EDN'S

ALL-STAR PC PROJECT

Many avid sports fans create fantasy teams composed of their favorite players. The players' performances in actual games determine the fantasy league team scores every week. We decided to do something similar at EDN, but our team is a very real PC. We assembled our players—high-performance PC components—to find out how they would play together in reality. Many of the products we eventually picked didn't even exist at the start of this project. We call our creation EDN's All-Star PC, because each component is a stellar performer.

We had many reasons for building the All-Star PC: We needed a powerful computer to test the many CAD and CAE software products that run on PCs, because many of these packages outstrip the capabilities of garden-variety PCs.

We wanted to illustrate the PC's architectural versatility. You can now find PC-based systems and single-board computers that meet the requirements of design projects ranging from instrument controllers to complex embedded systems.

And, we built EDN's All-Star PC to help you judge the true value of the many technological developments that took place in 1989. These developments presage major changes for PCs in 1990. For example, Intel's 80486 μP redefines the high-end PC; new SCSI-based data-storage products pack away massive amounts of data in PC-class systems; and new graphics products bring workstation-class resolution and performance to PC displays.

The five articles in this series will chronicle EDN's project, explaining how and why we selected each component. We built the All-Star PC to serve as an engineering workstation and biased our decisions accordingly. You may not agree with all our product selections—even some EDN editors disagree—but at least you'll understand how we made our particular choices. We hope our experiences will help you make better choices and speed you toward your goals.

Play ball!

STEVEN H LEIBSON, Senior Regional Editor

Sculpture by Kathy Jeffers/Sculpture Photography by Chris Vincent

EDN'S ALL-STAR PC

PART 1:
GROUNDWORK

It seemed so easy. Build the World's Most Powerful PC by picking the best components and melding them into an integrated whole. But every integration is tough, and the All-Star PC takes the problems of system integration to the extreme. The selection process, with vendors offering thousands of PC components, is daunting. And even when you've picked the components you want, making them work together is no picnic.

More than one million transistors stare at me through the clear plastic fob dangling from the keys to EDN's All-Star PC. The transistors reside on an immense silicon slab and are collectively known as Intel Corp's 80486 μP. This hunk of plastic and silicon makes a fitting symbol for the hyperspatial leap in PC performance that the 80486 empowers. The μP's die measures 0.619×0.414 inches—an unthinkable and unbuildable IC only a few short years ago. Similarly, a personal computer with the speed and capacity of EDN's All-Star PC could not have been built without several technological developments of the very recent past. This project, to tailor a PC to the needs of the engineer, demonstrates just how far these developments have taken the PC's architecture in its first decade.

Size played a major role in selecting the project enclosure. The VES 1000 enclosure system from Interface Electronics Inc fit the project's requirements exactly.

Engineers adopted PCs long before they were called personal computers. In fact, they adopted them even before the first μPs appeared. Hewlett-Packard's 9100 programmable desktop calculator, a proto-PC that appeared in the late 1960s, was developed by the company's Loveland Instruments Div for the express purpose of controlling lab instruments. An ancillary result was that it heralded the next decade's revolution in personal computing for engineers. The 1970s saw the arrival of microcomputers based on 8-bit processors, such as Intel's 8080 and Zilog's Z80 μPs, and electrical engineers conscripted many of these machines for hardware- and software-development tasks.

The PC, as introduced by IBM in 1981, accelerated the engineering community's acceptance of the personal computer as a valuable R&D tool. In fact, PC-based software products now dominate several categories of engineering software, such as µP software development, PLD design, and schematic capture, because the PC makes a cost-effective engineering workstation.

The early PCs, however, couldn't handle much of the tougher work assigned to engineering workstations because of memory, mass-storage, operating-system, and graphic-display limitations. EDN built the All-Star PC to explore the current limits of PC performance and to discover the differences between PCs and engineering workstations as they exist today. Simply put, the performance levels attained by EDN's experimental machine raise the ante in the war between engineering workstations and PCs.

