to other computing systems. This offers users an open system environment that permits access across a wide variety of interconnected computer systems, allowing the user to choose where work may best be processed. The result is a combination of flexibility and computing power unparalleled in the computer industry.

Fortran compilers and libraries

Cray Research offers the CFT77 Fortran compiler for the CRAY Y-MP computer system. This compiler fully complies with the ANSI standard 3.9-1978 (Fortran 77) and offers a high degree of automatic scalar and vector optimization. It permits maximum portability of programs between different computers and accepts many nonstandard constructs written for other vendors' compilers. Highly optimized (scalar and vector) object code is produced from standard Fortran code; users can program in standard Fortran syntax to access the full power of the CRAY Y-MP system architecture.

The Cray Fortran compiler CFT was the first Fortran compiler in the industry to automatically vectorize codes, automatically vectorize inner DO loops, and provide scalar optimization without sacrificing high compilation rates. As a state-of-the-art Fortran compiler, CFT77 not only generates highly vectorized, optimized, and multitasked code, but also offers array syntax and portability to CRAY X-MP and CRAY-2 systems as well as future Cray systems.

The compilers and Fortran library offer current Cray customers a high level of source code compatibility by making available on the CRAY Y-MP system Fortran extensions, compiler directives, and library interfaces that are available on other Cray Research products.

Fortran compiler features

- ANSI standard compliance
- Automatic optimization of code
  - —Vectorizes DO loops
  - —Generates multitasked code
- Portability of application codes a primary goal
- Library routines optimized for the CRAY Y-MP system
  - —Scientific library
  - —I/O library
  - —Multitasking library

The Fortran library and a library of highly optimized scientific subroutines enable the user to take maximum advantage of the hardware architecture. The I/O library provides the Fortran user with convenient and efficient use of external devices at maximum data rates for large files.

Multiprocessing

In conjunction with vectorization and large memory support, a flexible multiprocessing capability provides a major performance boost to large-scale scientific computing. Multiprocessing is a technique whereby an application program is partitioned into independent tasks that can execute in parallel on a CRAY Y-MP computer system. This results in substantial throughput improvements over serially executed programs. The performance improvements are in proportion to the parallelism inherent in the program, the number of tasks that can be constructed for the program, and the number of CPUs that can be applied to these separate tasks.

Three methods of multiprocessing can be used: macrotasking, microtasking, and automatic multitasking. Macrotasking is best suited to programs with larger, longer-running tasks. The user interface to the CRAY Y-MP macrotasking capability is a set of Fortran-callable subroutines that explicitly defines and synchronizes tasks at the subroutine level. These subroutines are compatible with similar routines available on other Cray products.

Microtasking, the second method of multiprocessing, breaks code into small units that can be executed in parallel on multiple processors. It has proven to be a very effective tool. Microtasking uses a preprocessor to allow programmers to multiprocess the low-level (fine granularity) parallelism found in many existing codes. Extremely fast synchronization allows microtasking's self-scheduling algorithm to make effective use of any available CPU cycles, providing effective load balancing of the system.

CFT77 provides an initial automatic multitasking capability that automatically partitions a program into tasks and efficiently uses whichever processors are available at any point during the running of the program.

Pascal

Pascal is a high-level, general-purpose programming language used as the implementation language for the CFT77 compiler and other Cray products. Cray Pascal complies with the ISO Level 1 standard and offers such extensions to the standard as separate compilation of modules, imported and exported variables, and an array syntax.

The optimizing Cray Pascal compiler takes advantage of CRAY Y-MP hardware features through both scalar optimization and automatic vectorization of FOR loops. It provides access to Fortran common block variables and uses a common calling sequence that allows Pascal code to call Fortran, C, and CAL routines.

C language

C is a high-level programming language used extensively in the creation of the UNICOS operating system and the majority of the utility programs that constitute the system. It is a widely used computer language available on processors ranging from microcomputers to mainframe computers to Cray supercomputers. C is useful for a wide range of applications and system-oriented programs. The C language is very popular in university environments and with the electronics and graphics industries. The availability of C complements the scientific orientation of Fortran. The Cray C compiler performs scalar optimization and vectorizes code automatically.

