THE ULTIMATE TEAM PLAYER

Lester T. Davis, winner of the Design News Special Achiever Award, supplied the technical vision that helped Cray Research dominate the supercomputer industry

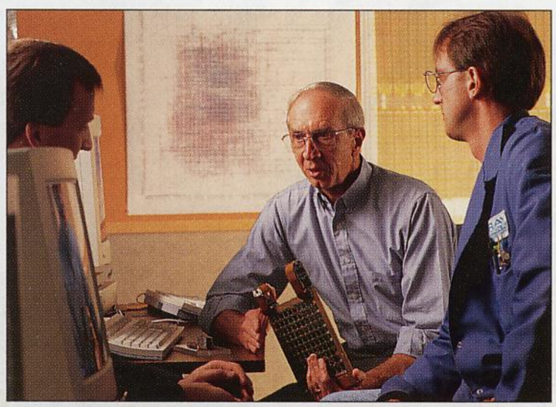
Charles J. Murray, Senior Regional Editor

Chippewa Falls, WI—Eighteen years ago, Lou Saye trekked from San Diego to the frigid north woods of Wisconsin to see the world's fastest computer. Saye, then a 31-year-old Convair engineer, arrived unannounced at Cray Research. His only wish was to see the little lab where the super-fast machines were built. Instead, he was greeted by a soft-spoken chief engineer who spent the next 90 minutes quietly expounding on the inner workings of supercomputers.

Saye came away so impressed that he uprooted his family and moved to Chippewa Falls without the promise of employment. "He was approachable, experienced, and enthusiastic in his own quiet way," Saye says of the engineer who talked with him that day. "After I'd met with Les Davis, I knew I wanted to work for Cray Research."

Saye isn't alone. Over the past 23 years, scores of supercomputer engineers have developed a fierce loyalty to Lester T. Davis. As a result, Davis has become the industry's ultimate team builder, an engineer who weaves talent together with the deft touch of an artist. "He's like the conductor of a symphony," says Jerry Brost, retired vice president of engineering for Cray Research. "He knows how to bring all the talent together to create beautiful music."

Davis' knack for team building, combined with his deep understanding of supercomputer technology, has indeed made music for Cray Research. During the past decade, Cray has dominated its industry to a degree matched by few firms in American business history. Last year, it accounted for 75% of supercomputer industry revenues, according to figures from International Data Corp. During that time, it emerged as the leader in massive parallel processing, a niche that it only just joined in 1993. And its grip on the parallel vector side of the business hasn't diminished: Around the world, Cray products accounted for more than 60% of the parallel vector machines sold last year.



Les Davis constantly worked in the background to clear the path for the company's engineers, but played a key role in every major machine that Cray Research has built.

