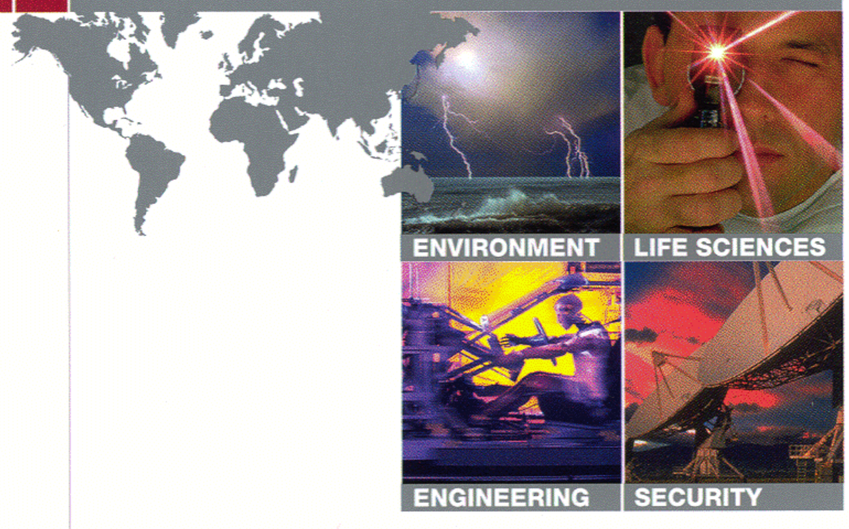
SOFTWARE OVERVIEW

CRAY X1
EXTREME PERFORMANCE

CRAY DESIGNED/BUILT/SERVICED

CRAY SOLUTIONS



EN ROUTE TO SUSTAINED PETAFLOPS COMPUTING

The Cray X1™ supercomputer is the first in the new, upwardly compatible series of extreme performance systems from Cray Inc. The Cray X1 system combines the most effective features of the Cray SV1™ series and Cray T3E™ architecture with the best of Cray operating systems and programming environments, and includes several important new software capabilities.

OPERATING SYSTEM

The UNICOS/mp™ operating system incorporates the best features of the UNICOS® and UNICOS/mk™ operating systems, and provides administrators with the tools they need to effectively schedule and allocate system resources.

The UNICOS/mp operating system includes a number of powerful capabilities that allow customers to maximize utilization of the Cray X1 system:

TRUE SINGLE SYSTEM IMAGE (SSI)

To application developers, users, and administrators, a Cray X1 system is a single system, regardless of its size. Applications can read and write memory and files regardless of where the application is running on the system. Users have a single login, and administrators have a single point of management and control for the entire system.

SCHEDULING ALGORITHMS

The UNICOS/mp operating system uses sophisticated scheduling algorithms to effectively schedule parallel applications, user commands, and operating system processes to share a Cray X1 system.

ACCELERATED APPLICATION MODE AND MIGRATION

Parallel applications can be run in accelerated application mode, which makes use of system memory mapping hardware to create logically contiguous nodes that help optimize application performance. To ensure maximum availability of contiguous nodes, UNICOS/mp transparently migrates applications within the system.

VARIABLE PROCESSOR UTILIZATION

Each Cray X1 CPU has four internal processors that can be used in either of two ways: together as a closely coupled, multistreaming processor (MSP), or individually as four single-streaming processors (SSPs). Applications can be built to run with one or more MSPs or with one or more SSPs, where the optimal choice depends on the algorithms used within the application.

FLEXIBLE SYSTEM PARTITIONING

Some customers may find it advantageous to partition their Cray X1 system. Partitioning allows system administrators to divide a system into two or more separate systems, each with an independent operating system image. These partitions can be separately booted, dumped, halted, and so on, without impacting other running partitions. Halted partitions can be combined into larger, or split into smaller partitions.

In addition to the above features, the UNICOS/mp operating system provides the standard features desired in most high-performance operating systems today, including:

Disk Storage Support. The UNICOS/mp operating system provides applications with high-performance I/O to direct-attached disks using the 64-bit, journaling XFS file system and SAN-attached disks through the StorNext™ File System from Advanced Digital Information Corporation.

Standard Networking Support. The operating system provides NFS distributed network file system; IPv4 TCP/IP, including the standard UNIX socket API; Domain Name Service (DNS) and Network Information Service (NIS) as client; and Network Time Protocol (NTP).

Interactive and Batch Processing. UNICOS/mp resource management works in tandem with PBS Pro™, the workload management system from Altair Engineering, Inc. that is based on NASA's Portable Batch System. It provides batch processing in addition to the Cray X1 system's interactive capability. Together with the application placement scheduler, the operating system accomplishes resource management, job placement, and site policy limit enforcement for users and jobs.

Checkpoint/Restart Capability. This feature improves the resiliency of long-running applications to system or environmental problems.