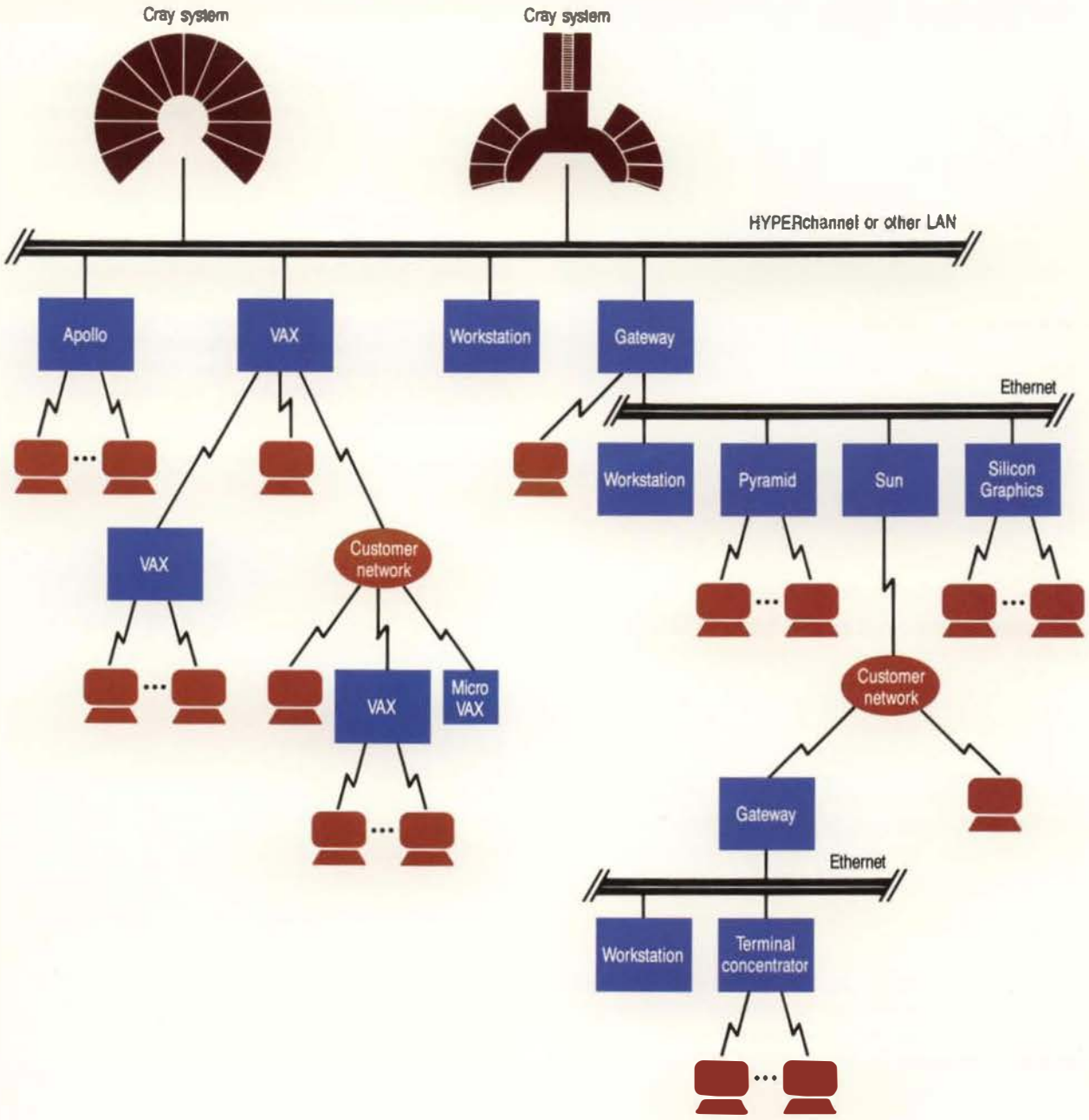
Networking

The wide array of available networking software products allows users to integrate a CRAY Y-MP system into a new or existing computer environment easily.

The TCP/IP networking suite is available on CRAY Y-MP computer systems running UNICOS, providing flexibility for integrating a CRAY Y-MP system into an open network architecture that supports the TCP/IP protocol suite.

