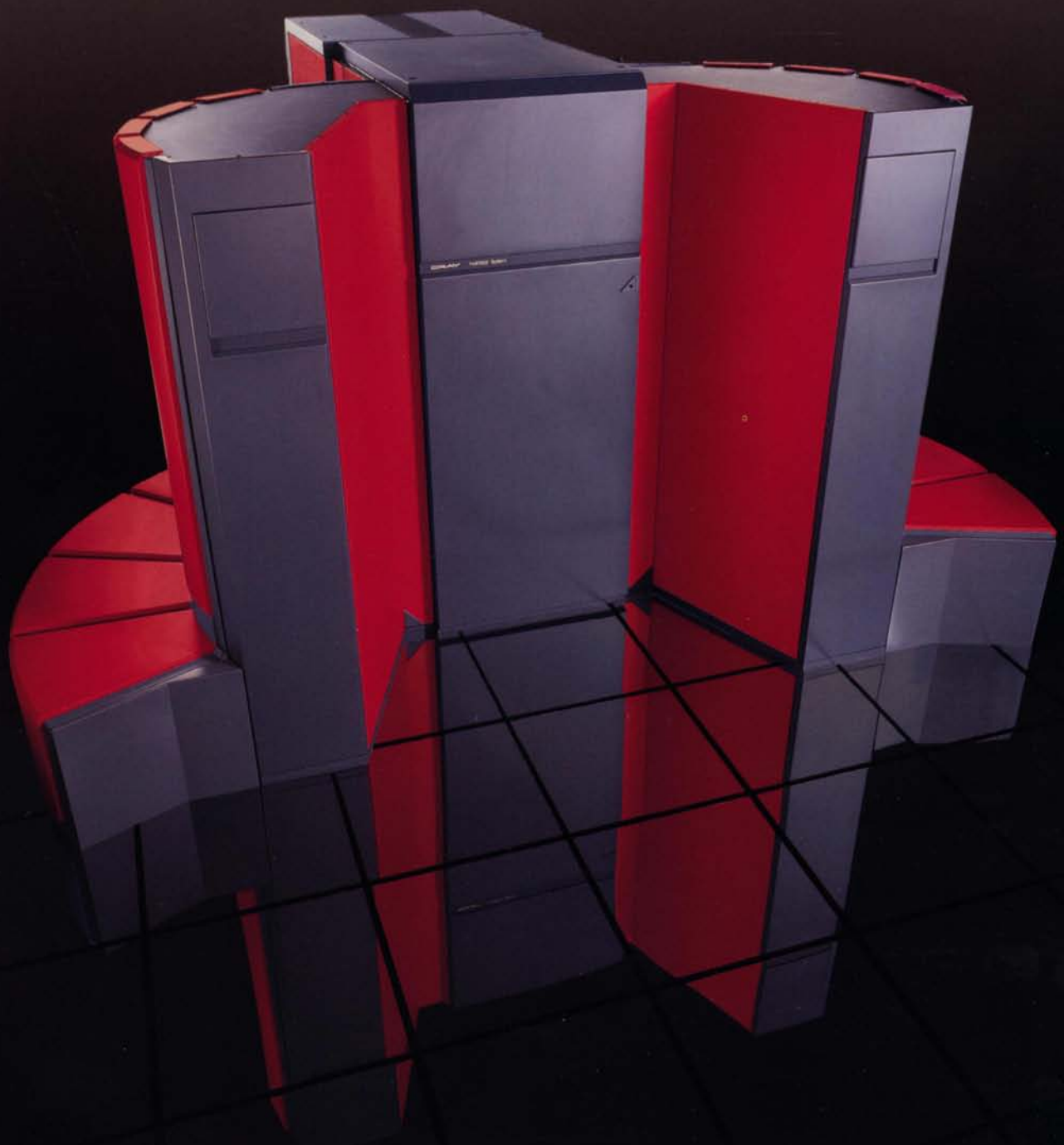
The CRAY Y-MP Series of Computer Systems



CRAY

Cray Research's mission is to develop and market the most powerful computer systems available. 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 and support.

The company's first product, the CRAY-1 computer system, was installed in 1976. The CRAY-1 computer, which was the first commercially successful vector processor, quickly established itself as the standard for large-scale computer systems. 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 on a single job for better program turnaround time. For the first time, multiprocessing and vector processing combined to provide a dramatic increase in computational performance over conventional scalar processing techniques. Introduced in 1988, the CRAY X-MP EA series of computer systems extended the CRAY X-MP line to accommodate a large real-memory address space.

Now, Cray Research is introducing a powerful replacement for the CRAY X-MP and CRAY X-MP EA series of computer systems. In continuing a tradition of leadership in supercomputing, Cray Research announces the CRAY Y-MP series of computer systems.

Introducing the CRAY Y-MP series of computer systems

Building on the foundation established by the field-proven CRAY-1 and CRAY X-MP computer systems, the CRAY Y-MP series of systems offers a new level of supercomputing performance to solve new and larger problems. The unique modular architecture of the CRAY Y-MP series allows for efficient parallel and vector processing, and the fast 6-nanosecond clock cycle time and very high I/O bandwidth provide unequaled gains in job throughput.

The CRAY Y-MP series of computer systems offers a wide range of computational power and memory capacity, and the modular nature of the series permits a high degree of field upgradability. The product line consists of three basic frame configurations: the CRAY Y-MP8, the CRAY Y-MP4, and the CRAY Y-MP2. As many as eight central processing units (CPUs) can be configured on CRAY Y-MP8 systems, and as many as four CPUs can be configured on CRAY Y-MP4 systems. One or two CPUs can be configured on CRAY Y-MP2 systems. Shared central memory is available in sizes of 16, 32, and 64 million words, with planned upgrades to 128 million words. The table at the bottom of the next page shows currently available CPU and memory configurations for the three models.