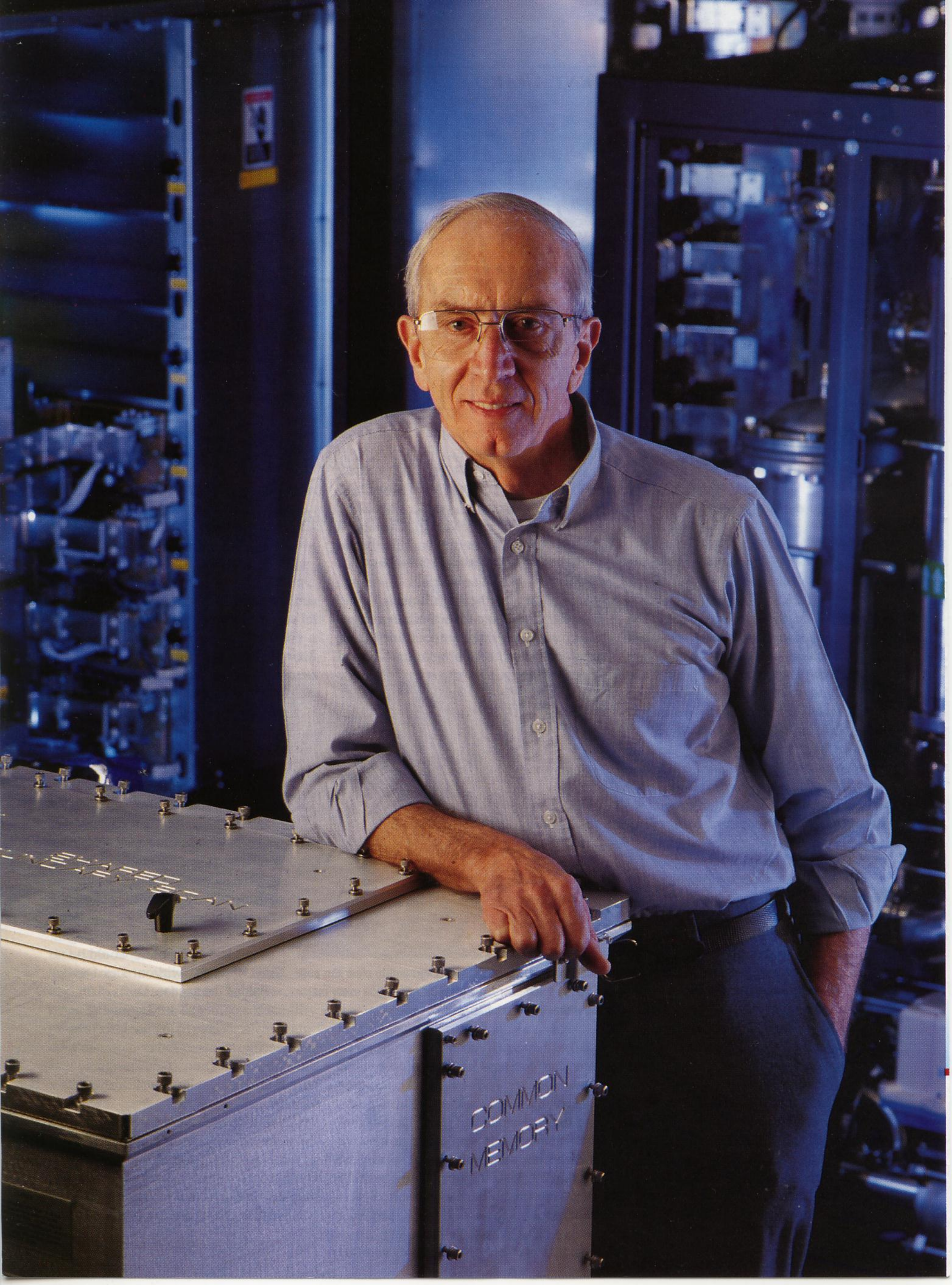
PHOTO BY PAUL SHAMBROOM

Such dominance would have been impossible without Les Davis, say Cray executives. Since the company's founding in 1972, Davis has played a key role in every major machine it has built. He served as chief engineer on the stunningly successful CRAY-1, introduced in 1976. He then guided the company's technical efforts on a string of even more successful machines—from the CRAY X-MP to the recently introduced CRAY T90—before retiring at the end of 1994.

"His technical contributions are so important, you can't focus on one or two things that he's done," notes former Cray CEO John Rollwagen. "To put it simply, there would be no Cray Research without Les Davis."

Behind the scenes. Davis dismisses such comments, attributing the company's success to intense efforts by its engineering teams. "Today, you can't be the circuit designer, logic designer, and master architect," he says. "It truly takes a team effort."

His assertion is hard to contradict. In the past decade, supercomputing technology has grown astonishingly complex. Operating speeds have climbed to more than 300 billion calculations per second (see sidebar). Integrated circuit (IC) tech-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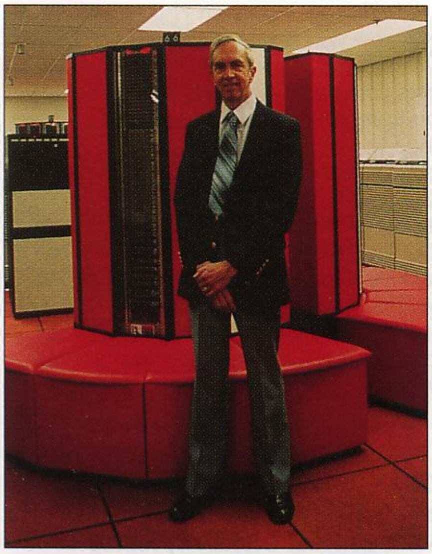
MEMORY



Davis pushed for the company to build the CRAY X-MP computer as a back-up to the CRAY-2 system.

nology has advanced exponentially: In 20 years, Cray Research has graduated from two-gate ICs to 800,000-gate ICs. Circuit board technology has jumped, too. The CRAY-1 used five-layer circuit boards—still considered a significant feat. But the new CRAY T90 uses *40-layer* boards.

