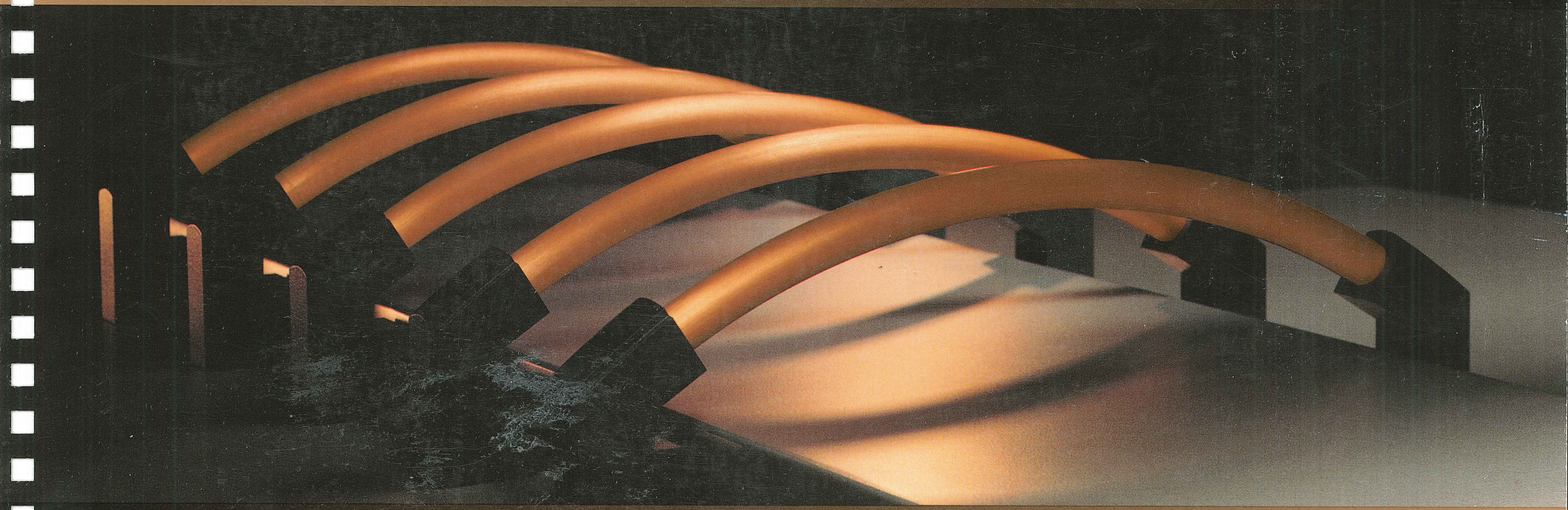
Introducing
The CRAY T90 Series
of Supercomputers



90 SERIES

CRAY T90 Series

The customer profiles that follow demonstrate the value of previous-generation Cray Research supercomputers for solving large-scale problems in science and industry. The breakthroughs these systems made possible foreshadow the greater breakthroughs now possible with the CRAY T90 series.

The CRAY T90 series is the newest, most powerful family of supercomputers from Cray Research. The successor to the world's most popular supercomputers, the CRAY C90 series, the CRAY T90 series takes supercomputing to a higher level of performance. A combination of Cray Research's world-renowned supercomputing expertise and leading-edge technologies, CRAY T90 systems are the most powerful computational tools on the market today. These unique systems empower you to break through today's limitations to realize tomorrow's possibilities.

With the power of the CRAY T90 series, scientists and engineers can more cost-effectively simulate chemical reactions, automobile crash tests, ocean currents, financial risk scenarios, even the delivery of babies. The predictive knowledge that digital science provides helps users design better and safer products, reduce manufacturing costs, and accelerate product design cycles. As a result, they are able to meet market requirements faster and move on to the next innovation.

In short, CRAY T90 systems allow you to plan for tomorrow by helping you see what it looks like today.

The CRAY T90 series the most powerful general purpose computers ever built

What do you mean by general purpose?

General purpose means that CRAY T90 systems excel in a wide range of applications. They can be used for many purposes because they run powerful standards-compliant software and industry-endorsed application packages.

What about MPP—isn't that the fastest?

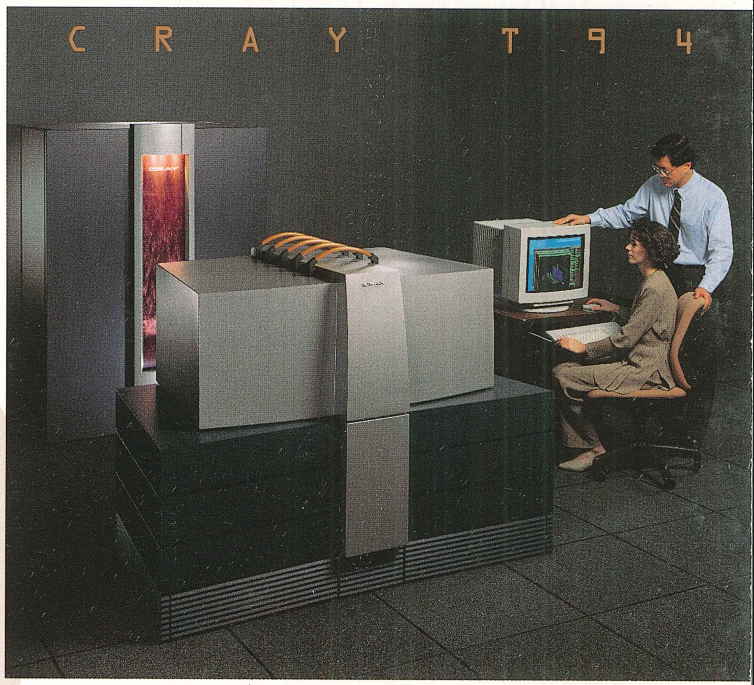
There is no question that massively parallel processing (MPP) systems are fast on certain applications, but few codes are optimized for MPP systems. CRAY T90 systems are fast, reliable workhorses capable of running a much broader range of high-performance applications today.

