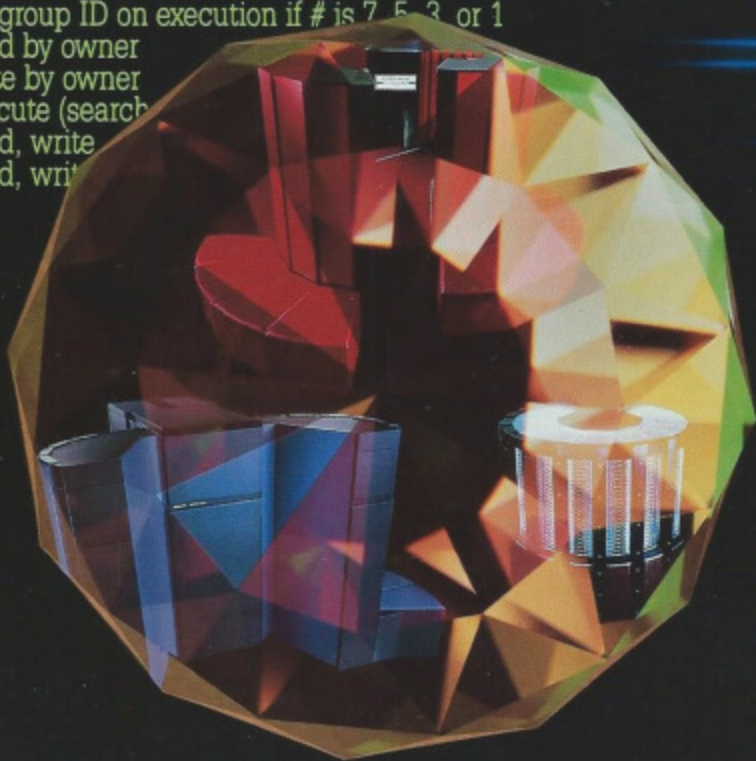# UNICOS

operating system
for Cray supercomputers

4000   Set user ID on execution
20#0   Set group ID on execution if # is 7, 5, 3, or 1
0400   Read by owner
0200   Write by owner
0100   Execute (search
0070   Read, write
0007   Read, writ

rlogin cray 2 –L
ftp cray get /user/ti   x/rps/doc

dispose test –n test.memo –m vm2 –f CB –d ST

CRAY

UNICOS

The mission of Cray Research is to design, manufacture, market, and support the most powerful computing systems available. To achieve this goal, the company provides high-performance software that can be integrated into existing environments while taking maximum advantage of the unique hardware characteristics of Cray computer systems.
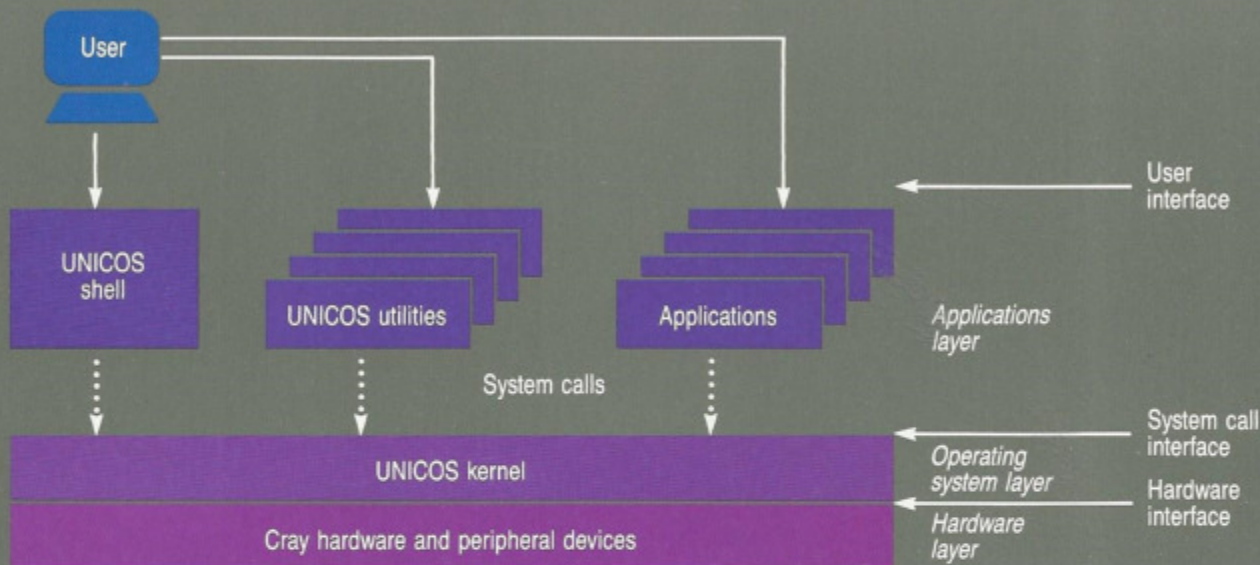
Reflecting this commitment, Cray Research has developed the UNICOS operating system, which is based on the AT&T UNIX System V operating system. UNICOS provides a smooth integration into the user's environment, while achieving maximum supercomputer performance.