The 6-nanosecond clock cycle time enables a peak performance ranging from 333 megaflops on CRAY Y-MP2 systems configured with a single processor to 2.67 gigaflops on CRAY Y-MP8 systems configured with eight processors.

The CRAY Y-MP series is based on new architecture and technology. Using Very Large Scale Integration (VLSI) gate-array circuits developed by Cray Research, CRAY Y-MP systems can now perform many functions that previously required multiple chips on a single chip. Similarly, using 12-layer, large-format printed circuit boards combined into four-board modules, CRAY Y-MP systems enhance the Cray tradition of achieving efficiency through innovative high-density packaging. A captive liquid cooling system efficiently removes heat from each module.

With up to 128 million 64-bit words of directly addressable central memory, the CRAY Y-MP series enables users to solve complex problems without the need for out-of-memory programming techniques. The CRAY Y-MP series may also be configured with an optional SSD solid-state storage device of 32-, 128-, 256-, or 512-million word capacity to address even larger problems that require extensive I/O and out-of-memory solution techniques.

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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 series.

The input/output capabilities of the Model D I/O Subsystem (IOS) complement the CRAY Y-MP CPUs and enable fast, efficient data access and processing. On the CRAY Y-MP8 system, a second IOS can be added for increased I/O capability. Each IOS can be connected to as many as 24 Cray Research disk storage units.

A 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 CRAY Y-MP series runs programs under the UNICOS operating system. This provides for easy portability of programs developed under UNICOS on CRAY X-MP and CRAY-2 computer systems. The CRAY Y-MP series also runs the COS operating system, developed for CRAY X-MP systems, on up to four processors and 16 million words of memory.

The CRAY Y-MP series of computer systems offers the most powerful and cost-effective computing solutions available for large-scale applications.

CRAY Y-MP series highlights

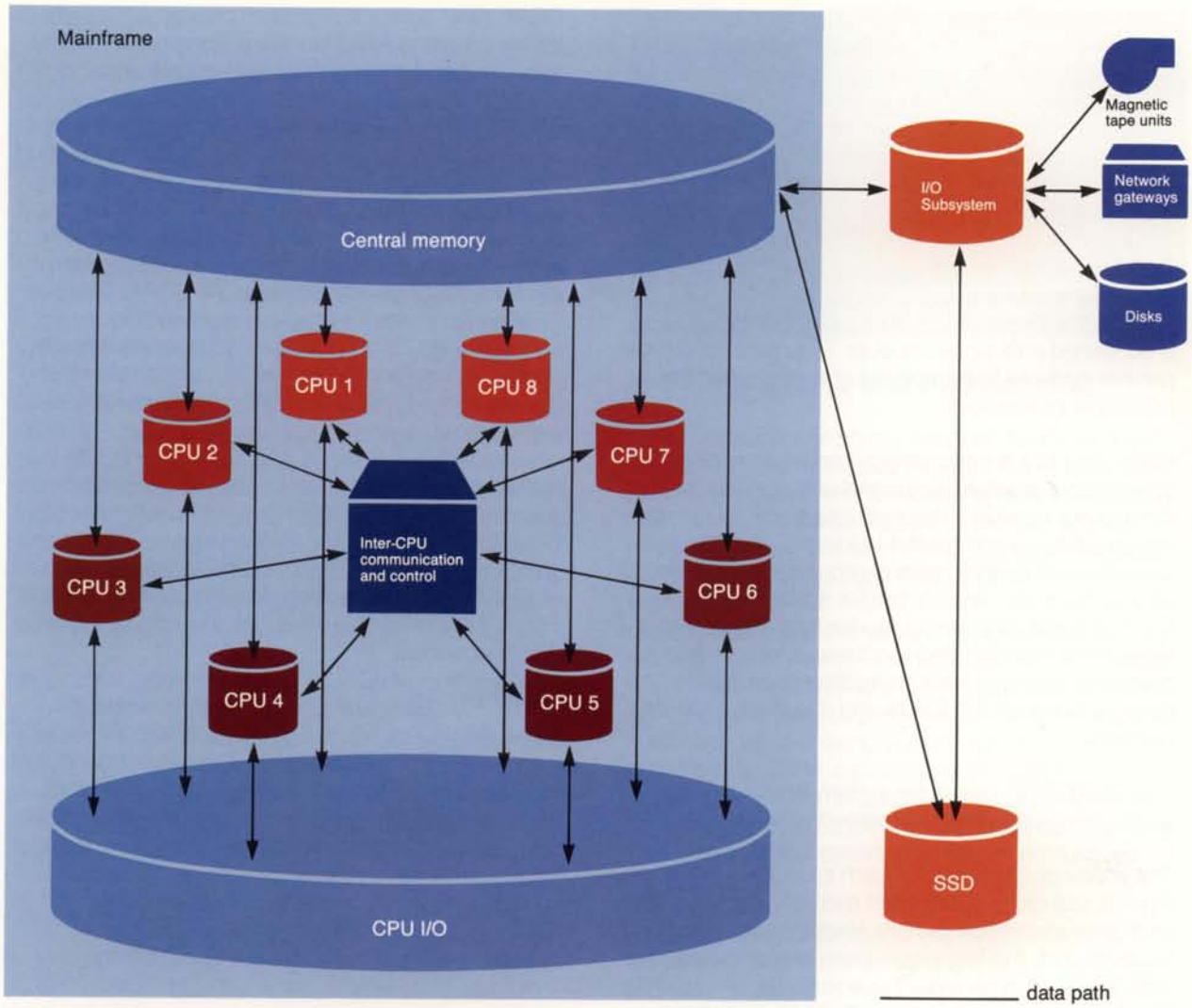
- One, two, four, or eight processors
- 6-nanosecond clock cycle
- Flexible hardware chaining for vector operations
- Gather/scatter and compressed index vector support
- Flexible processor clustering for multitasking applications
- CRAY X-MP compatible instruction capability
- Four parallel memory ports per processor
- Dedicated registers for efficient interprocessor communication and control
- 16, 32, 64, or 128 million words of memory
- 32-bit addressing capability
- 64, 128, or 256 memory banks
- SECDED memory protection
- One or two I/O Subsystems