What exactly does high-performance mean?

Exceptional throughput is achieved through a balanced combination of fast processors, fast memory, and fast I/O. If your workload includes a combination of many different application or program characteristics and degrees of parallelism, the CRAY T90 series is your best overall performance solution.

CRAY T90 systems deliver exceptional performance through powerful hardware and software technologies, including

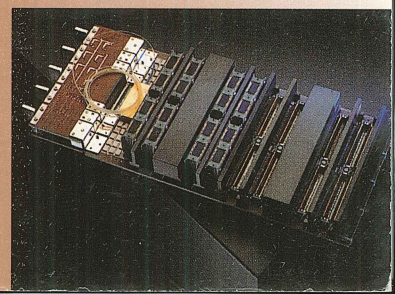
- Scalable, easy-to-use parallelism
- Unrivaled memory and I/O bandwidth, removing data transfer limitations found on other server-based architectures
- Optional SSD solid-state storage device for increased application flexibility and throughput
- Powerful standards-based system software that reduces the complexities of the system for the user
- Application software optimized to take advantage of the high-performance system architecture



Technology

SRAM memory module

Each memory module in a CRAY T90 system holds 256 Mbytes in 16 memory banks of 16 Mbytes each. Each bank has two spare chips so that failing memory chips can be replaced without physical machine access.



Dow Chemical

"The advent of very fast computers like the CRAY C92 system and recent advances in computational methods like the G2 theory have enabled chemists at the Dow Chemical Company to routinely determine thermodynamic properties of molecules."

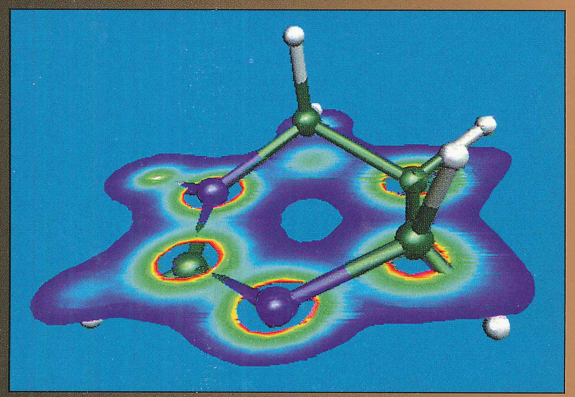
Nelson Rondan
Chemist
Dow Chemical Company

Nelson Rondan saves Dow Chemical Company time and money when the company designs and develops new plants and products. His tool? A CRAY C90 supercomputer, predecessor to the CRAY T90 systems, used to compute the largest known ab initio G2 thermochemical calculations. With help from Cray Research scientists, Rondan computes the heat of formation—the energy involved in the formation of one mole of a compound from the constituent elements—for five- and six-membered heterocyclic molecules. The CPU-intensive calculations require multiple gigabytes of disk space and large amounts of memory.

Rondan is one of many Dow scientists worldwide who are turning the consistently accurate G2 method into a standard analytical tool. By using a Cray Research system to perform G2 calculations, Rondan is able to obtain heats of formation with comparable or better accuracy than experimental methods with a precision in the range of 1-2 kcal/mol. This achievement is made possible only by combining the CRAY C90 system with incore and parallelized computational kernels for Møller-Plesset and Quadratic CI calculations in the *Gaussian 92* ab initio quantum chemistry software package.

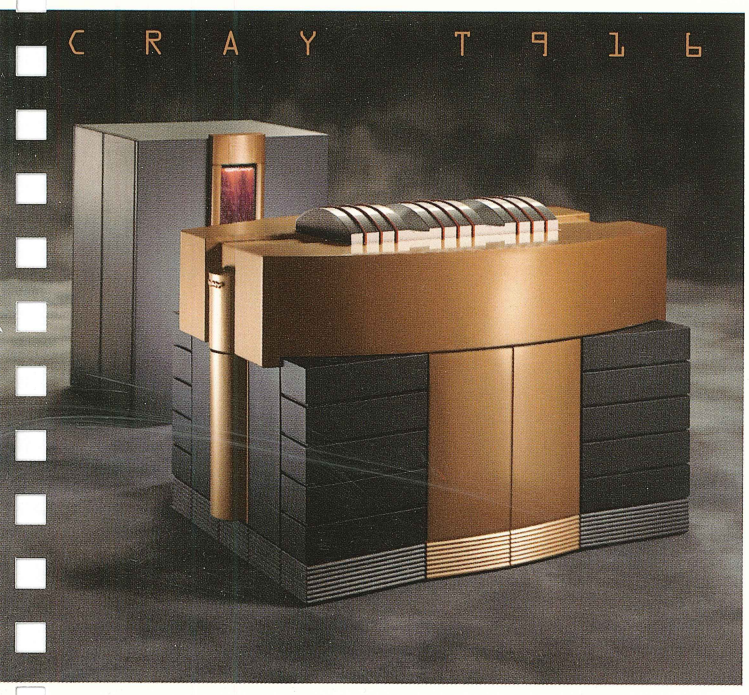
Dow researchers began using Cray Research systems in 1989, through the National Center for Supercomputing Applications. In early 1994, to allow more intensive use of supercomputing resources, Dow acquired the use of a CRAY C90 system located at Cray Research's computing center in Eagan, Minnesota.