UNICOS combines the power and functionality of UNIX with the advantages of using a Cray computer system in the following ways:

- Its modular design enhances overall performance and reliability.
- Like UNIX, it is written in the C programming language and is functionally equivalent to other UNIX systems. Thus, users already running UNIX can now run the same operating system environment on micro-computers, minicomputers, mainframes, and Cray super-computers — making it easy to transport data between systems.
- It has the advantage of being portable across Cray systems. This provides the user with the ability to take advantage of Cray systems today and more powerful Cray systems in the future.

- It provides flexible connectivity, which allows a Cray computer system to be integrated easily into the user's existing environment.

UNICOS goes far beyond the standard UNIX system by providing many enhancements that enable the user to attain true supercomputer performance. These enhancements include:

- High-speed I/O capabilities
- Flexible, high-performance communication capabilities
- Multiprocessor and multi-tasking software
- Batch services
- Cray Fortran (ANSI 78) compilers and tools
- Basic file security

Diagram labels:

- User
- UNICOS shell
- UNICOS utilities
- Applications
- System calls
- UNICOS kernel
- Cray hardware and peripheral devices
- User interface
- Applications layer
- System call interface
- Operating system layer
- Hardware interface
- Hardware layer

UNICOS runs on CRAY-2 systems and on CRAY Y-MP, CRAY X-MP, and CRAY-1 systems that have at least 2 million words of memory and an I/O Subsystem (IOS).

Performance and functionality

With efficient I/O, excellent multiprocessing capabilities, and low system overhead, UNICOS provides Cray users with the performance and functionality they require.

UNICOS combines the powerful utility programs of a UNIX system with the performance of Cray Research supercomputer programming products. This combination provides capabilities such as microtasking (on CRAY Y-MP and CRAY X-MP systems), memory management, and efficient I/O.

Portability

Because technology changes rapidly, Cray Research sought an operating system that could be moved readily from one Cray architecture to another. The portability of UNICOS provides a single operating system

supported across the Cray product line.

In turn, users can upgrade to more powerful Cray computer systems quickly because application interfaces are compatible across the Cray product line. Thus, applications running under UNICOS can be moved between Cray computer systems, both today and in the future.

Connectivity

UNICOS provides users with multiple choices for connecting to the wide variety of existing customer communications environments.

UNICOS offers the capability of connecting Cray systems to existing systems via the U.S. Department of Defense standard TCP/IP protocol suite or through Cray-proprietary station products.
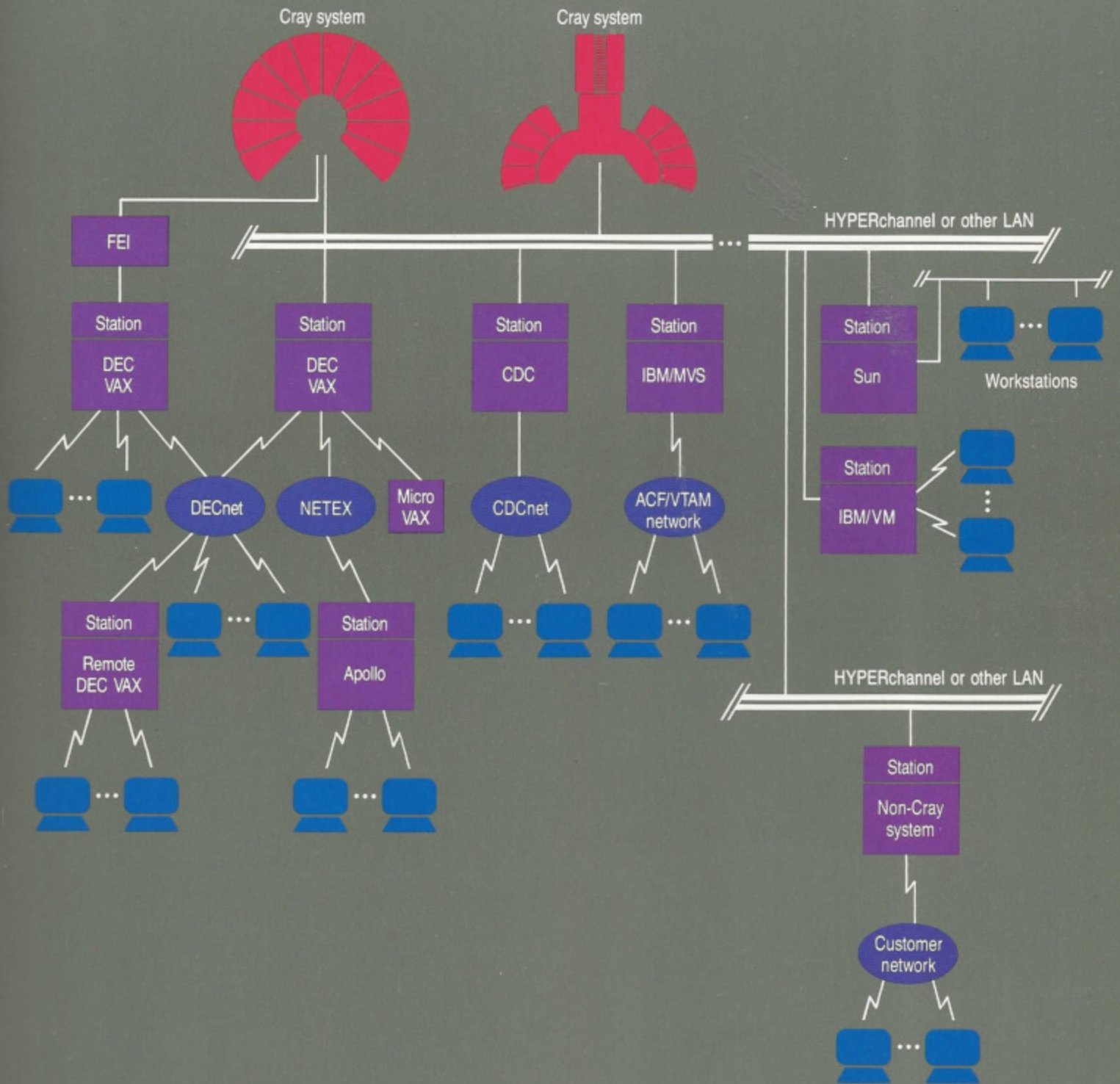
The TCP/IP protocol allows the Cray computer system to communicate as a peer with other vendors' systems or with existing networks, which can include mainframes, minicomputers and workstations, as well as other Cray computer systems. The TCP/IP network environment provides file transfer facilities, virtual terminal access, and tools upon which users can build distributed applications.