CRAY Y-MP CPU and Memory Configurations

Frame	CPUs	64-Mword	32-Mword	16-Mword
8	8	CRAY Y-MP8/864[1]	CRAY Y-MP8/832[2]	
	4	CRAY Y-MP8/464[1]	CRAY Y-MP8/432[2]	
4	4		CRAY Y-MP4/432[3]	CRAY Y-MP4/416[4]
	2		CRAY Y-MP4/232[3]	CRAY Y-MP4/216[4]
	1		CRAY Y-MP4/132[3]	CRAY Y-MP4/116[4]
2	2			CRAY Y-MP2/216[5]
	1			CRAY Y-MP2/116[5]

[1]Memory will be upgradable soon to 128 Mwords.
[2]Memory is upgradable now to 64 Mwords and will be upgradable soon to 128 Mwords.
[3]Memory will be upgradable soon to 64 Mwords.
[4]Memory is upgradable now to 32 Mwords and will be upgradable soon to 64 Mwords.
[5]Memory will be upgradable soon to 32 Mwords.

CRAY Y-MP8 recommended 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 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 system throughput.

Processors

Each of the identical CPUs in a CRAY Y-MP system is contained on a single module. This modular design permits systems to be upgraded easily by adding additional processors.

Each CPU 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 and coordinates the three types of processing available on all Cray computer systems (vector, scalar, and address). Each of these processing modes has its own set of 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 vector processing.

The scalar performance of each processor is derived 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 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 demanding register-to-register or memory-to-memory vector operations.

CRAY Y-MP computer systems provide high performance using ANSI standard Fortran without the need for hand-coding or algorithm restructuring.

CRAY Y-MP computer systems also include 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.

A 2500-gate emitter-coupled-logic (ECL) gate array, custom designed by Cray Research, is the building block for the CRAY Y-MP CPU. A single CPU module contains an entire CPU plus logic for memory conflict resolution, I/O channels, and semaphore registers. Each of the identical CPUs has a clock cycle 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 time-sharing among jobs.

Data structure

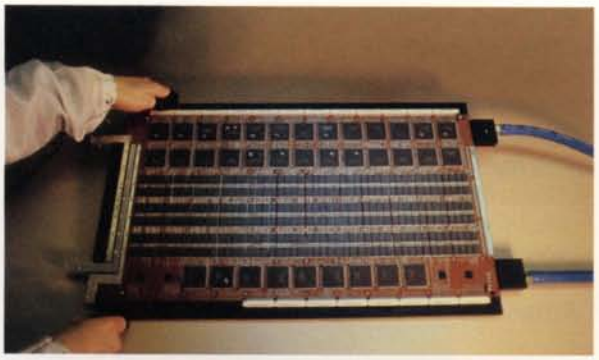
CRAY Y-MP system internal character representation is in ASCII. Each 64-bit word can accommodate eight characters. All integer arithmetic is performed in 32-bit or 64-bit twos complement mode. Floating-point numbers (64-bit quantities) consist of a signed magnitude binary coefficient and a biased exponent. CRAY Y-MP systems can also run 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 series of computer systems has from 16 to 128 million 64-bit words of directly addressable central memory in 64, 128, or 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 operations.

All processors of the CRAY Y-MP system share 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 CRAY Y-MP2, CRAY Y-MP4, and CRAY Y-MP8 frames can hold 8, 16, or 32 memory modules, respectively. Each of the modules contains from one to four million 64-bit words, or about 16 to 64 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 turnaround time using multiprocessing and multitasking techniques. Multitasked applications that are run on the CRAY Y-MP8 system can realize speed increases of nearly eight times that of single-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 segments of a program (tasks) to be executed in parallel, while sharing a common memory space, potentially resulting in substantial throughput improvements over programs serially executed on a single CPU. In particular, if a job requests all of main memory, then using all processors provides maximum system efficiency.

Performance improvements are determined by the amount of parallelism inherent in a program and the number of CPUs that can be applied to the separate tasks over a given unit of time.

When executing in multitasking mode, any number of identical processors can be dynamically assigned to perform multiple tasks for 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 simple Fortran directives. In addition, the hardware provides built-in detection of deadlocks within a cluster of processors.

Autotasking

For multiprocessor CRAY Y-MP computer systems operating under the UNICOS operating system, the CFT77 Fortran compiling system can partition a program automatically among multiple processors, enabling parts of the program to execute in parallel. For codes with high levels of parallelism, autotasking has resulted in speedups of 1.95 to 1 in a two-processor system, 3.9 to 1 in a four-processor system, and 7.8 to 1 in an eight-processor system.