The global Dow Chemical user community accesses the CRAY C90 system from secure sites in Europe and the United States for chemical process simulation, chemical fluid dynamics, environmental modeling, and computational chemistry. These computational researchers provide the greater scientific community at Dow with the necessary quantitative modeling and analysis for solving mechanistic and property related problems in their product and process design efforts. Applications include the commercially available AspenPlus, FIDAP, *Gaussian 92,* and DISCOVER programs, as well as several heavily used proprietary programs. The Dow Chemical Company manufactures and supplies more than 2000 product families, including chemicals and performance products, plastics, hydrocarbons and energy, and consumer specialties. The company operates 183 manufacturing sites in 33 countries and employs about 55,400 people worldwide.



Dow's CRAY C90 system was invaluable in calculating the heat of formation of this heterocyclic molecule.

better performance



The demands of high-bandwidth computing go beyond fast processors and fast memory. A balanced simulation server requires an I/O architecture that can feed the computational capabilities of the system. The CRAY T90 series offers the fastest I/O of any computer system available.

Why is I/O performance so much better?

The CRAY T90 series supports today's most advanced industry-standard I/O technologies, including multiple ATM, FDDI, and HIPPI connections. CRAY T90 systems use efficient I/O libraries to maximize system bandwidth.

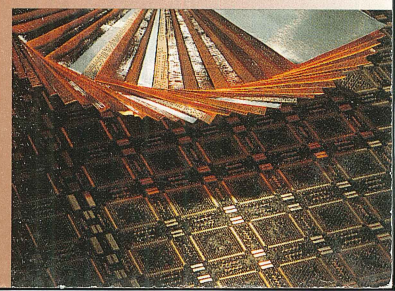
Disk drive technology support includes IPI drives and, in the future, SCSI and fiber channel disks offering a maximum disk capacity of 64,000 Gbytes (64 Tbytes) of storage. File system extensions include disk striping and disk caching. Large file system support and logical volume support further enhance storage performance. The CRAY T90 series also supports solid-state storage devices to maximize system performance.

In addition, a great variety of third-party tape and tape silo products are supported through BLOCK MUX and ESCON technology.

Technology

52-layer PC board

The printed circuit boards are made up of two 22-layer boards for circuitry and one 8-layer board for power distribution. These three boards are then joined to make one 52-layer PC board.



f a s t e

Your applications run faster on a CRAY T90 system

"The joint evolution of the MSC/NASTRAN software and Cray Research computers has produced spectacular results in a wide variety of structural analysis applications over the past 15 years. The next generation of Cray Research computers, the CRAY T90 series, will enable us to improve the performance and sophistication of analysis even more, resulting in cost reduction and increased product reliability in many industries ranging from automotive to aerospace."

Louis Komzsik
Chief Numerical Analyst
The MacNeal-Schwendler Corporation

"We believe that the high performance computing requirements for simulating tomorrow's materials will need the power of a CRAY T90."

John Newsam
Senior Director
BIOSYM Technologies, Inc.

The CRAY T90 series is designed to solve problems on your critical path. Not just selected benchmarks. CRAY T90 systems allow you to run jobs with hundreds of thousands of variables requiring extraordinary I/O capabilities—jobs that won't run on workstations or workstation clusters.

How do you get such good performance from these applications?

Cray Research has over 200 analysts throughout the world who are specialists in various engineering and scientific disciplines and have access to the world's most powerful computer systems to help customers solve their problems. This combination of expertise and system access is unique in the industry.

The Cray Research applications staff forms partnerships with customers to attack the challenges facing their organizations. Cray Research experts also work closely with application software developers to ensure that the highest level of applications performance is provided to all our customers.

Cray Research's standards-based system software transparently delivers scalable application performance. Our industry-leading compilers automatically parallelize, vectorize, and scalar-optimize standard application codes, ensuring that you get the best possible performance from your CRAY T90 system.

We also offer 64-bit IEEE floating point compatibility. IEEE floating point enhances file compatibility with workstations and makes it easier to share data in a networked environment.

a p p l i c a

"The success of virtual prototype testing products such as PAM-CRASH, PAM-STAMP, and PAM-FLOW of the PAM-SYSTEM suite is dependent on the availability of high-performance computing systems such as those built by Cray Research. As this technology develops and proliferates, it is generating a demand for more powerful and affordable high-performance systems. ESI Group believes that the announcement of the CRAY T90 series is a major landmark in the advancement of virtual prototype testing."