Yet, even the engineers who acknowledge the team theory say that Davis' role was immeasurable. Davis, they say, provided the technical vision to build a line of multiple-processor vector machines—from the CRAY X-MP to the CRAY T90—that dominated the industry. He saw the need to break with tradition and cross over into massive parallel processing and low-cost supercomputing. He also led engineers down the best technical paths, gently pulling back on the reins when they grew too aggressive, and prodding them forward when they set their sights too low. Most of all, they say, Davis cleared their paths for success.

"Whenever you'd talk to him, he would take out his notepad," says Steve E. Nelson, vice president of strategic initiatives for Cray Research. "He'd make a note, then you'd find out later that he had helped you out. But he would never say anything about it."

Davis' bond with engineers runs deep. A practical man who usually dresses casually, he has shied away from personal publicity throughout his career. When he served as executive vice president and was later elected to the company's board of directors, he remained in the Chippewa Falls engineering facilities, 100 miles from the company's headquarters.

Among Cray engineers, Davis is regarded as the ultimate team player. He blended talent, handled egos, and built confidence. He guided teams and asked tough questions to ensure that they were on course. "Les could always stump you," says Brost. "No matter how well prepared you were, Les thought of technical questions that you hadn't. He had an understanding of every component, from the transistors to the printed circuit boards. He knew how to make it all work."

The key to his success, however, may have been his uncanny knack for knowing what was feasible. When engineers grew too technically aggressive, Davis was the first to understand the risks. And when they failed to push the state-of-the-art far enough, he nudged them forward. "When I was working for a competitor, I heard all these great things about Les and I never believed them," says Tony Vacca, vice president of engineering for Cray. "But I've learned that they're all true. You have to work for him to know how good he really is."

Bootstrap success. Davis' success at Cray Research, however, didn't always seem pre-ordained. Unlike most Fortune 500 executives, he graduated from a state school with an electrical engineering degree. Even then, he did it the hard way, working days and attending night classes for seven years before earning a baccalaureate degree from the University of Minnesota at age 32.

Born in Minneapolis in 1930, Davis started his college education at the University of St. Thomas in the Twin Cities. Like many computer pioneers, he gained his initial technical experience in the Navy, earning communications and radar certificates. Returning from the service in 1955, he spotted a newspaper ad for a technician's position with Engineering Research Associates (ERA), then a division of Univac. His first visit to ERA impressed Davis. "The interview seemed to suit my liking," he recalls. "The company was a little disorganized, but it didn't appear to be terribly hierarchical."

Davis accepted an offer from ERA over other, more secure opportunities. His new employer stationed him in a drafty glider factory, where he started out by winding wires onto tiny magnetic cores. Though he didn't realize it at the time, he was engaged in a historic project. ERA, one of the world's first companies to make computers, was studying alternatives to the vacuum tube. His group tested magnetic cores; another group examined a relatively untested device called the transistor. The project leader: A brilliant 29-year-old engineer named Seymour Cray.

Later, when a wave of ERA engineers migrated to a start-up called Control Data in 1959, Davis joined them. There, he worked on the Control Data 6600, often regarded as the world's first supercomputer.