Station software, developed by Cray Research, runs on many systems and workstations and provides a logical connection to Cray computers. A station enables the Cray system to act as a natural extension to a user's familiar computing environment. Cray stations provide the capabilities of job submission, file transfer, and interactive access to Cray computer systems.
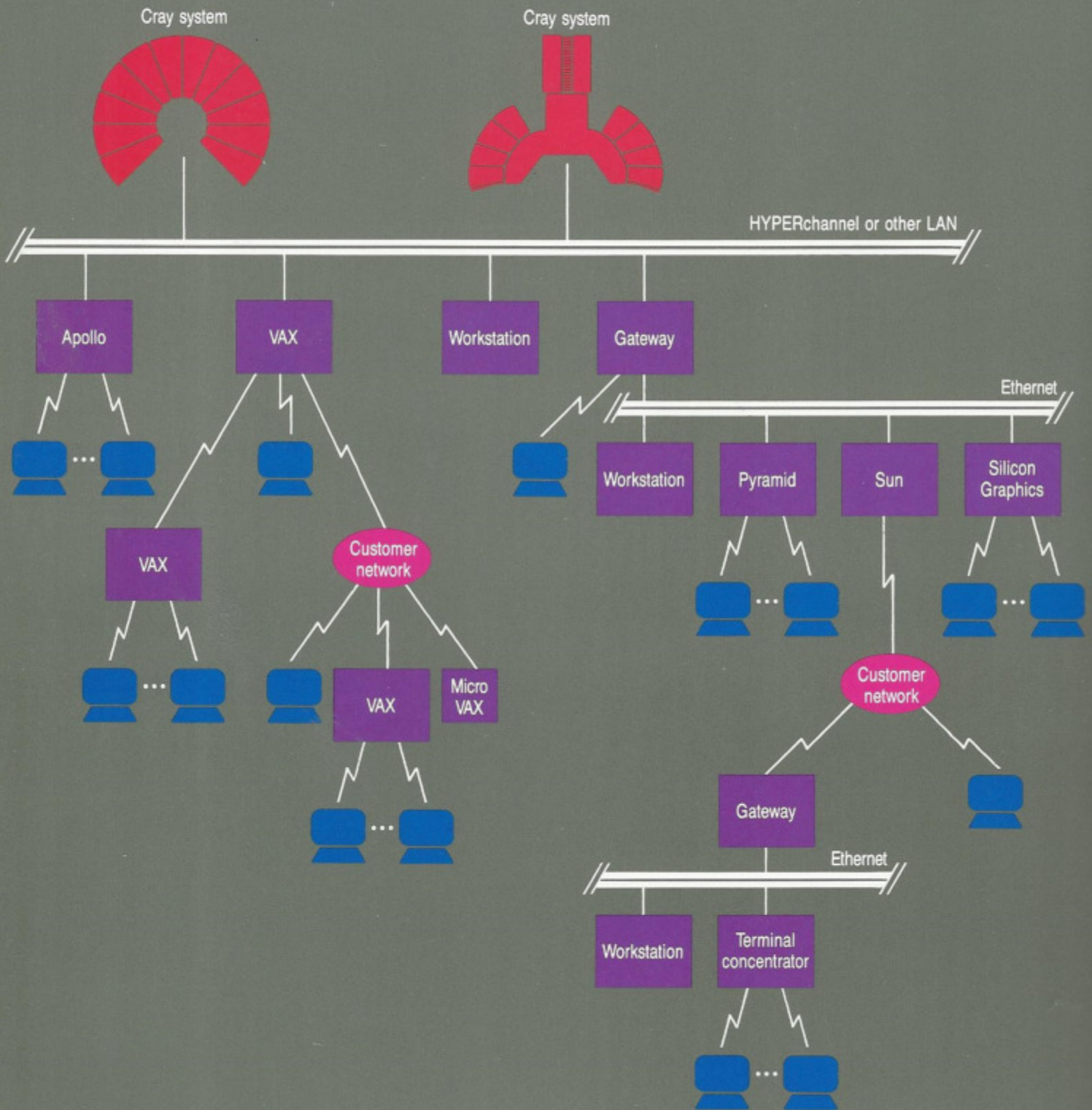
Standard Cray station software is available for the following systems: IBM MVS and VM, CDC NOS, NOS/BE, and NOS/VE, DEC VAX/VMS, Data General RDOS, Apollo AEGIS, and specific implementations of AT&T UNIX System V and the 4.2 release of the Fourth Berkeley Software Distribution (4.2 BSD). In addition, station software for UNISYS, Honeywell Bull, and Data General AOS operating systems is currently available from third-party sources.