Cray Research also provides station software products that offer access to proprietary protocol implementations (such as SNA, DECnet, and CDCnet) through network gateways. Station software runs on a variety of systems and workstations to provide the logical connection to a CRAY Y-MP computer system running UNICOS or COS. Standard Cray station software is available for the following systems: IBM MVS and VM, CDC NOS, NOS/VE, and NOS/BE, DEC VAX/VMS, and a variety of computers and workstations running UNIX. Station software for Unisys and Honeywell Bull systems is also available from third-party vendors.

Sample multiple-vendor TCP/IP configuration



Utilities

A set of software tools assists both interactive and batch users in the efficient use of the CRAY Y-MP system.

A variety of debugging aids allows users to detect program errors by examining both running programs and program memory dumps. These aids include symbolic interactive debuggers and symbolic post-mortem dump interpreters. Performance aids assist in analyzing program performance and optimizing programs with a minimum of effort.

The *Perftrace* utility, for example, supplies statistics on computer performance for individual program units within a program. The information comes from the Hardware Performance Monitor, which is standard on the CRAY Y-MP computer. Other performance utilities include *Flowtrace*, which prints information on all procedure calls, and *Ftref*, which provides a calling tree and other structural information about a program.

A source code control system tracks modifications to files. This is useful when programs and documentation undergo frequent changes due to development, maintenance, or enhancement. Several text editors offer versatility for users wishing to create and maintain text files. Operational support facilities enable proper management of the system.

Included with each release of UNICOS is on-line documentation in a format familiar to UNIX users and help facilities for quick reference of information.

CAL

The Cray assembler, CAL, provides a macro assembly language that is especially helpful for tailoring programs to the architecture of the CRAY Y-MP system and for writing programs requiring hand-optimization.

COS migration

The Guest Operating System (GOS) feature of the COS operating system allows users to run both COS and UNICOS concurrently on the CRAY Y-MP system. A maximum of four CPUs and 16 million words of memory can be dedicated to COS. The Guest Operating System feature provides downward compatibility with the CRAY X-MP systems for running production codes under COS. It also is a valuable migration tool for migrating completely from COS and running only UNICOS on the CRAY Y-MP computer system. A variety of additional migration tools have been created to further ease conversions of Fortran code from COS to UNICOS, COS datasets to UNICOS files, and COS job control language statements to UNICOS commands.

Software summary

- UNICOS, which is based on the AT&T UNIX System V operating system
- Enhancements to UNICOS for the large-scale scientific computer environment
- A vectorizing Fortran compiler
- An optimized Fortran mathematical and I/O subroutine library
- A scientific subroutine library optimized for the CRAY Y-MP system
- A multitasking library
- A wide variety of system utilities
- A vectorizing C compiler
- A vectorizing ISO Level 1 Pascal compiler
- CAL, the Cray macro assembler
- Software for connecting to multi-vendor environments
- A wide variety of major application programs

Applications

In addition to Cray Research system and application software, a wide variety of third-party and public domain application programs can be run in Cray COS and UNICOS environments. These codes can take immediate advantage of the higher performance of the CRAY Y-MP system for applications such as computational fluid dynamics, structural analysis, mechanical engineering, nuclear safety, circuit design, seismic processing, image processing, molecular modeling, and artificial intelligence.

Cray Research provides suppport for the ongoing process of converting and maintaining application software on Cray computer systems. A comprehensive catalog of available programs is published by the Cray Applications Department.

This application software, teamed with Fortran, C, and Pascal compilers, editors, debuggers, libraries, database management tools, and many other software tools and products, provides users with the software they need to use a CRAY Y-MP system to its fullest capabilities.

The CRAY Y-MP computer system provides balanced performance for the most demanding applications. Researchers and engineers can apply the CRAY Y-MP computer system to problems previously considered computationally intractable, as well as solving existing problems faster and with greater precision.