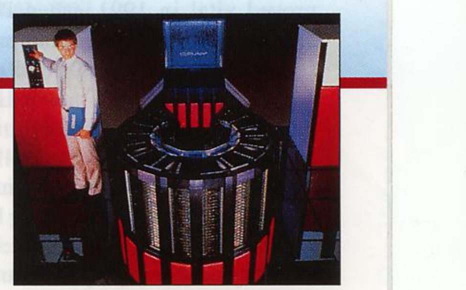
Like many supercomputers that succeeded it, the 6600 dramatically advanced the state-of-the-art, and its engineers struggled tirelessly to make it work. In 1962, the 6600's frustrated pro-

A SUPERCOMPUTER SCENARIO

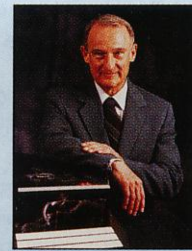
1976 CRAY-1 puts Cray Research on the map.

'82 The CRAY X-MP: Designed as a back-up, it became one of Cray's most popular machines.

'84 CRAY-2: "World's most expensive aquarium" was immersion cooled.



The Competitor in Colorado Springs



Seymour Cray with the CRAY-3, which used gallium arsenide ICs.

It's not a division and it's not a subsidiary. Cray Computer Corp. is, in fact, a competitor of Cray Research.

The only relationship between the two is their founder: Seymour R. Cray. Cray launched the new company in 1989 when Cray Research stopped funding his gallium arsenide supercomputer, the CRAY-3. In a move that angered some stockholders, Cray Research spun off the new company with $100 million cash and modern facilities in Colorado Springs.

Though Cray Computer is struggling to stay afloat, some industry experts say that its latest machine, the CRAY-4, may be competitive. The machine incorporates gallium arsenide integrated circuits, has a 1-nsec clock cycle, and sells for under $6 million. "A system rated at 16 gigaflops for under $6 million positions Cray Computer to capture a best-in-class price-performance prize," says Christopher Willard, manager of high-performance technologies at International Data Corp.

If Seymour Cray's new machine is a technical success, it won't surprise Les Davis. "Only a few individuals in the world can design an entire supercomputer, front to back," Davis says. "Seymour is one."

ject leader, Seymour Cray, moved his crew from St. Paul to the tiny town of Chippewa Falls, WI, 100 miles to the east. There, in Cray's birthplace, they hoped to focus more efficiently on their task. Davis and 30 other engineers journeyed to Chippewa with their families, despite the fact that the company offered no financial support for their move.

He, his wife, and two children moved into an unheated cottage on a nearby lake, while they tried to sell their home in St. Paul. "We sold it just before the cold weather moved in," Davis recalls. With the proceeds from the sale, the Davis family departed the cold cottage for a heated home in Chippewa Falls.

After the success of the 6600, Cray and Davis worked together on the Control Data 7600 and 8600 supercomputers. The 8600, however, never reached fruition. Funding for the machine eventually was cut off, and Seymour Cray left Control Data to start a new firm—Cray Research, Inc.

Risky new venture. Days after the formation of Cray Research in April 1972, Seymour Cray called Les Davis. He was starting a niche firm that would build the industry's fastest computers, he said, and wanted Davis to join him.

Though Davis had four children and a secure position as general manager of CDC's Chippewa Falls operation, he never blinked. He took the risk of joining a start-up because of his confidence in Seymour Cray, he says. At times, Cray had nearly single-handedly carried the high-performance computing operation at Control Data. He was—and still is, Davis says—one of the rare engineers that can design an entire supercomputer from front to back. He wrote Boolean equations, laid out circuits, developed logic, determined the architecture, designed compilers, wrote software, and even put together user manuals. "I had a lot of confidence in Seymour," he says. "I thought the move was worth the risk."

In some respects, the new company was merely an extension of the old. Its facility, in Hallie, a town adjoining Chippewa Falls, was only 1,000 feet from the old Control Data lab.