Numerous communication hardware options are supported by UNICOS. The Cray Research Front-end Interface-1 (FEI-1) provides a point-to-point connection between a Cray system and a front-end computer system, while the Network Systems Corporation HYPERchannel adapter provides multi-point connections to a wide variety of computer systems. The Cray Research FEI-3 provides a gateway interface to Ethernet. The HSX-1 100-Mbyte/sec communication channel connects the Cray computer system to very fast customer-furnished equipment such as high-speed graphics devices. The VAX Supercomputer Gateway provides a high-performance direct connection between the Digital VAXcluster environment and a CRAY X-MP computer system. The Cray Research fiber optic link allows an FEI to be separated from a Cray computer system by distances of up to .621 miles (1000 meters) with complete electrical separation of the connected devices.

Cray system

Cray system

HYPERchannel or other LAN

FEI

Station
DEC
VAX

Station
DEC
VAX

Station
CDC

Station
IBM/MVS

Station
Sun

Workstations

DECnet

NETEX

Micro
VAX

CDCnet

ACF/VTAM
network

Station
IBM/VM

Station
Remote
DEC VAX

Station
Apollo

HYPERchannel or other LAN

Station
Non-Cray
system

Customer
network

UNICOS

Cray system

Cray system

HYPERchannel or other LAN

Apollo

VAX

Workstation

Gateway

Ethernet

VAX

Customer
network

Workstation

Pyramid

Sun

Silicon
Graphics

VAX

Micro
VAX

Customer
network

Gateway

Ethernet

Gateway

Ethernet

Workstation

Terminal
concentrator

Kernel

The UNICOS kernel provides the interface to the underlying hardware. It has a simple, well-constructed, and clean structure with short and efficient software control paths. The small size of the UNICOS kernel allows for fast, easy adaptation to each Cray computer.

Cray Research has substantially enhanced the kernel in the area of I/O processing and in the efficient use of very large data files. Other significant enhancements include support for asynchronous I/O used to overlap I/O processing with other computing, improved file system performance and reliability, multiprocessing, and user multitasking.

Shell

Perhaps the most visible and powerful of the UNICOS utilities is the command interpreter, called the shell. The shell is a high-level programming language that provides a customized user interface. The shell functions as another user process, reducing the risk that user programs will interfere with system processing.

UNICOS offers the standard AT&T UNIX Bourne shell and the Berkeley C shell. Both shells provide parameter definition and substitution, local and global variables, iteration, conditional execution based on parameter variables and tests on the environment, and the completion status of the individual job steps. The C shell also allows both forward and backward branching in script control statements.

Shell programming is accomplished through the use of shell scripts, which allow users to group command lines into a file for a single command execution. This grouping allows the initiation of a complex series of tasks or the execution of a repetitive procedure to be accomplished simply and quickly. Batch processing is also implemented with shell scripts.

Shell script files are analogous to IBM job control language (JCL) procedure files or to Cray operating system COS procedure files. The power of the shell as a language and the building-block nature of the UNICOS utilities combine to make shell scripts easy to write and maintain.

Operational environment

The UNICOS operational environment includes batch and interactive capabilities, security, and the UNICOS tape subsystem.

Batch and interactive capabilities

UNICOS offers both the flexibility of strong interactive capabilities and the power of batch processing. A primary function of every Cray computer system is the efficient processing of long-running programs requiring large memory and high I/O bandwidth. UNICOS includes the Network Queueing System (NQS), which provides a batch service capability that allows users to submit, control, monitor and terminate batch jobs. NQS can be configured to provide the optimum throughput of batch jobs, based on the workload profile.

Jobs can be submitted directly from the Cray computer system or from a Cray station. They may also be submitted over a TCP/IP network from either another Cray computer system running NQS and UNICOS or from other systems running NQS on specific implementations of UNIX.

UNICOS provides an interactive environment allowing the user to communicate from a local computer system to a Cray supercomputer. For example, users can combine the graphics capabilities of a workstation and the computing power of a Cray computer system to perform interactive modeling of physical phenomena. From a workstation, users can monitor the progress of an application, suspend its execution, modify the program or data, resubmit it, and receive instant feedback as results are displayed. A workstation can act as a window to the Cray computer system, while UNICOS allows computationally intensive work to be executed easily on the Cray computer system.