Alain de Rouvray
President and Chief Executive Officer
Engineering Systems International

i o n s

Reliability moves to a higher level

r e l i a b l e

The CRAY T90 series builds on the reliability of past systems, taking it to an even higher level.

Why are CRAY T90 systems more reliable than other systems?

All new technology incorporated in the CRAY T90 series was chosen not only to increase system speed but also to improve reliability and availability.

Most of the new CRAY T90 technology minimizes the number of mechanical connections, virtually eliminating the need for wires. In addition, the following reliability improvements have been incorporated:

- Extra power supplies. Each of the CRAY T90 system voltage busses includes a backup power supply. This allows the system to keep running, even if a power supply fails.
- Tape automated bonding (TAB). Chips are mounted on printed circuit boards using TAB technology, eliminating chip packaging and minimizing connections.
- Offline processor configuration. A software configuration utility enables you to configure a processor offline for repair.
- Zero insertion force connections. Processor and memory modules can be installed and removed easily because of our advanced electrically activated connectors.
- Hardware error correction. Spare chips in the memory stacks allow memory chip failures to be resolved at the discretion of system users, because hardware error correction prevents system failures if memory chips fail.
- Single board functional modules. This technology reduces the number of interconnects, the weight of the machine, and the number of piece parts.
- Software availability and resiliency capabilities. These capabilities include checkpoint/restart, interactive session protection, reliable disk storage including RAID technology, alternate disk paths, disk mirroring, guaranteed network file transfers, and automatic power on/off.

Modeling the Human Heart

"The CRAY C90 was a real breakthrough, giving us a chance to succeed that we didn't have before. We wouldn't have attempted the model without it. Now we feel that we're on the edge of starting to use this 3-D heart as a practical scientific tool."

Charles Peskin
Medical Researcher
Courant Institute of Mathematical Sciences

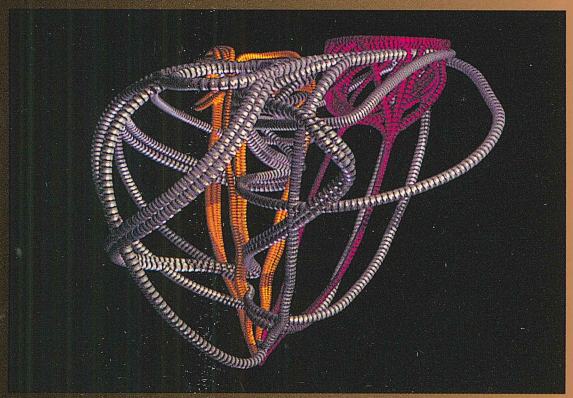
A computational model of blood flow in a human heart, its nearby valves, and major vessels could move medical research beyond animal and clinical studies toward a better understanding of normal and diseased heart function. Carried out largely on a CRAY C90 supercomputer, predecessor to the CRAY T90 systems, the model gives new meaning to the word experiment.

"In the model, we can make changes and try things we couldn't try with a living heart," said Charles Peskin, a medical researcher who, with colleague David McQueen, built the three-dimensional model. "We can induce disease states to see what they do to the heart, and different types of heart valves can be 'implanted' in the model to see how they function."

From their office at New York University's Courant Institute of Mathematical Sciences, Peskin and McQueen, who previously used a CRAY Y-MP system, began accessing the CRAY C90 system at the Pittsburgh Supercomputing Center in early 1993. The 16-processor CRAY C90 system completed a single simulated heartbeat—with every part of the model, each chamber and valve, performing on cue—in 150 CPU hours. Peskin and McQueen figure it would have taken three years of real time on a previous-generation supercomputer to simulate that same beat, because of both less advanced hardware and restricted access to computer resources for an application this large.

Peskin and McQueen are not alone in considering this single simulation a success. They won the 1994 Computerworld Smithsonian Award for Breakthrough Computational Science. In addition, their "immersed boundary method," an innovative approach to modeling fluid flows interacting with a flexible, elastic boundary, such as the muscle fibers of the heart, has influenced other biological fluid flow modeling.

The Pittsburgh Supercomputing Center (PSC) provides high-performance computing resources via the Internet to scientists across the United States. Formed as a partnership between the University of Pittsburgh, Carnegie Mellon University, and Westinghouse Electric Corporation, PSC is one of four national supercomputing centers. Its computing resources—which currently include a CRAY C90 and a CRAY T3D massively parallel processing (MPP) system—have been used by over 8600 scientists and engineers located at more than 570 universities and research centers.



The fiber structure of the heart wall, the mitral valve (purple) and the aortic valve (yellow). The structure is part of the heart model developed by Charles Peskin and David McQueen.

UNICOS designed with your production computing needs in mind

UNICOS is designed with your production needs in mind. This should come as no surprise given Cray Research's years of experience delivering a high-performance multiprocessing UNIX operating system as part of a production-quality software environment.

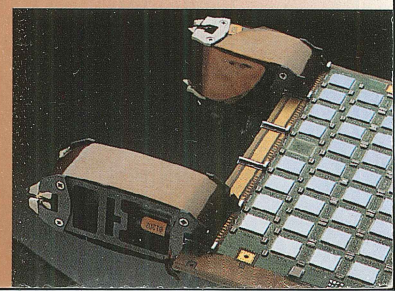
What's unique about UNICOS?