Life at Cray Research, however, had a distinctly different flavor. It was simpler, but far more risky. Unlike Control Data, where the failure of the 8600 supercomputer had been tolerated, there could be

A Cray Research Sampler

PRODUCT NAME	NUMBER OF SYSTEMS SHIPPED THROUGH 1994	THEORETICAL PEAK SPEED	PRICE RANGE (IN MILLIONS)
CRAY-1 1976-1984	61	167.0 MFLOPS	$4 TO $11.2
CRAY X-MP 1982-1989	126	941.0 MFLOPS	$2.5 TO $16
CRAY-2 1984-1990	27	1.9 GFLOPS	$12 TO $17
CRAY Y-MP 1987-1993	344	2.7 GFLOPS	$2.2 TO $23
CRAY C90 SERIES 1990-1994	61	16.0 GFLOPS	$2.5 TO $42
CRAY J916 1994-PRESENT	82	3.2 GFLOPS	$0.2 TO $1.5
CRAY T3D 1993-PRESENT	33	307.0 GFLOPS	$2.2 TO $74*

* A CRAY T3D HAS NEVER BEEN SOLD AT THIS PRICE

'87 CRAY Y-MP: Successful follow-on to the CRAY X-MP.

'90 CRAY C90: Davis' choice for the future.

'93 CRAY T3D: Massive parallelism comes to Cray Research.

'94 CRAY J916: Starts at $200,000.

no misfires at this new company. If the CRAY-1 failed, the company would quietly fade away.

The combination of Cray and Davis was a perfect match, however. Cray started with a clean sheet of paper, wrote the Boolean equations, then designed the hardware. Davis took the opposite approach: He viewed supercomputers as a system, and ensured that all sub-systems operated in concert. Davis oversaw the design of each separate aspect of the machine: memory, processors, disk drives, input/output, cooling, and virtually every other major part. "I always looked at it this way: Seymour thought them up, and Les made them work," explains Rollwagen.

Unlike the 8600, which had employed discrete components, the CRAY-1 used integrated circuits. As a result, its reliability proved far better. The machine's one processor measured about three feet by five feet, and consisted of several hundred electronic modules. In all, it contained about 25 miles of wiring.

Still, the machine's performance came at a cost. Tight packaging and high speed generated searing heat. To remove it, Davis assigned M. Dean Roush, a mechanical engineer, to develop a cooling system. Up to that time, supercomputers had been air cooled. But Roush designed a Freon-based cooling system. When the machine ran, heat flowed from the chips to the PC boards, to metal plates, through sets of wedges, and into tubes containing flowing Freon. The Freon carried the heat to a compressor, thus lowering the temperature inside the processor.

In 1976, Cray Research arranged to place its first machine at Los Alamos National Laboratories on a trial basis. It was an immediate hit. By 1984, 61 of the machines had been sold, most to labs such as Los Alamos, Lawrence Livermore, and the National Center for Atmospheric Research.

"The CRAY-1 was a perfect mixture," Brost recalls. "It combined the brilliance of Seymour Cray with the intuitiveness of Les Davis. Les was able to harness Seymour's genius—along with the talent of all the other engineers—and create a great product."

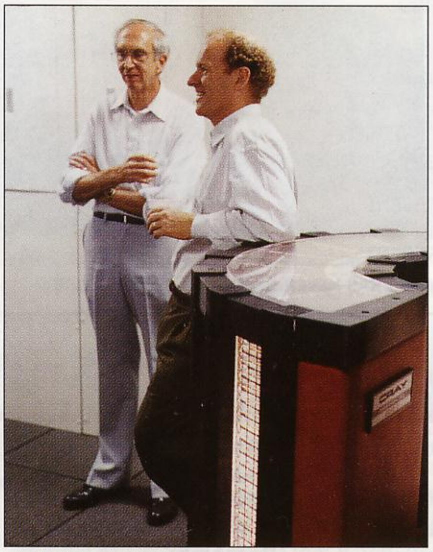
New user community. In the wake of the CRAY-1's success, management anxiously anticipated the company's next big project: the CRAY-2. But Davis was one of the few who saw the need for a competing project inside the company. Initially, the new program was viewed as an insurance policy in the event Seymour Cray's CRAY-2 didn't reach its goals.

But the back-up, known as the CRAY X-MP, soon became the primary project. Davis hand-picked a crew, headed by computer architect Steve Chen. The machine's far-reaching goal was the use of two processors operating in parallel. Others had attempted parallel processing with limited success. Anticipating difficulties, Davis assigned one of the company's best engineers—Alan J. Schiffleger—to design a control system and logic to run two processors at a time.