Input/output processing

Cray Research's Model D I/O Subsystem (IOS) is an integral part of the CRAY Y-MP design, acting as the mainframe's data distribution point. The IOS gathers and distributes data for a variety of network gateways and peripherals such as disk storage 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 computational interference.

One I/O Subsystem is configured on each CRAY Y-MP4 and CRAY Y-MP2 system; either one or two I/O Subsystems is configured on the CRAY Y-MP8 system. Each IOS contains a maximum of four interconnected I/O processors (IOPs), each with its own local memory, and a common buffer memory. Four IOPs are standard in a single-IOS configuration; six, seven, or eight IOPs can be used in a dual-IOS configuration.

Buffer memory is solid-state secondary storage accessible by all of the IOPs in each of the IOS units. Buffer memory of 4 million words (32 million bytes) is standard; buffer memory of 8 million words or 32 million words is optional. 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. Under UNICOS, buffer memory can be used for storing library software or for swapping devices between main memory and the optional SSD, providing extremely fast access times.

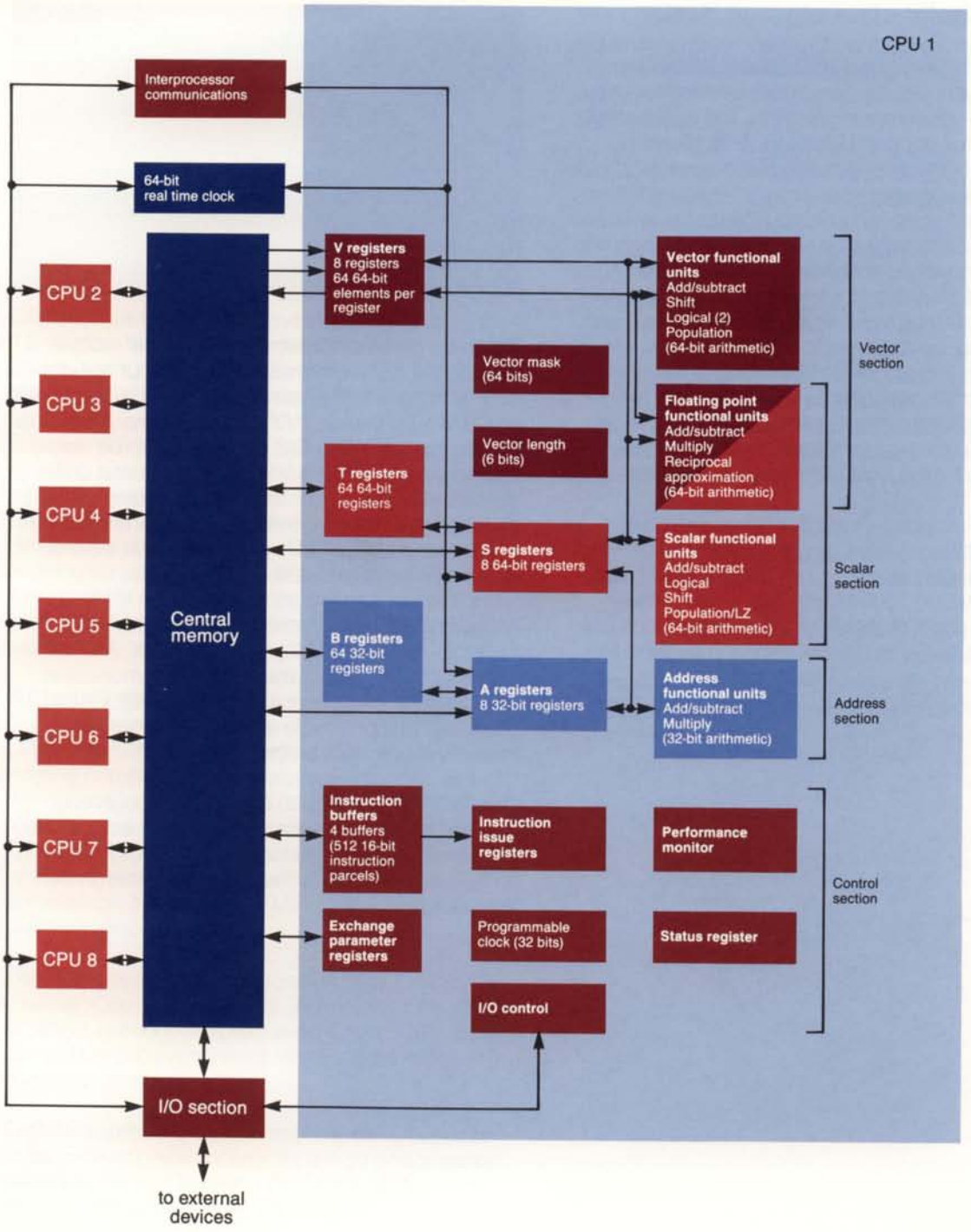
CRAY Y-MP computer systems support three different channel types, identified by their maximum transfer rates of 6 Mbytes/sec, 100 Mbytes/sec, and 1000 Mbytes/sec, respectively. Eight 6-Mbyte/sec, eight 100-Mbyte/sec, and two 1000-Mbyte/sec channels are available on the CRAY Y-MP8 computer system; four 6-Mbyte/sec, four 100-Mbyte/sec, and two 1000-Mbyte/sec channels are available on the CRAY Y-MP4 computer system; and two 6-Mbyte/sec, two 100-Mbyte/sec, and one 1000-Mbyte/sec channel are available on the CRAY Y-MP2 computer system.

The 6-Mbyte/sec channels pass control information between central memory and the IOS or between central memory and the network gateways. The 100-Mbyte/sec channels transfer data between central memory and the IOS, between the IOS and an optional SSD, or between the IOS and the SSD. The 1000-Mbyte/sec channels transfer data between central memory and the SSD.