The most powerful hardware on the planet won't do much without an equally powerful operating system making it accessible to users. UNICOS has many features that maximize the throughput and performance of the CRAY T90 high-performance architecture:

- Multithreading provides scalable parallel operating system efficiency.
- High-performance I/O capabilities such as flexible file, asynchronous (no buffering), and multitasking improve parallel processing efficiency.
- Automatic parallel processing support (Auto-tasking) and multitasking provide efficient parallel applications performance on multiple processors.
- Fully automatic optimizing compiling systems maximize performance on standard code (Fortran 90, Standard C, and C++).
- The industry's highest performing math libraries enable you to access hardware performance features transparently.
- High Performance Parallel Interface (HIPPI), Fiber Distributed Data Interface (FDDI), and ATM networking capabilities enable data transmission speeds of up to 100 Mbytes/s.
- Full conformance with the UNIX System V operating system with BSD extensions.
- Resiliency features to ensure high system availability to users.
- Security features such as multi-level security, access control lists, authentication, security auditing/logging, Kerberos, and restricted superuser privileges protect the confidentiality of your mission-critical data against unauthorized access.
- Unified resource management capabilities adjust dynamically to overall system workload changes to provide maximum system throughput efficiency and resource utilization.

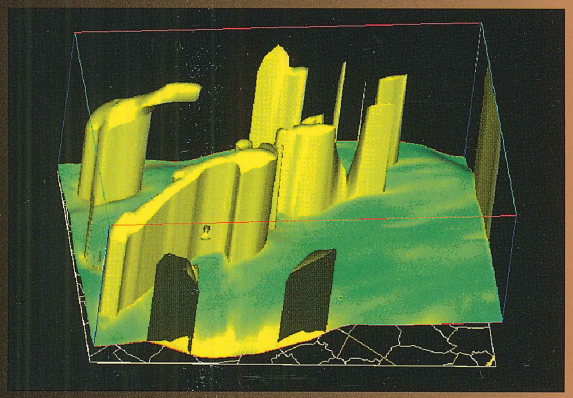
eZIF connectors

Electrically-activated zero insertion force (eZIF) connectors carry impedance-controlled signals from one module to another. Each carries over 400 signals in about an inch of PC board edge. Adding electrical current disengages the connector, allowing for removal of the module.



"It was crucial to use the CRAY Y-MP system to obtain adequate speed and temporary storage space for simulations of this size. Running UAMGUIDES on even faster machines could allow modelers to run more simulations and lead to an even more efficient policy-making process."

Eng Pua
Scientist
North Carolina Supercomputing Center



An ozone isosurface plot over the North Carolina UAM simulation domain for the June 1988 air pollution episode.

So successful is UAMGUIDES—an interface to the Urban Airshed Model (UAM), an ozone-compliance simulator required by the Clean Air Act of 1990—that modeling groups across the United States have asked the North Carolina Supercomputing Center (NCSC) to develop a portable version.

NCSC's Environmental Programs Group used the center's CRAY Y-MP system, a previous-generation parallel vector system from Cray Research, to develop UAMGUIDES as a labor-saving interface to UAM. Running UAM is very complex; each simulation requires many large files and large amounts of temporary data storage, and several detailed analyses are necessary to compare proposed regulations and determine the best clean-air policies. UAMGUIDES makes the low-level details transparent and streamlines the process so that modelers can successfully carry out their simulations in a reasonable amount of time. UAMGUIDES also includes scientific visualization techniques capable of 2D, 3D, and 4D graphical displays for data quality assurance and results analysis. North Carolina's monitoring domain consists of 60 x 90 x 5 grid cells, an area that covers two-thirds of the state.

NCSC installed its CRAY Y-MP system, the first in the Southeast, in 1989. In 1994 the center upgraded its CRAY Y-MP system and added a CRAY T3D massively parallel processing (MPP) supercomputer. The CRAY Y-MP system will be upgraded in 1995 to a CRAY T90 supercomputer. Approximately 1200 users from all fields of science access the Cray Research systems at NCSC. Of the approximately 30 applications run on the system, chemistry and engineering programs are the most heavily used, including ANSYS, *Gaussian 92*, AMBER, FIDAP, DISCOVER, and DMol.

Located in Research Triangle Park, North Carolina, the North Carolina Supercomputing Center is a nonprofit organization that provides access to some of the world's most advanced computers, as well as computational expertise and training courses. With a focus on computational science, visualization, environmental programs, education, training, and new technologies, NCSC promotes collaboration between industry and academia and stimulates technology-based economic development in North Carolina.

open supercomputing

We make sure our computers thrive in your environment

We call it open supercomputing—a computing environment built on industry standards to provide familiarity and ensure interoperability across the multi-vendor systems on your network—no matter what the combination of resources.

Support for the following networking and distributed computing standards allows the CRAY T90 series to thrive in your existing environment:

- Communication protocols: TCP/IP and ISO/OSI
- Distributed client/server computing: ONC, OSF/DCE
- Distributed data: NFS, OSF/DFS
- Distributed batch processing: NQS, NQX
- Distributed parallel programming: PVM parallel virtual machine message passing
- Media connections: Ethernet, HIPPI, FDDI, and ATM
- Windowing and visualization: X Window System, MOTIF, Distributed GL

To provide transparent access to distributed data across local and wide area networks, Cray Research offers sophisticated, standards-based data management and hierarchical storage management solutions. From the most sophisticated network of peripherals to networks of PCs and Macintoshes—we talk to them all.