Accounting capabilities are based on standard UNIX System V practices.

Commands and shells are based on standard UNIX practices.

Basic security capabilities, including access control lists (ACLs).

System activity monitoring and reporting tools.

USA CORPORATE HEADQUARTERS **Seattle** Washington/**Madison** Alabama/**San Jose** California/**Peachtree City** Georgia/**Greenbelt** Maryland/**Brighton** Michigan/**Mendota Heights** Minnesota/**Lawrenceville** New Jersey/**Albuquerque** New Mexico/**Houston** Texas/**Chippewa Falls** Wisconsin

INTERNATIONAL **Canberra** Australia/**Sao Paulo** Brazil/**Ottawa** Canada/**Beijing** China/**Helsinki** Finland/**Paris** France/**Munich** Germany/**Milan** Italy/**Herzlyia** Israel/**Tokyo** Japan/**Oslo** Norway/**Johannesburg** South Africa/**Daejeon** South Korea/**Madrid** Spain/**Enskede** Sweden/**Zug** Switzerland/**Amersfoort** The Netherlands/**Taipei** Taiwan/**Reading** United Kingdom

SOFTWARE OVERVIEW

CRAY X1
EXTREME PERFORMANCE

PARALLEL PROGRAMMING MODELS

Many of today's most demanding supercomputer applications use parallel programming, and Cray X1 application programmers have access to the industry's most complete set of models, with a unique combination of industry standard and proprietary options.

Shared-memory parallel models. OpenMP and Cray directives for multistreaming on an MSP offer moderate levels of parallelism within a single node module of a Cray X1 system. These compiler-based models are particularly powerful when used as a performance accelerator in combination with one of the more scalable parallel programming models listed below. POSIX threads are also supported.

Traditional distributed-memory parallel models. MPI and SHMEM subroutine-based message-passing models were developed initially for cluster and MPP systems where processors typically did not have direct access to remote memory.

Up-and-coming global distributed-memory parallel models. Co-array Fortran and Unified Parallel C (UPC) compiler-based models are rapidly growing in use on many vendors' platforms. These models do exceptionally well on the Cray X1 system, taking advantage of the direct access to memory throughout the system.

Each programming model can be used alone, or combined with one another, producing benefits such as allowing programmers to combine shared- and distributed-memory models in a single application, or to optimize a highly-portable model (using MPI, for example) by limited and selective use of a higher performance model within key kernels or subroutines.

PROGRAMMING ENVIRONMENTS

The Cray X1 programming environments include a powerful and complete set of compilers, libraries, and tools that allow application developers to fully exploit the advantages of the Cray X1 hardware.

The Cray X1 compilers conform to universally accepted standards, with fully automatic vectorization and parallelization features developed at Cray over the past 30+ years. A rich set of language extensions, compiler directives, and debugging options coupled with very high reliability provide for a productive and rewarding development environment.

Fortran Compiler

The Cray Fortran Compiler, which translates Fortran programs into Cray X1 object files, fully supports the Fortran language through the Fortran 95 standard (ISO/IEC 1539-1:1997 Part 1), including Fortran 77, Fortran 90, and selected features from the proposed Fortran 2000 standard.

C and C++ Compilers

The Cray C and C++ compilers, which translate C and C++ programs into Cray X1 object files, support the LP64 data type model, which includes 16-, 32-, and 64-bit data types. The Cray C and C++ compilers implement industry standards ISO/IEC 9899: 1999 (C99) and ISO/IEC 14882: 1998 respectively.

The Cray X1 programming environments include a number of libraries similar to those provided with earlier Cray vector and MPP systems. These libraries have been tuned to perform well on the Cray X1 architecture, and to allow applications to take advantage of the unique features of the hardware and the operating system.

These libraries include:

High-performance scientific library (LibSci), which includes routines from libraries such as BLAS, LAPACK, BLACS and ScaLAPACK.

Language support libraries, including Cray's flexible file I/O (FFIO) system for source-independent I/O optimizations.

System libraries.

The Cray X1 programming environments provide exceptional tools to help debug and optimize applications, including:

Etnus TotalView debugger. A scalable debugger for high-performance computing that works with parallel and serial applications. TotalView® allows interactive, symbolic debugging of serial and parallel applications written in Fortran, C and C++. Debugging of both distributed-memory and shared-memory parallel applications is fully supported.

CrayPat (Cray Performance Analysis Tool). An extremely powerful tool that assists developers in obtaining the best possible performance for their applications. CrayPat uses several types of hardware- and software-based performance analysis methods to quickly show developers where to focus their optimization efforts.

CRAY INC

CORPORATE HEADQUARTERS 411 First Avenue South Suite 600 Seattle WA 98104-2860

TELEPHONE 206 701 2000 **FAX** 206 701 2500 **E-MAIL** info@cray.com **WEB** www.cray.com