Basic file security

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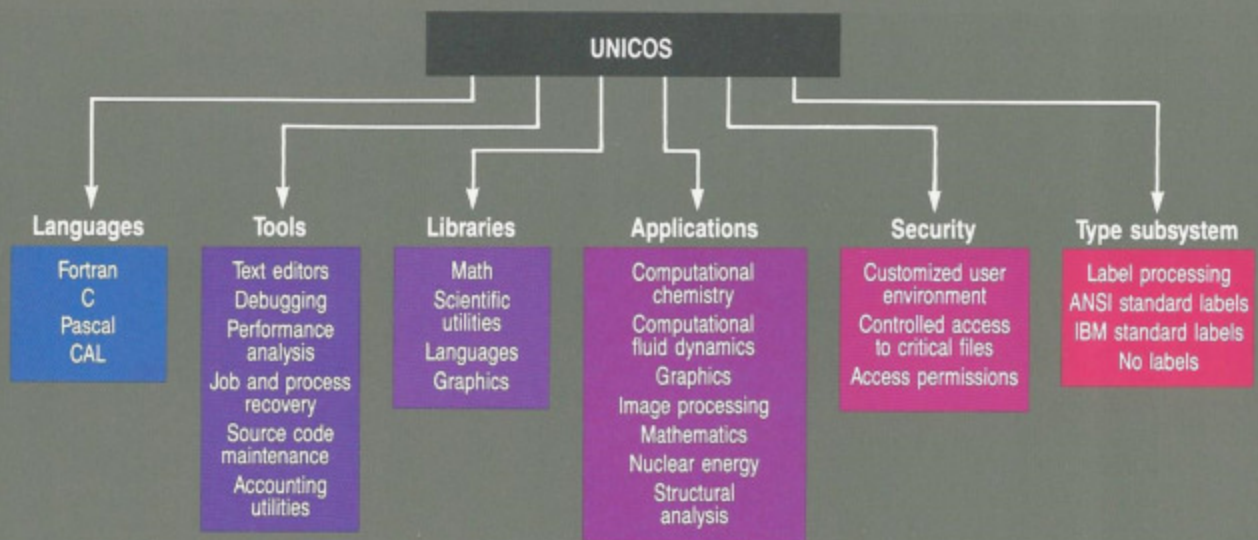
A system administrator can create a system profile to provide a customized initial environment for each user. To aid in controlling access to critical files, each user can be assigned to one or more logical groups. Associated with each file in the system is a set of access permissions. The system administrator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

UNICOS tape subsystem

The UNICOS tape subsystem runs on CRAY Y-MP, CRAY X-MP, and CRAY-2 computer systems, making it possible to store extensive amounts of data while using the computational power of the Cray mainframe for data analysis and large-scale problem solving.

Tapes may be used for both online back-ups and restores for user files. They may also be accessed on a limited basis by user programs to store data.

Programming environment

```
                          ┌─────────────┐
                          │   UNICOS    │
                          └─────────────┘
```

Languages	Tools	Libraries	Applications	Security	Type subsystem
Fortran C Pascal CAL	Text editors Debugging Performance analysis Job and process recovery Source code maintenance Accounting utilities	Math Scientific utilities Languages Graphics	Computational chemistry Computational fluid dynamics Graphics Image processing Mathematics Nuclear energy Structural analysis	Customized user environment Controlled access to critical files Access permissions	Label processing ANSI standard labels IBM standard labels No labels

The UNICOS programming environment includes languages, tools, libraries, and applications.

Languages

Cray Research provides three high-level languages with UNICOS: Fortran, C, and Pascal, as well as the Cray assembly language (CAL). Additionally, SIMSCRIPT and Portable Standard LISP (PSL) are available for Cray systems, and Ada and Common LISP compilers are under development.

Fortran is the traditional workhorse on Cray computer systems. Cray Research has invested significant resources in Fortran development, enabling the Fortran compilers to generate code that makes optimum use of the powerful Cray hardware.

The Fortran, C, and Pascal compilers feature automatic vectorization of FOR loop structures. All languages supported by Cray Research fully implement standard versions of the language plus useful extensions to provide additional functionality and to minimize the difficulties of porting applications from other computer environments.*

Programs written in one language can call routines written in another language.

CAL is a powerful assembly language that is especially helpful for tailoring programs to the architecture of a Cray mainframe and for writing programs requiring hand-optimization to the hardware.

Tools

The UNICOS operating system programming environment offers users the following tools:

☐ Text editors
☐ Debugging aids
☐ Dynamic and static performance analysis tools
☐ Job and process recovery
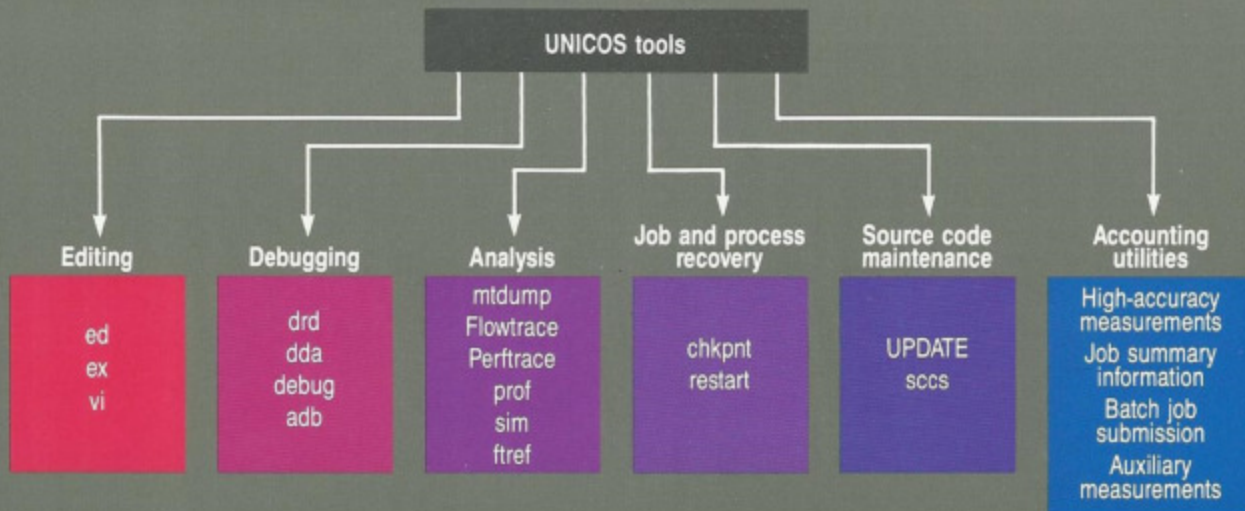☐ Source code maintenance
☐ Accounting utilities