If it's that open, isn't system security a problem?

Security features and restricted superuser privileges protect the confidentiality of your mission-critical data against unauthorized access. These features provide functionality equivalent to a U.S. Department of Defense B1 "Trusted Network Component" security rating. This functionality provides security between UNICOS and other systems on a network.

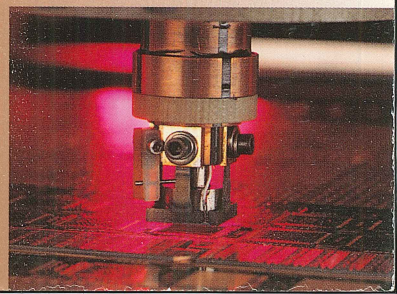
How do you fit on the information superhighway?

We already travel the superhighway—as a matter of fact, we're the fastest vehicle on the road. The Global Information Infrastructure (GII) requires that all systems communicate easily with each other. We have already exceeded this basic requirement and are actively involved in areas that require high-bandwidth computing such as medical imaging and video on demand.

Technology

Automated pick and place

The bond head for the logic chip pick and place equipment. The equipment inspects the chip, excises and forms the leads, aligns the chip to the PC board, and reflows the solder to attach the part.



Bayer AG

"The results we achieved running plantwide dynamic simulations on the Cray system demonstrate a great potential for reducing operating and capital costs, both on existing and on newly designed chemical plants."

Lothar Lang
Process Engineer, responsible for dynamic simulations and the optimization of chemical plants
Bayer AG

"The ability to fully optimize our production processes gives Bayer a competitive advantage in terms of quality, flexibility, and cost."

Ludger Brüll
Manager of Supercomputer Applications
Bayer AG

To maximize capacity and minimize waste in its chemical processing plants, Bayer AG purchased a CRAY C90 supercomputer, predecessor to the CRAY T90 systems, in 1993. Bayer engineers use the system to model the internal operations of these complex plants, allowing them to predict the effects of changes to a plant's operating characteristics and fine tune operations and control.

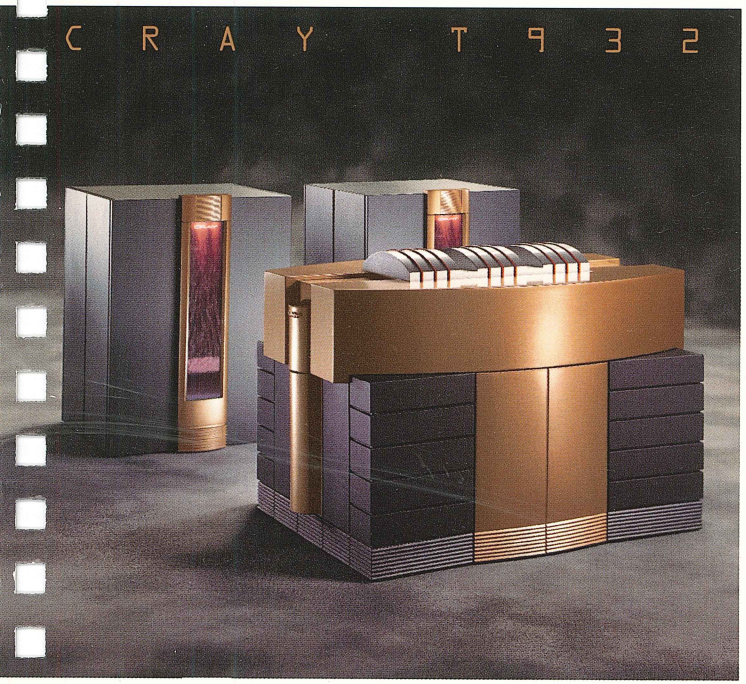
The Bayer group, an international enterprise with about 150,000 employees and operations in some 150 countries, manufactures a variety of chemical products. Founded by Friedrich Bayer in Germany as a production facility for aniline dyestuffs in 1863, Bayer today has organized its core businesses into six main sectors: polymers, organic products, industrial products, health care, agrichemicals, and imaging technologies. Products range from insecticides and fertilizers to polymers, plastics, synthetic rubber, fibers, resins, organic chemicals, dyes, pigments, pharmaceuticals, ceramics, and photographic materials. Bayer's research initiatives include materials science, DNA research, AIDS research, drug development, and molecular biology.

Bayer's CRAY C90 system serves a community of more than 20 plant engineers who primarily run Aspen Technology's SPEEDUP dynamic modeling software. The SPEEDUP package has been optimized to take advantage of the vector processing capabilities of Cray Research systems. The combination of optimized application software and the performance capacity of the Cray Research parallel-vector system enables engineers to perform plantwide simulations for Bayer plants worldwide. This capability has been used, for example, to model a complex, heat-integrated distillation system at one of Bayer's main production facilities. The dynamic process model included some coupled distillation columns and required the repeated solution of a system of more than 75,000 differential algebraic equations, making it the largest known industrial SPEEDUP application in production use in the world.