Input/output highlights

- Standard I/O Subsystem with four I/O processors
- Optional second I/O Subsystem with two, 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-optics link
  - 100-Mbyte/sec external channel (HSX-1)

CRAY Y-MP8 system organization



The SSD solid-state storage device

Cray Research's optional SSD solid-state storage device is a very fast random-access device for use with CRAY Y-MP computer systems. The SSD permits algorithms that support I/O-intensive applications such as out-of-memory solution techniques. It is used for large prestaged or intermediate files that are generated and manipulated repeatedly by user programs. The system may also use it for swapping programs and for holding commonly accessed libraries and other frequently accessed programs, thereby improving overall system performance. 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 for the most recently used data. This operating system feature automatically provides SSD access for the most I/O-intensive processes.

System performance on I/O-intensive applications is significantly enhanced by the SSD's exceptionally high transfer rates and short data access times. Transfer rates of 100 to 1000 Mbytes/sec per channel and access times of less than 25 microseconds can be achieved between the SSD and the CRAY Y-MP mainframe.

SSD highlights

- Optional 128-million-word (1-Gbyte), 256-million-word (2-Gbyte) or 512-million-word (4-Gbyte) external SSD
- Optional 32-million-word (256-Mbyte) or 128-million-word (1-Gbyte) internal SSD
- One or two 1000-Mbyte/sec channels to CPUs
- SECDED memory protection
- Software support
- One, two, or four 100-Mbytes/sec channels

SSDs are offered in external and internal models. An external SSD is housed in its own four-column cabinet integral to the mainframe. It can be configured on CRAY Y-MP8 and CRAY Y-MP4 systems. An internal SSD is housed in the IOS cabinet. It can be configured on any CRAY Y-MP system. External SSDs are available in sizes of 128 million words (1 Gbyte), 256 million words (2 Gbytes), and 512 million words (4 Gbytes). Internal SSDs are available in sizes of 32 million words and 128 million words.

A CRAY Y-MP2 mainframe communicates with the SSD through a 1000-Mbyte/sec channel. A CRAY Y-MP8 or CRAY Y-MP4 mainframe communicates with the SSD through one or two 1000-Mbyte/sec channels, which provide a maximum aggregate transfer rate of 2000 Mbytes/sec.

The SSD is connected to each IOS through one, two, or four 100-Mbyte/sec channels. These connections enable 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 the DD-49 disk drive. 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 milliseconds. The DS-40 disk subsystem is comprised of four DD-40 disk storage units, with a storage capacity of 20.8 Gbytes. (A second string of four DD-40 disk storage units may be daisy chained on a single controller to provide a total storage capacity of 41.6 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 using disk striping, a software technique 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, allowing consecutive blocks to be accessed in parallel. The resultant I/O performance improvements are determined by the number and types of disk drives used.

Network gateways

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

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

Digital Equipment Corporation offers a VAX Supercomputer Gateway, which provides a high-performance direct connection between the Digital VAXcluster environment and a 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 and CRAY Y-MP systems. Up to seven front-end interfaces can be accommodated on a single-IOS CRAY Y-MP system; up to fourteen can be accommodated on a dual-IOS 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 manufactured by IBM, CDC, DEC, Data General, Unisys, and Honeywell Bull.
- The Cray Research FOL-1 fiber-optics 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 with a Sun or Motorola workstation, provides a gateway interface between a CRAY Y-MP system and an Ethernet local area network or other VME-based device.

Physical characteristics

The CRAY Y-MP8 or CRAY Y-MP4 mainframe cabinet (containing CPUs and memory), an IOS cabinet, and an SSD cabinet are connected in a Y-shaped configuration. The CRAY Y-MP2 mainframe cabinet (containing CPUs and memory) and the IOS cabinet are connected in an I-shaped configuration.

The rectangular CRAY Y-MP mainframe chassis contains the CPU and memory modules, power supplies, power distribution unit, and coolant hoses. CRAY Y-MP8 and CRAY Y-MP4 mainframes occupy 16 square feet (1.5 square meters) of floor space; CRAY Y-MP2 mainframes occupy 11.1 square feet (1 square meter).

Each IOS consists of four vertical columns arranged in a 90° arc occupying 15 square feet (1.4 square meters) of floor space. On CRAY Y-MP8 and CRAY Y-MP4 systems, one IOS is attached directly to the mainframe chassis and forms one leg of the Y configuration. The IOS on CRAY Y-MP2 systems and the optional second IOS on CRAY Y-MP8 and CRAY Y-MP4 systems is housed in a stand-alone cabinet that can be up to 9.5 feet (2.9 meters) from the mainframe cabinet.

CRAY Y-MP8 system specifications

Mainframe

Number of CPUs	8
Bipolar memory (Mwords)	32, 64, or 128
Clock cycle (nsec)	6
6-Mbyte/sec channels	8
100-Mbyte/sec channels	8
1000-Mbyte/sec channels	2

SSD Solid-state Storage Device

Memory size (Mwords)	32, 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, 8, or 32	8, 12, or 16

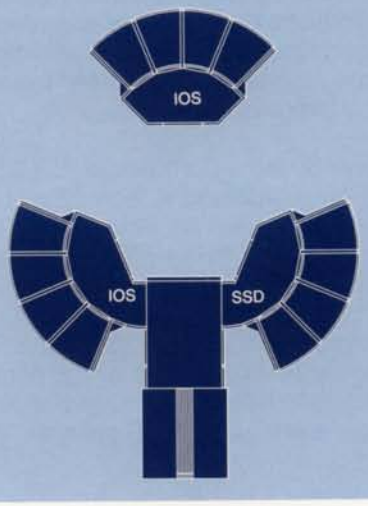
The external SSD cabinet on CRAY Y-MP8 and CRAY Y-MP4 systems consists of four columns arranged in a 90° arc occupying 15 square feet (1.4 square meters) of floor space. It forms the other leg of the Y configuration on the systems. CRAY Y-MP2 systems do not have an external SSD cabinet.