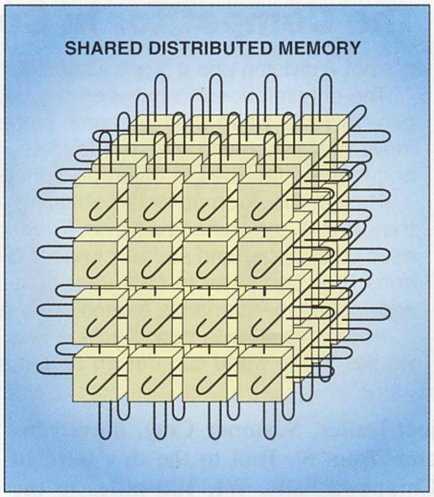
The design was further complicated by a shorter clock period—the CRAY X-MP's goal was 9.5 nsec. It also used a 16-gate array and 16 pins to a package, which complicated the wiring, packaging, and cooling. Being intimately familiar with the company's expertise, Davis personally selected engineers to do circuit design, floating-point design, packaging, cooling, and a variety of other tasks.

The result: a booming success. While the CRAY-2 team fell behind schedule, the CRAY X-MP reached the market in 1982. By 1989, it had doubled the sales of the CRAY-1. "It surprised people in our company who viewed it as a little more than an enhancement to the CRAY-1," Brost says.

The success of the CRAY X-MP carried over to the company's next project:



Davis, Rollwagen, and the CRAY-2: 'Seymour thought them up, and Les made them work,' according to former Cray CEO Rollwagen.



CRAY T3D design employed a three-dimensional 'memory torus,' in which memory nodes were connected to other nodes in three directions. The torus minimized slow communication.

the follow-on CRAY Y-MP, which incorporated eight parallel vector processors. The machine was an even bigger success than the CRAY X-MP: In six years, Cray Research sold 344 CRAY Y-MPs, ranging in price from $2.2 million to $23 million.

More significantly, Cray Research's supercomputers made in-roads with a new class of customer: private industry. The new machines were faster, more reliable, and better understood. They offered operating systems and software. And they appealed to engineers as well as scientists. As a result, a new user community sprang up, and Cray began selling machines to the aerospace, automotive, petroleum, chemical, and pharmaceutical industries.

Discord in Chippewa. For Cray Research, however, the introduction of the CRAY Y-MP also marked the beginning of the most trying period in the company's history. Prior to an economic slump in 1987, the firm funded three competing programs: Steve Chen's MP project; Seymour Cray's CRAY-3; and a CRAY Y-MP follow-on called the CRAY C90.

With the economy in a downturn, however, management decided it could no longer carry all three. The MP—an aggressive design aiming for development of a 1-nsec clock—was the first to go. "It was a difficult decision," Davis recalls. "We looked at its progress and the funding it needed and felt we couldn't afford it."

Chen moved his project outside the company. Garnering funding from IBM, he started a new firm, Supercomputer Systems, Inc (SSI). By 1993, however, SSI had no product; IBM stopped funding it; and the firm soon folded.

If cutting the MP was difficult, however, eliminating the CRAY-3 from the budget proved excruciating. The CRAY-3 was daring—it replaced silicon chips with gallium arsenide—but its riskiness was offset by the fact that its designer was Seymour Cray. Still, it competed with the CRAY C90, a machine that offered compatibility with the CRAY Y-MP. And the CRAY C90 project was staffed by an eager young group of engineers with strong credentials.

In a painful decision, Davis supported the CRAY C90, which led to the departure of Cray. "It was difficult to see Seymour go," Davis recalls. "Most of the people here viewed it with sadness."

The decision, however, may have been less painful for Cray himself. In a move that angered some stockholders, the company spun off Cray's project as a separate company, complete with $100 million and a facility in Colorado Springs.

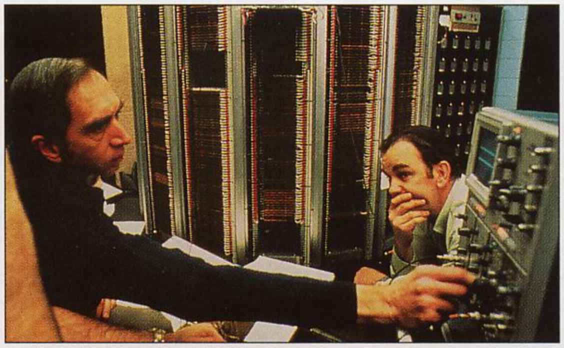
Ultimately, the move proved to be a good one. Sixty-one CRAY C90 series machines were sold at prices ranging from $2.5 million to $42 million each. Not a single CRAY-3 was ever sold.