One such application is the simulation of physical phenomena — the analysis and prediction of the behavior of physical systems through computer modeling. The CRAY Y-MP computer system offers increased capacity to conduct three-dimensional simulations of a wide variety of problem domains such as weather forecasting, aircraft and automotive design, energy research, reservoir simulation, and seismic analysis. It also provides an opportunity to find challenging solutions for applications such as genetic engineering, artificial intelligence, quantum chemistry, and economic modeling. The CRAY Y-MP computer system offers an increased capacity to explore further new solution techniques or increased resolution.

With its increased I/O bandwidth, the CRAY Y-MP computer system offers dramatic improvements in throughput over CRAY X-MP computer systems. Vectorization and multiprocessing with up to eight processors and the faster, larger memory and faster clock yield very high computation rates. In practical terms, this means that problems previously considered unsolvable or too costly to solve, even with CRAY X-MP computer systems, now become solvable and economically feasible.

Applications

- Fluid dynamics
- Circuit simulation and design
- Structural analysis
- Energy research
- Weather forecasting
- Atmospheric and oceanic research
- Quantum chemistry
- Artificial intelligence
- Genetic engineering
- Signal and image processing
- Molecular dynamics
- Petroleum exploration and recovery
- Process design
- Economic modeling
- Applied mathematics
- Finance
- Advanced graphics

Support and maintenance

Cray Research has developed a comprehensive array of support services to meet customer needs. From pre-installation site planning through the life of the installation, hardware engineering and system software support is provided locally and through technical centers throughout the company. Cray Research also provides comprehensive user documentation for both hardware and software products. Technical software training is offered to customers on-site or at Cray regional and corporate training facilities.

Cray Research has extensive experience serving the supercomputer customer — over a decade of experience spanning a wide variety of customers and applications. Professional, responsive support from trained specialists is just part of the service commitment that Cray Research makes to every customer.

Cray Research recognizes the need for high system reliability while maintaining a high level of performance. The use of higher-density integrated circuits and an overall higher level of component integration set the stage for CRAY Y-MP hardware reliability to meet or exceed the reliability of previous Cray systems. Components used in CRAY Y-MP systems undergo strict inspection and checkout prior to assembly into a system. A CRAY Y-MP computer system undergoes rigorous operational and reliability tests prior to shipment.

Preventive maintenance techniques ensure that system performance is high; effective and timely maintenance is a routine operation. Diagnostic software quickly isolates any problem that may occur. The faulty system element may then be optionally deconfigured and the system operated in a degraded mode, or the element may be replaced immediately and the system restarted fully configured. All system elements are readily accessible for replacement. Further diagnosis and repair of the faulty element may then be completed off-line.

The Cray Research philosophy is to replace system elements on-site, providing minimum system downtime and the highest system availability.

About Cray Research, Inc.

Cray Research was organized in 1972 by Seymour R. Cray, a leading designer of large-scale scientific computers, along with a small group of computer industry associates. The company was formed to design, develop, manufacture, and market large-capacity, high-speed computers.

The first model produced was the CRAY-1 computer system in 1976. This was followed by the CRAY X-MP system in 1982 and the CRAY-2 system in 1985. Each offered a considerable improvement in performance over its predecessors. The CRAY Y-MP computer system continues this tradition of computing excellence from Cray Research.

The CRAY Y-MP computer system demonstrates Cray's continued commitment to overall performance. Over the years, Cray Research has offered new products such as the DS-40 disk subsystem and the SSD solid-state storage device to complement the Cray computing systems and to continually improve computational capacity for users.

Cray Research has more experience than any other vendor in producing software for supercomputers. This software assures that every Cray computing system is used to its fullest. From the revolutionary CFT compiler — the first Fortran compiler to automatically vectorize code — to Cray's industry-leading multitasking capability, and to today's UNICOS operating system supported with full-featured ANSI standard Fortran, C, and Pascal compilers, Cray Research develops software that allows users easy access to the computer architecture while maintaining low system overhead and high reliability. In addition, Cray Research's networking software and support for connecting Cray supercomputers into any existing computing environment is unmatched.

Today, Cray Research is the world leader in supercomputers, with more than 200 installations worldwide. The company operates manufacturing, research, development, and administrative facilities in Chippewa Falls, Wisconsin and the Minneapolis, Minnesota area. The company has sales and support offices throughout North America and has subsidiary operations in Western Europe and the Far East.

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CCMP-0301

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