The CRAY Y-MP CPUs use a 2500-gate ECL gate array chip, custom designed by Cray Research. The use of these chips, which typically have 300- to 350-picosecond propagation delays, enables more efficient use of subcircuits and higher component density to yield a substantial improvement in performance over CRAY X-MP systems.

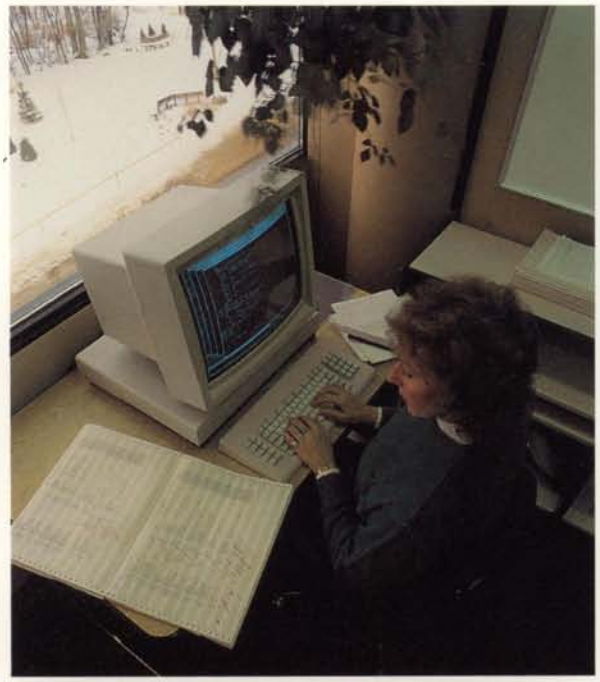
Use of the 2500-gate gate array enables an entire CRAY Y-MP CPU to be contained on a single module. The resulting densely-packed modules and the power supplies are cooled by chilled liquid, thus maintaining the necessary internal system temperature, contributing to high system reliability, and minimizing the need for expensive room cooling equipment.

The SSD and the IOS use high-speed 16-gate 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-MP8 footprint



Software



CRAY Y-MP computer systems come with state-of-the-art software, including UNICOS, a Cray 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 and the advanced computational power of CRAY Y-MP computer systems. 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 CRAY Y-MP systems, thus protecting user software investments.

The Cray operating system COS is also available, allowing programs developed in the CRAY X-MP/COS 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 vectorizing, scalar optimizing, and autotasking 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); portable standard Lisp; and a number 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 now available, Cray Ada, Common Lisp, and SIMSCRIPT compilers are under development.

The CRAY Y-MP computer systems are 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. This extensive support facilitates connections of Cray supercomputers to workstations and to other vendors' systems and operating 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 either an interactive or batch environment. Significant features of UNICOS include support for asynchronous I/O, improved file system performance and reliability, multiprocessing, and multitasking. UNICOS efficiently manages high-speed data transfers between a 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 for use in program development and maintenance. User programs can be ported easily between UNICOS and other UNIX systems.

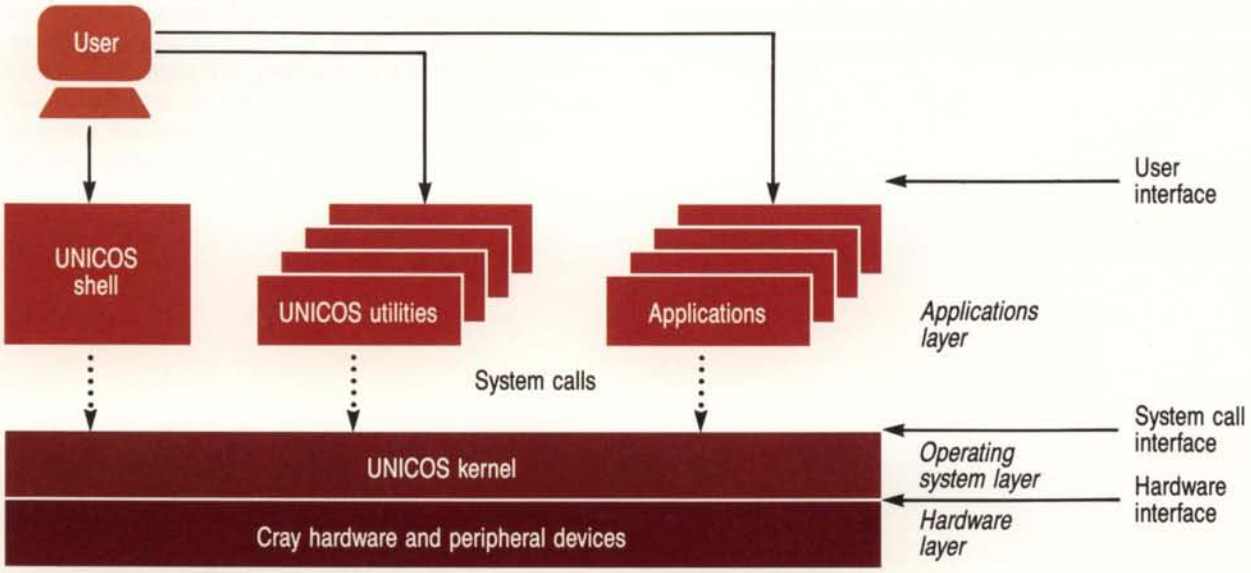
UNICOS is based on UNIX System V, an operating system developed by AT&T. In recent years, versions of UNIX have become available on many different computer systems. Like UNIX, UNICOS is written in the C programming language. It contains a small kernel that is accessed through system calls and a large, diverse set of utilities and library programs. The UNICOS 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 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 jobs. The standard UNIX process accounting features have been augmented with accounting features more appropriate for a supercomputing environment.