The CRAY C90 decision, say engineers, was further proof of Davis' ability to set the technical tone for the company. "Les knows when to reach and when to accept the technology that's already in place," Vacca explains. "He knows how to walk that fine line."

MPP leadership. Davis' ability to walk the fine line, and to remain technically flexible, has kept Cray Research atop the supercomputer heap in the 1990s. That flexibility proved vital in 1991, when Davis gathered an engineering team to pursue massive parallel processing (MPP).

At one time, the mere thought of microprocessor-based computers would have been heresy in the halls of Cray Research. Many Cray engineers were reticent about the technology because of programming difficulties and slow memory communications. But, in 1991, analysts predicted a bright future for massively parallel computers. The machines, which parcel out pieces of large projects to microprocessors, were gaining favor as a long-term means of advancing computer speed.

Behind Davis' leadership, Cray Research exceeded its goal of a 1995 introduction with the debut of the CRAY T3D in the fall of 1993. The machine combined microprocessors with Cray's knowledge of supercomputers. Its design employed a three-dimensional "memory torus," in which memory nodes were connected to other nodes in three directions.



Davis in 1979 with the CRAY-1: Cray's engineering team devised a Freon-based cooling system that mimimized the machine's searing heat inside the processor.

The concept, known as shared distributed memory, enabled any microprocessor in the machine to address any memory. It minimized the problem of slow memory-to-processor communication that had often plagued MPP systems.

Result: Cray quickly jumped from a zero market share in MPP to a leadership role within one year. Incredibly, Cray's dramatic climb through the MPP ranks occurred when other supercomputer makers—such as Thinking Machines and Kendall Square Research—struggled financially.

The flexibility demonstrated in the CRAY T3D program will serve the company well in the coming years, Davis says. With national defense spending down, Cray Research must look for new customers and design products to accommodate them.

New direction. The firm already moved in that direction with the introduction of the CRAY J916 supercomputer last year. Operating at a peak speed of 3.2 gigaflops, the CRAY J916 offers distinctly lower performance, but at prices that are a fraction of those of the big machines. The machine's low cost has enabled Cray to find dozens of new customers.

"It's not just a matter of building the fastest machine anymore," Davis explains. "It's a matter of price-performance. We have to learn to make some tradeoffs."

Cray Research also must learn to make tradeoffs as its engineers adjust to life without Les Davis. Company executives say that Davis' retirement leaves a gaping hole in the technical hierarchy. "Les Davis has personally had more to do with overall successes achieved by Cray Research in the past 22 years than any single person without exception," says John Carlson, chairman and CEO of Cray Research.

In his retirement, Davis tentatively plans to continue to advise Cray Research in the product-development area. He also will serve as a consultant to a major government agency with an interest in high-performance computing.

"He'll be missed," Vacca says. "His leadership has made Cray Research almost embarrassingly successful. Under Les Davis, people wanted to come to work and build supercomputers." dn

How fast is super-fast?

Imagine punching 1+1+1+1... on your pocket calculator. If you punch one operation per second, how long would it take you to reach the same number of calculations that a CRAY X-MP can do in a second?

Even if you know supercomputers, the answer may surprise you: Without time off to eat or sleep, you'd need 29.8 years.

That's daunting, but it's easier than keeping up with a CRAY T3D. With a peak theoretical speed of 307 gigaflops, the CRAY T3D can do as many as 307 billion calculations per second. Accomplishing that with a hand calculator working at one operation per second would take 9,734 years.

Some supercomputer engineers still hope to reach a teraflop—one trillion calculations per second—by the turn of the century. How fast is that? With a hand calculator, it could take more than 31,000 years.

Reprinted from **DESIGN NEWS** March 6, 1995