Text editors
Three text editors are available to the UNICOS user. The first, *ed*, is a line editor that offers speed and versatility, requiring very little computer time to complete editing tasks. Users can enter line editor commands at a terminal or include them in a shell script. The second, *vi*, is a screen-oriented display editor; changes made to a file are quickly reflected on the terminal screen. And the third, *ex*, is a line editor within *vi* that is useful for making large-scale changes to more than one part of a file.

Debugging aids
UNICOS supports a variety of debugging tools that aid users in detecting program bugs by examining both running programs and program memory dumps. Supported debugging aids include symbolic interactive debuggers (DRD, adb) and symbolic postmortem dump interpreters (DDA, DEBUG). These debugging aids execute either interactively or in batch mode.

*Full Fortran 77 (ANSI standard X3.9-1978) is provided by CFT77 and CFT, and is under development in CFT2.

UNICOS

UNICOS tools					
Editing	**Debugging**	**Analysis**	**Job and process recovery**	**Source code maintenance**	**Accounting utilities**
ed ex vi	drd dda debug adb	mtdump Flowtrace Perftrace prof sim ftref	chkpnt restart	UPDATE sccs	High-accuracy measurements Job summary information Batch job submission Auxiliary measurements

Performance analysis tools
Dynamic analysis tools accumulate and analyze performance data from an executing program. These tools are generally used for timing and event counting.

mtdump (multitasked programs):

□ Unformatted dump analysis of the multitasking history trace buffer

Flowtrace (Fortran, C, and Pascal programs):

□ Report of CPU time, I/O time, and wallclock time for each subprogram
□ Dynamic calling tree
□ Subprogram counter

Perftrace (Fortran, C, and Pascal programs):

□ Program performance analysis at the subprogram level for CRAY X-MP computer systems
□ Detailed information for achieved megaflop rates and use of functional units, using the hardware performance monitor on CRAY X-MP computer systems

prof (Fortran, C, and Pascal programs):

□ Determination of time spent in various subprograms and code blocks on CRAY-2 systems

sim (Fortran, C, and Pascal programs):

□ Interactive system simulator
□ Individual code segment times
□ Memory management
□ Single-step execution traces

The static performance analysis tool (ftref) analyzes Fortran compiler output independent of any program input data.

ftref (Fortran programs):

□ Detailed Fortran program report
□ Static calling tree
□ Summary of multitasking subroutines

Job and process recovery
UNICOS will preserve batch-type processes over an orderly system shutdown. It will recover the processes when the system is restarted and continue processing from the point of interruption. Two UNICOS utilities, *chkpnt* and *restart*, allow the user to save a job process to a file for later recovery.

Source control products
UNICOS provides full support for two source control products.