Close collaboration between Bayer, Cray Research, and Aspen Technology produced the right technical solution for this customer. Through large-scale simulation Bayer engineers can determine today the plant operations needed to meet tomorrow's production demands.

Scalable configurations offer the best fit

scalable performance



CRAY T90 systems come in a wide variety of configurations to meet your unique requirements. From the low-cost single-processor CRAY T94 system to the powerful top-of-the-line CRAY T932 system, each system offers excellent scalability, allowing your computer resources to grow efficiently with increasing demand.

The CRAY T94 system offers up to four processors at entry level pricing. The CRAY T916 system offers twice the performance of a CRAY C916 system, our previous top-end system, at a fraction of the cost. The CRAY T932 system offers about four times the performance of a CRAY C916 system.

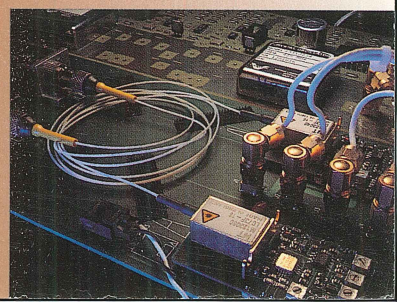
System Configuration

Model	Maximum Processors	Central Memory (Mbytes)	Cooling	I/O Bandwidth
CRAY T94	4	512 to 1024	Air or liquid	> 8 Gbytes/s
CRAY T916	16	1024 to 4096	Liquid	> 17 Gbytes/s
CRAY T932	32	4096 to 8192	Liquid	> 35 Gbytes/s

Technology

Optical clock deck

The system clock signal begins here. An oscillator produces a clock signal which is sent to a laser where the electrical signal is converted to a light signal. The light signal is distributed to every module where it is converted back to an electrical signal.



"Each new generation of Cray Research supercomputer enhances DuPont's ability to compete more effectively in the global marketplace."

David Dixon
Research Leader/Research Fellow
DuPont

DuPont scientists use Cray Research supercomputers to help in the search for chlorofluorocarbon (CFC) alternatives—at a tenth of the cost of traditional experimental methods. In 1988, DuPont decided to stop selling CFCs in industrialized nations by the end of the year 2000—later adjusted to the end of 1994—and the quest for CFC alternatives was on.

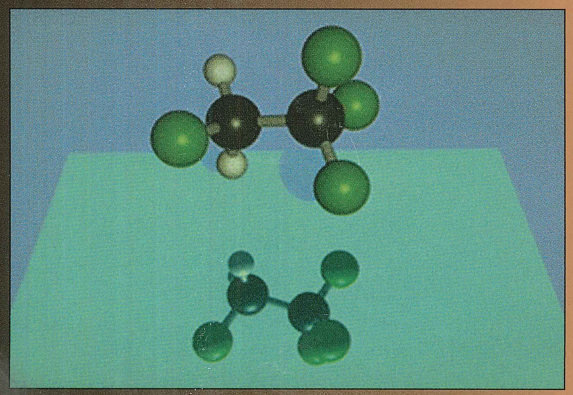
Scientists had to find a compound with the same desirable properties as CFCs (nonflammable, noncorrosive, nonexplosive, and low toxicity) but without the same adverse effects on the Earth's ozone layer. One important technical problem is developing new catalysts for the economic production of CFC alternatives. This catalyst development requires thermodynamic data for a wide range of molecules. More data means that more potential substitutes may be explored.

In one week, DuPont scientists can perform a set of calculations for thermodynamic properties of an alternative compound. This week of computational time costs $5000, including setup and analysis. Experimental measurements would take much longer (on the order of three months) and typically cost $50,000—not including the time required to synthesize and purify reasonable amounts of the compound.

Aside from directly saving time and money on research, DuPont has gained a distinct advantage in the global marketplace: the most complete (and proprietary) library of thermochemical data for CFC alternatives.

In 1986, DuPont was the first chemical industry company to purchase a Cray Research supercomputer. DuPont scientists have conducted their work with CFC alternatives on several previous-generation Cray Research systems. Based on its success with these earlier systems, DuPont most recently installed a CRAY C94 supercomputer. Primary applications for the CFC alternatives work include *Gaussian 92,* GRADSCF, and DGauss in the Cray Research UniChem program.

DuPont is a diversified chemical, energy, and specialty products company with a strong tradition of discovery. Its global businesses are constantly evolving and continually searching for new and better ways to use DuPont's human, technological, and financial resources to improve quality of life for people around the world.



1,1,1,2-tetrafluoroethane (CF_3CH_2F), or HFC-134a, a replacement refrigerant, as depicted by the program OASIS on a CRAY Y-MP system. Carbon shown in black, fluorine in green, and hydrogen in white.

Simulating Tomorrow . . .

Shape your future . . . today

With our new CRAY T90 series, we have pushed parallel-vector technology to new heights—helping you reach new levels of performance in your quest for solutions. A CRAY T90 system is your key to breakthrough discoveries in scientific and engineering computing.

Just ask the process engineers at Bayer; or the medical researchers at the Courant Institute; or the chemists at Dow Chemical Company; or the scientists at the North Carolina Supercomputing Center; or the researchers at DuPont.