Users may initiate asynchronous processes that can communicate with one another. A variety of command-language interpreters (shells) are available. UNICOS offers the standard AT&T UNIX Bourne shell and the University of California Berkeley 4.3 BSD C shell. Other shells can be created to provide different command interfaces for users.

Overview of the UNICOS operating system



UNICOS provides a multi-user UNIX environment 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 can 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 CRAY Y-MP systems for data analysis and large-scale problem solving. Tapes can be accessed by user programs and used for 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 environment that permits access across a wide variety of interconnected computer systems, allowing distributed processing for an optimal workload distribution. 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 CRAY Y-MP computer systems. This compiler is fully compliant with the ANSI standard 3.9-1978 (Fortran77) and offers a high degree of automatic scalar and vector optimization. It permits maximum portability of programs between different computer systems 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 or autotasked 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 through the porting of Fortran extensions, compiler directives, and library interfaces.

Fortran compiler features

- ANSI standard compliance
- Automatic optimization of code
  - Vectorizes DO loops
  - Generates multitasked code
- Portable application codes
- Library routines optimized for CRAY Y-MP systems
  - Scientific library
  - I/O library
  - Multitasking library

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

Multitasking

Together with vectorization and large memory support, a flexible multitasking capability provides a major performance boost to large-scale scientific computing. Multitasking 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 programs executed on a single processor. The performance improvements are determined by the parallelism inherent in the code and the number of CPUs that can be applied to these separate tasks.

Three generations of multitasking have evolved: macrotasking, microtasking, and autotasking. Macrotasking is best suited for programs with larger 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 generation of multitasking, breaks code into small units that can be executed in parallel on multiple processors, greatly enhancing system performance. Microtasking uses a preprocessor, which reads user-supplied directives, to allow users to multitask 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.

The Cray Fortran compiler CFT77 provides autotasking, which automatically partitions a program into tasks and efficiently uses whichever processors are available at any point during the running of the program. In addition, autotasking supplies a convenient, powerful set of directives that allow a programmer to first invoke the automatic preprocessor, and then to fine-tune the code for even better performance.

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 extensions to the standard such 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 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 creating the UNICOS operating system and the majority of the system utility programs. 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 availability of C complements the highly scientific Fortran language. The Cray C compiler performs scalar optimization and vectorizes code automatically.

Networking

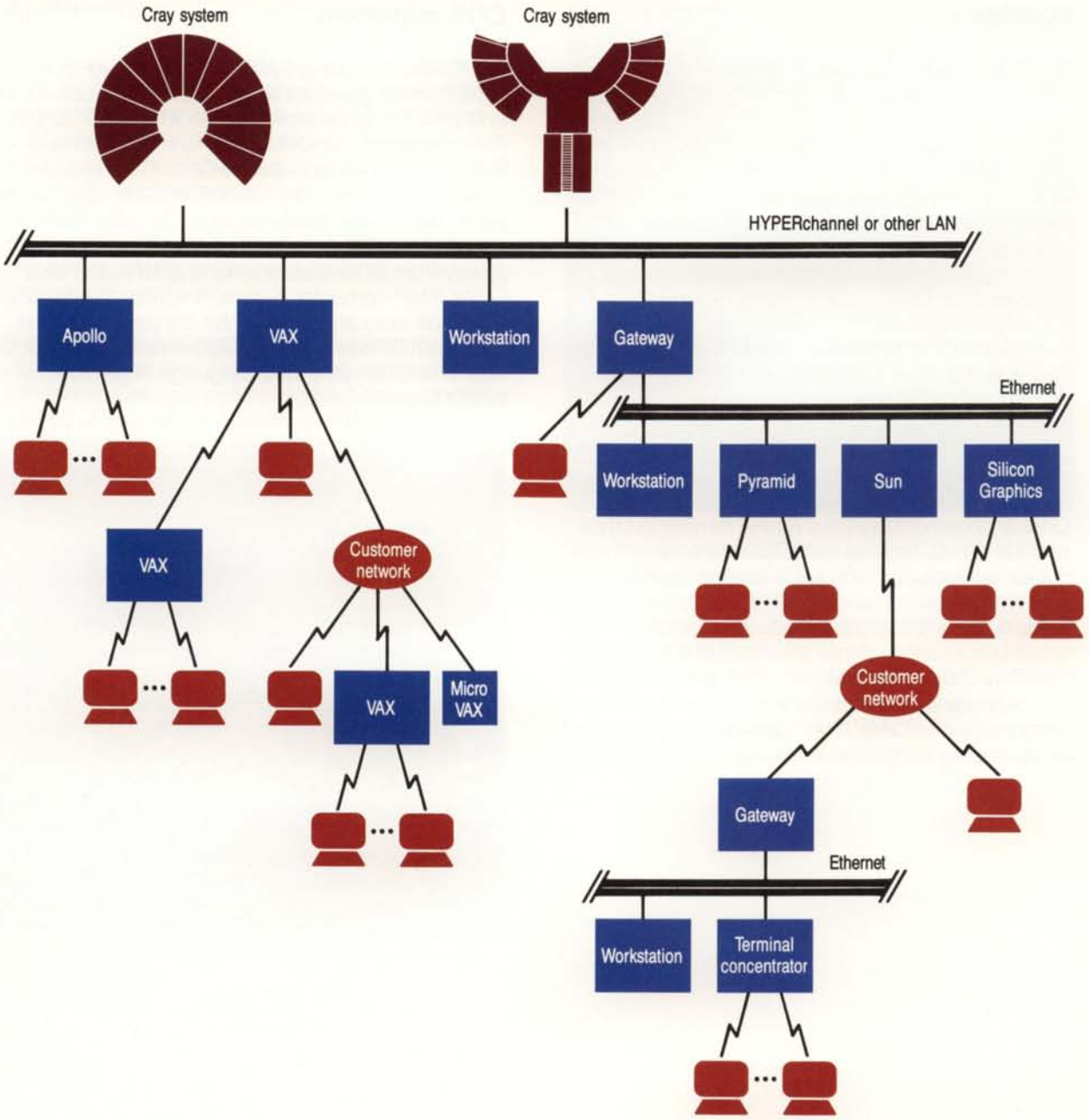
The wide array of available networking software products ensures smooth system integration when a CRAY Y-MP system is added to a new or existing computer environment.