UPDATE is a line-oriented batch editor used to create and modify program libraries and to produce output for use as input to other programs, particularly compilers and assemblers. UPDATE also operates under COS. The UPDATE utility PLCOPY allows users to move program libraries from COS to UNICOS. UPDATE also provides a number of directives for managing and tracking software changes. For example, conditional directives can be used to state the conditions under which a range of text is written to a compile file. Common decks allow users to maintain a
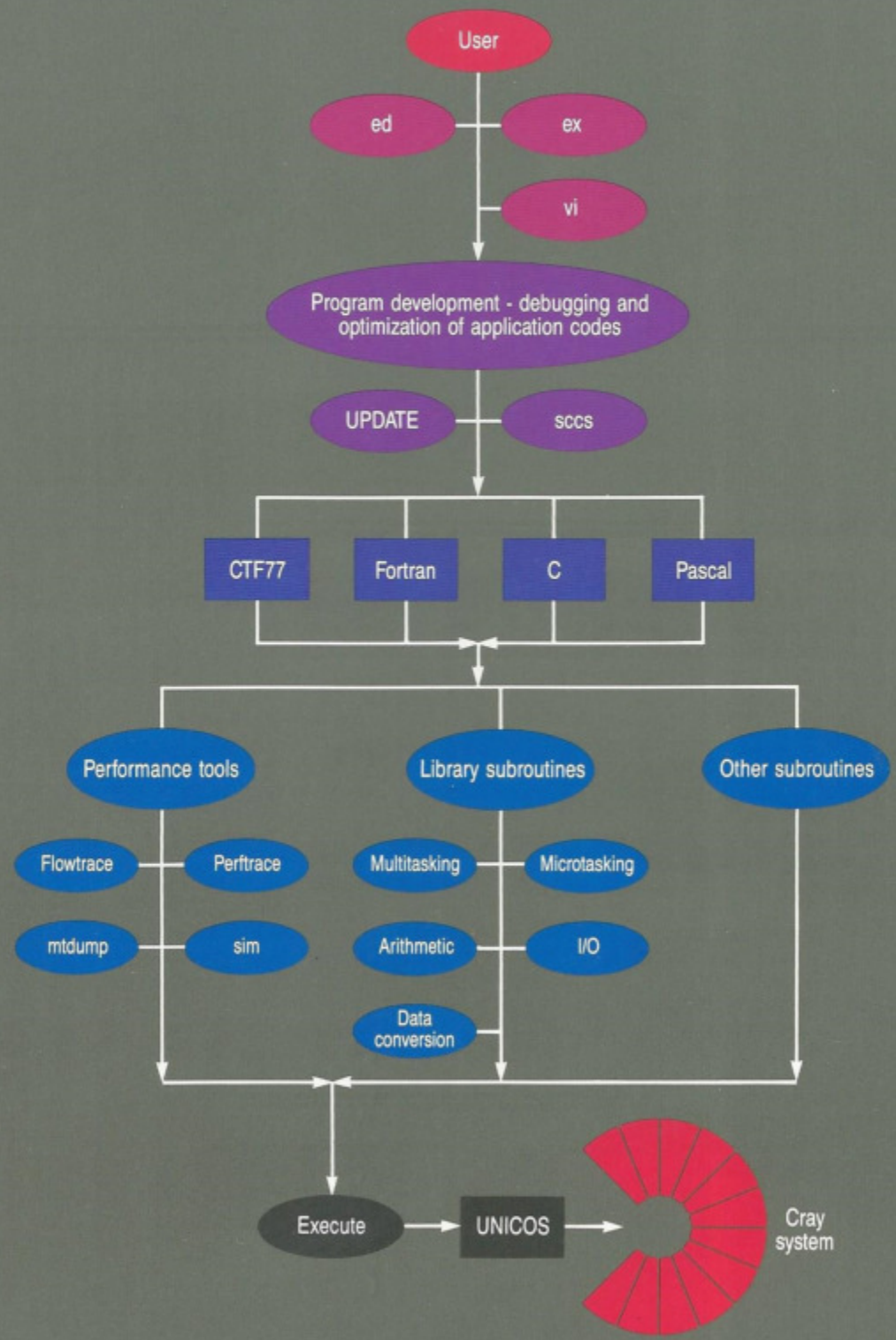
User

Text editors

Program management Source code maintenance

Languages

Object program performance aids

Executable program

User

ed — ex

vi

Program development - debugging and optimization of application codes

UPDATE — sccs

CTF77 | Fortran | C | Pascal

Performance tools | Library subroutines | Other subroutines

Flowtrace — Perftrace | Multitasking — Microtasking

mtdump — sim | Arithmetic — I/O

Data conversion

Execute → UNICOS → Cray system

UNICOS

single copy of common text and to be assured that the most up-to-date copy is always used in a deck that calls it.

Source Code Control System (SCCS) tracks modifications to files; this is useful when programs and documentation undergo frequent changes due to development, maintenance, or enhancement. SCCS allows users to:

□ Store files of text
□ Retrieve particular versions of files
□ Control updating privileges to files
□ Identify the version of a retrieved file
□ Record the time, location, and reason for a change, as well as the user who made each change to a file