Or hundreds of other Cray Research customers who are putting powerful Cray Research technology to work in new and exciting ways.

We are committed to helping you reduce your product design cycles, get your products to market faster, evaluate more design options, and make more efficient use of your engineers' time. This is where the value of the CRAY T90 series meets your bottom line, by enabling you to collapse the solution time required for large, complex simulations.

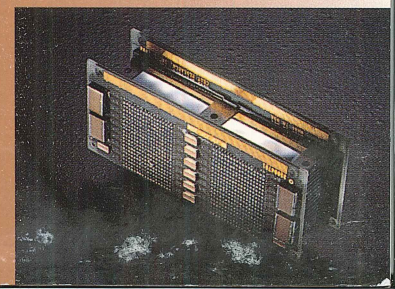
And, while it's true that CRAY T90 systems contain substantial technological breakthroughs, more breakthroughs will come when you put a CRAY T90 system to work. That's when today's problems become routine and problems you once thought impossible suddenly come within reach. Don't just plan for tomorrow . . . shape it today.

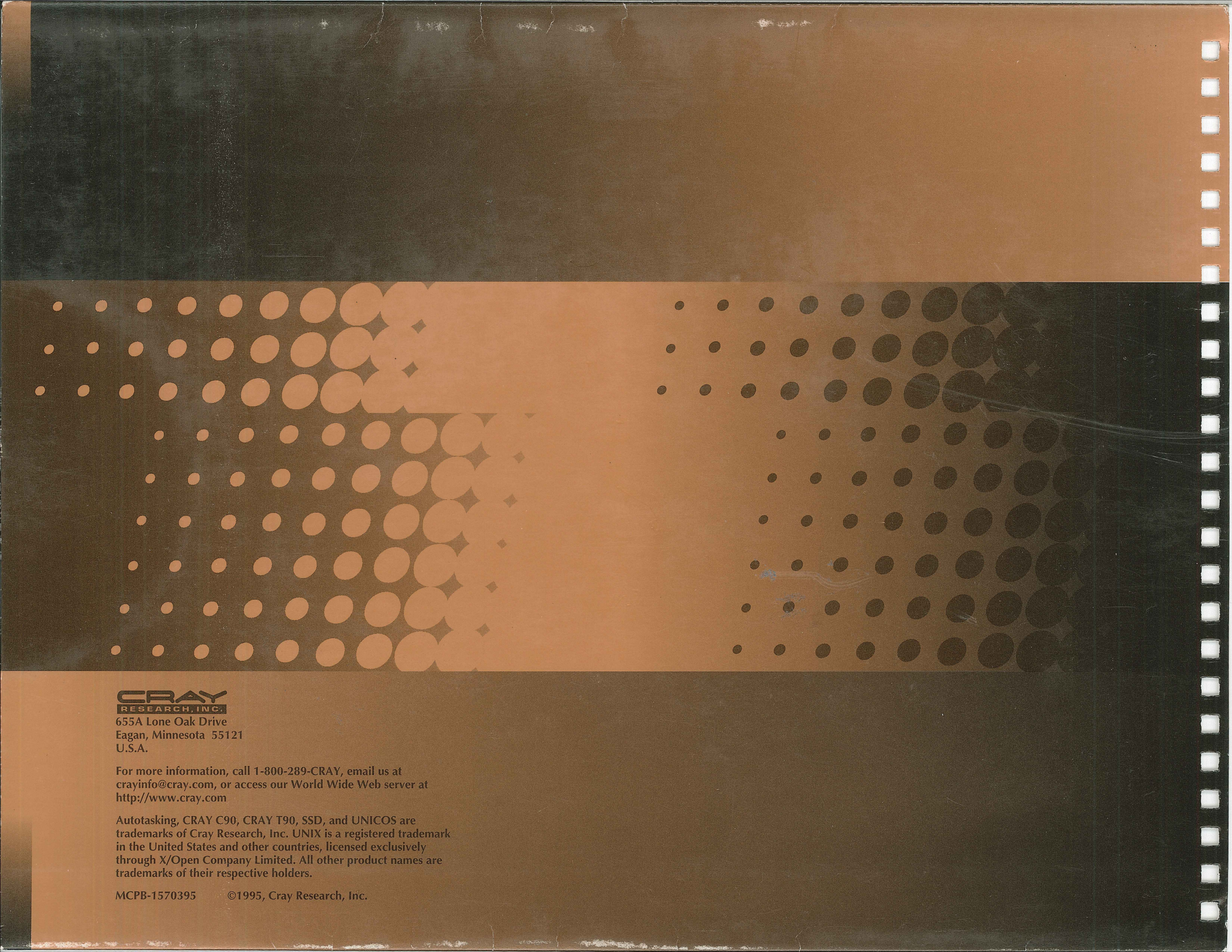
. . . Today

Technology

SRAM memory stack

Each memory stack contains 40 4-Mbit SRAMs for a total of 2 million 64-bit words. There are 16 stacks on a memory module. The chips are soldered between two PC boards. The stack is plugged into a connector on the memory module.





CRAY RESEARCH, INC.
655A Lone Oak Drive
Eagan, Minnesota 55121
U.S.A.

For more information, call 1-800-289-CRAY, email us at crayinfo@cray.com, or access our World Wide Web server at http://www.cray.com

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