The TCP/IP networking protocol is available for CRAY Y-MP computer systems running UNICOS.

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 the UNIX operating system. Station software for Unisys and Honeywell Bull systems is available from third-party vendors.

Cray networking software allows execution of programs that have communicating processes existing on a CRAY Y-MP system and on a network of engineering workstations. Users can interact with the Cray program while using a graphics terminal, tablet, or mouse. Graphical output from the Cray system appears on the workstation screen.

Sample multiple-vendor TCP/IP configuration



Utilities

A set of software utilities are available for both interactive and batch users of CRAY Y-MP systems.

Debugging aids allow users to examine both running programs and program memory dumps to check for errors. These aids include symbolic interactive debuggers and symbolic postmortem dump interpreters. Performance aids are available for analyzing program performance and optimizing programs.

A source code control system tracks file modifications. This is useful when programs and documentation undergo frequent changes. Several text editors are available to create and maintain text files. Operational support facilities enable proper management of the system.

On-line documentation in a format familiar to UNIX users and help facilities for quick reference of information are included with each release of UNICOS.

CAL

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

COS migration

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

Software summary

- ☐ UNICOS, based on the AT&T UNIX System V operating system
- ☐ Enhancements to UNICOS for large-scale scientific computer environments
- ☐ A vectorizing and autotasking 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 applications software, a wide variety of third-party and public domain application programs can be run in UNICOS and COS environments. These codes can take immediate advantage of the higher performance of CRAY Y-MP systems for applications in areas 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 ongoing support for converting, maintaining, and optimizing applications software on Cray computer systems. A comprehensive catalog of available programs is available through the distribution center in Mendota Heights, Minnesota; order publication number AP-1000-UB.

The applications software, teamed with Fortran, C, and Pascal compilers, editors, debuggers, libraries, source code management tools, and many other software tools and products, provides users with the software they need to use a CRAY Y-MP system to their best advantage.

An important class of applications is the simulation of physical phenomena — the analysis and prediction of the behavior of physical systems through computer modeling. CRAY Y-MP computer systems offer increased capacity to conduct three-dimensional simulations for a wide variety of problems, such as weather forecasting, aircraft and automotive design, energy research, reservoir simulation, and seismic analysis. It also provides an opportunity to find solutions to challenging problems in genetic engineering, artificial intelligence, quantum chemistry, and economic modeling.

Applications

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

With their increased I/O bandwidth, CRAY Y-MP computer systems offer 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. This means that problems previously considered impossible or too costly to solve, even with CRAY X-MP computer systems, are now possible and economically feasible.

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, ongoing hardware service and system software support is provided. 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 over a decade of experience serving supercomputer customers. Ongoing hardware and software support from trained specialists is part of the service commitment that Cray Research makes to every customer.

Cray Research strives to provide high system reliability while maintaining high performance. Higher-density integrated circuits and an overall increase in component integration have set the stage for CRAY Y-MP hardware reliability to meet or exceed that of previous Cray systems. Components used in CRAY Y-MP systems undergo strict inspection and checkout prior to assembly. A CRAY Y-MP computer system undergoes rigorous operational and reliability tests prior to shipment.

Preventive maintenance techniques ensure that system availability is high. On-line diagnostic software provides ongoing error detection and isolation. This ongoing preventive maintenance decreases the need for off-line diagnostics and minimizes down time.

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 in 1976, was the CRAY-1 computer system. 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 the Cray Research tradition of computing excellence.

The CRAY Y-MP computer system demonstrates Cray Research'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 computer systems and to continually offer increased computational capacity to users.

Cray Research has more experience than any other vendor in developing software for supercomputers. Cray software, which allows users easy access to the computer architecture while maintaining low system overhead and high reliability, ensures that every Cray computer system is used to its fullest. The UNICOS operating system is supported with full-featured ANSI standard Fortran, C, and Pascal compilers. In addition, Cray Research's networking software and support are unsurpassed.

Today, Cray Research is the world leader in supercomputers, with more than 250 installations worldwide. In addition to operating manufacturing, research, development, and administrative facilities in Wisconsin, Minnesota, and Colorado, the company has worldwide sales and support offices.

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