SCCS provides an excellent software maintenance environment under UNICOS.
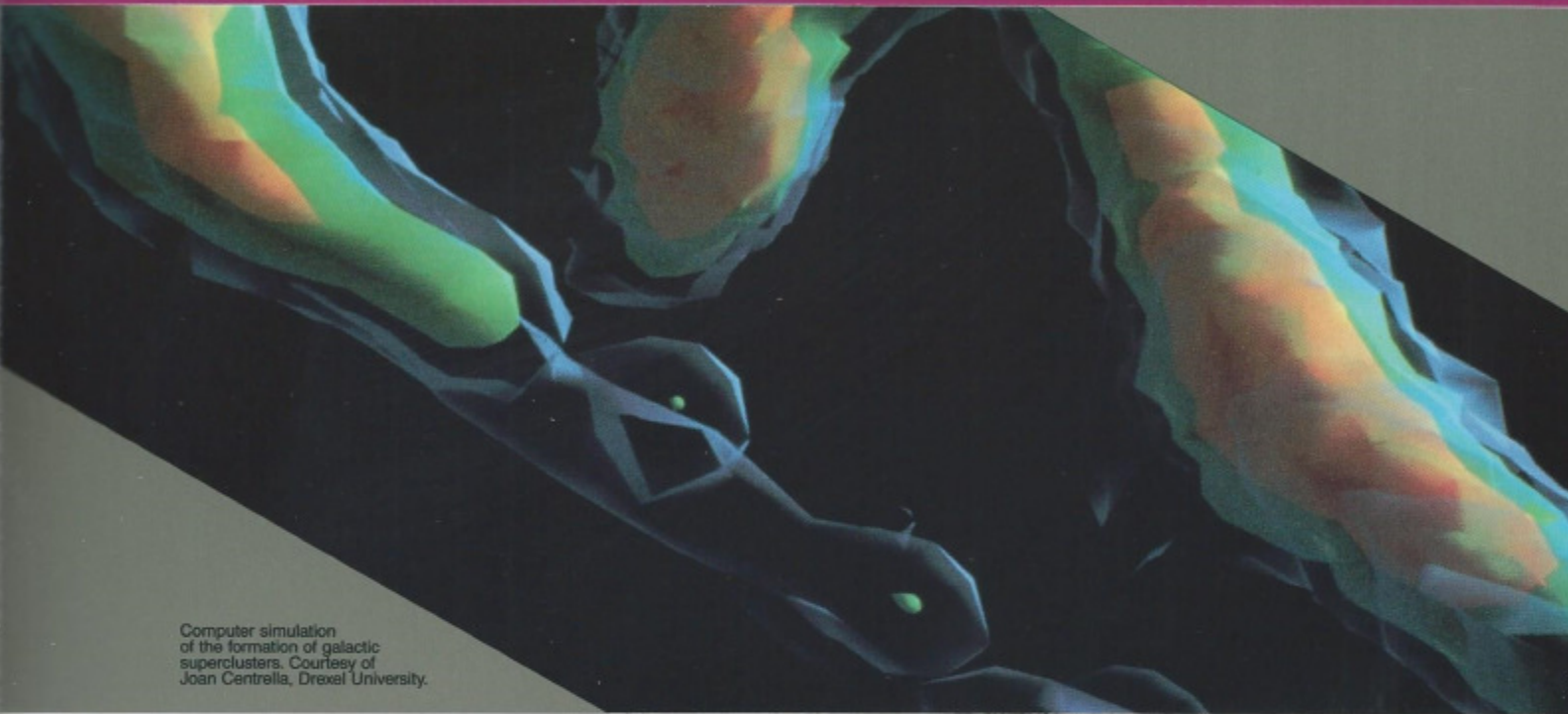
Accounting utilities
Cray Research has augmented the standard UNIX process accounting features with accounting mechanisms appropriate for a supercomputer environment that includes batch processing capabilities. UNICOS accounting features include:

□ High-accuracy measurements that include I/O and memory wait time, I/O request count, and job priority
□ Job summary information for completed processes available at any point in a job
□ Batch job submission, initiation, and termination records
□ Auxiliary measurements, including multiple-CPU usage and device-specific I/O counts

UNICOS library support

A library is a collection of sub-programs used explicitly by the user or implicitly by the compiler. Some of the libraries included with UNICOS are:

□ Standard C
□ Fortran—including numerous I/O extensions
□ Pascal
□ Mathematics—such as exponentiation, double precision, and complex arithmetic
□ Scientific applications—such as vectorized linear algebra and Fast Fourier Transforms
□ Utilities—such as memory management and timing
□ Multitasking and microtasking

Computer simulation
of the formation of galactic
superclusters. Courtesy of
Joan Centrella, Drexel University.

Applications

Researchers and engineers use Cray computer systems for generating solutions to problems previously considered computationally intractable, as well as for solving more commonplace problems faster and with greater accuracy. Many of the most widely used application programs are currently available and supported to run in Cray UNICOS environments. Cray Research actively is converting additional application programs to UNICOS. These applications include:

- □ Computational chemistry
- □ Computational fluid dynamics
- □ Electronics
- □ Financial modeling
- □ Graphics
- □ Image processing
- □ Mathematics
- □ Medical research
- □ Nuclear energy
- □ Petroleum
- □ Physics
- □ Structural analysis
- □ Transportation optimization
- □ Weather forecasting

Cray Research remains committed to supporting the broadest base of application capability and to supporting the migration and enhancement of this capability for Cray UNICOS environments.

Support and service

Cray Research provides support for all of its software products.

Migration support

Migration support is available for customers who decide to migrate their software from COS to UNICOS. Migration tools have been created to simplify conversion. These tools aid in the conversion of Fortran code from COS to UNICOS, COS datasets to UNICOS files, and JCL to UNICOS commands.

Also, the Guest Operating System (GOS) feature of COS allows users to run both COS and UNICOS (COS release 1.15 or later is required).

Analyst support

Cray Research offers local and regional software technical support, providing service for all Cray software products and ensuring software reliability.

Training

Technical software training is available through the Software Training Department in Mendota Heights, Minnesota, and through regional training facilities. Classes can also be taught at a customer's facility.

Publications

Cray Research provides comprehensive software documentation for using and maintaining the UNICOS operating system.

UNICOS documentation includes general overview manuals and primers; reference manuals for utilities, languages, and products supported under UNICOS; and system-level programming manuals. Each release also includes on-line documentation and ready reference cards for quick access to information.

Cray Research continues to provide users with the most powerful computing systems available. UNICOS delivers supercomputer performance with multiprocessing, fast I/O, and low system overhead. UNICOS offers a UNIX operating environment that provides both a standard user interface and common product set across the Cray Research product line. Cray Research will continue to enhance UNICOS and develop systems that look beyond the current state of the art in both hardware and software performance.

Additional information on the UNICOS operating system is available from any Cray Research sales office.