Critics whine that the PC stifled growth in the computer industry and suppressed technological innovation over the last decade. However, a more accurate look at the computer industry, developed by talking to many component vendors, exposes the truth: the PC's sales volume provides the economic incentive that drives innovation and development in display technology, mass-storage devices, semiconductor memory, peripheral products, and even battery technology. Although PCs may not have developed the same respectable patina as workstations for engineering applications, PCs carry substantial weight in the engineering market. For these reasons, EDN deemed PC technology sufficiently important to warrant this series.

The machine's heart and soul

Fate placed Intel's 8088 µP into IBM's original Model 5151 PC. Engineers at IBM's Entry Level Systems Div liked the processor's architecture, which provided 16-bit computing power coupled with an inexpensive 8-bit bus. They also liked the µP's 1M-byte address space, which seemed titanic when compared to the 64k-byte addressing capabilities of the then-dominant 8-bit processors. Lack of software for the 8088's architecture didn't deter IBM's engineers, nor did the software dearth last long. Commercially available software packages for the PC now number in the tens of thousands; Intel estimates that this software base is worth $15 billion.

Since the fateful introduction of the IBM PC, several vendors have introduced increasingly powerful µPs that feature object-code compatibility with Intel's original 8086 and 8088. Intel designed several of these successors. Its 80486 µP is the latest product of that evolution, and became, though not intentionally, the heart of EDN's All-Star PC (see **box**, "Changing processors in midstream").

Several of the 80486 µP's features make it an excellent choice as a processor for a PC-based engineering workstation. It combines the features of Intel's 80386 µP, 80387 floating-point processor, a 4-way set-associative cache controller, and 8k bytes of cache RAM (**Fig 1**). This high integration level saves board space, reduces power consumption, and assures the system designer of a finely tuned system core. Intel fully exploited the advantages of integration by using interconnection schemes such as dual 32-bit data buses and a 128-bit bus between the cache RAM and the prefetcher. The 80486's designers also took advantage of the device's inherent parallelism. For example, the ALU and floating-point unit can operate concurrently.

To further boost its performance, the designers identified frequently used 80386 instructions by using code traces from existing programs. A 1.2-million transistor budget allowed designers to reduce the clock-cycle counts on critical instructions by replacing sequential microcode with high-speed circuitry. **Table 1** shows some results of these optimization efforts. The 80486 achieves significantly better performance than the 80386 on a clock-cycles-per-instruction (CPI) basis. In fact, the **table** shows that the 80486 can also better the CPI performance of so-called RISC (reduced-instruc-

Photography by The Photo Works and Steven Leibson unless otherwise noted.

tion-set computer) µPs, whose claim to fame is low CPI counts. However, with 1.2 million transistors, you could hardly call the 80486 a RISC µP.

Other 80486 features have also proven important to the overall performance of EDN's All-Star PC. The processor's prefetch unit can theoretically fetch four 32-bit instructions in five clock cycles (normal bus cycles require at least two clock cycles per bus transfer). This burst-access mode mates quite well with the capabilities of fast-page-mode DRAMs (dynamic RAMs) and reduces or eliminates the need for secondary cache memory external to the µP. The µP's paging and segmentation units provide the memory-management resources required by multiuser operating systems such as Unix. The units allow advanced PC software to extract additional performance from system resources, even when running under Microsoft's DOS. However, the interaction between the memory-management circuitry and other system components also caused a few interesting problems, as you'll see in subsequent articles.

Even supposedly minor features make the 80486 a good choice for EDN's All-Star PC. For example, the µP generates and checks memory parity, so you don't have to include parity-generation and checking circuitry in your design. Further, the 80486's clock input requires only a 1× clock signal, so you don't need to pipe 50- or 66-MHz signals around your board, as you did for 80386-based designs. The latter is a small feature that may help keep the FCC off your back. But the biggest feature that makes the 80486 the right choice for a PC-based workstation is its compatibility with the original 8088 instruction set and the 50,000 or so commercial programs that use these instructions.

By itself, even a super processor

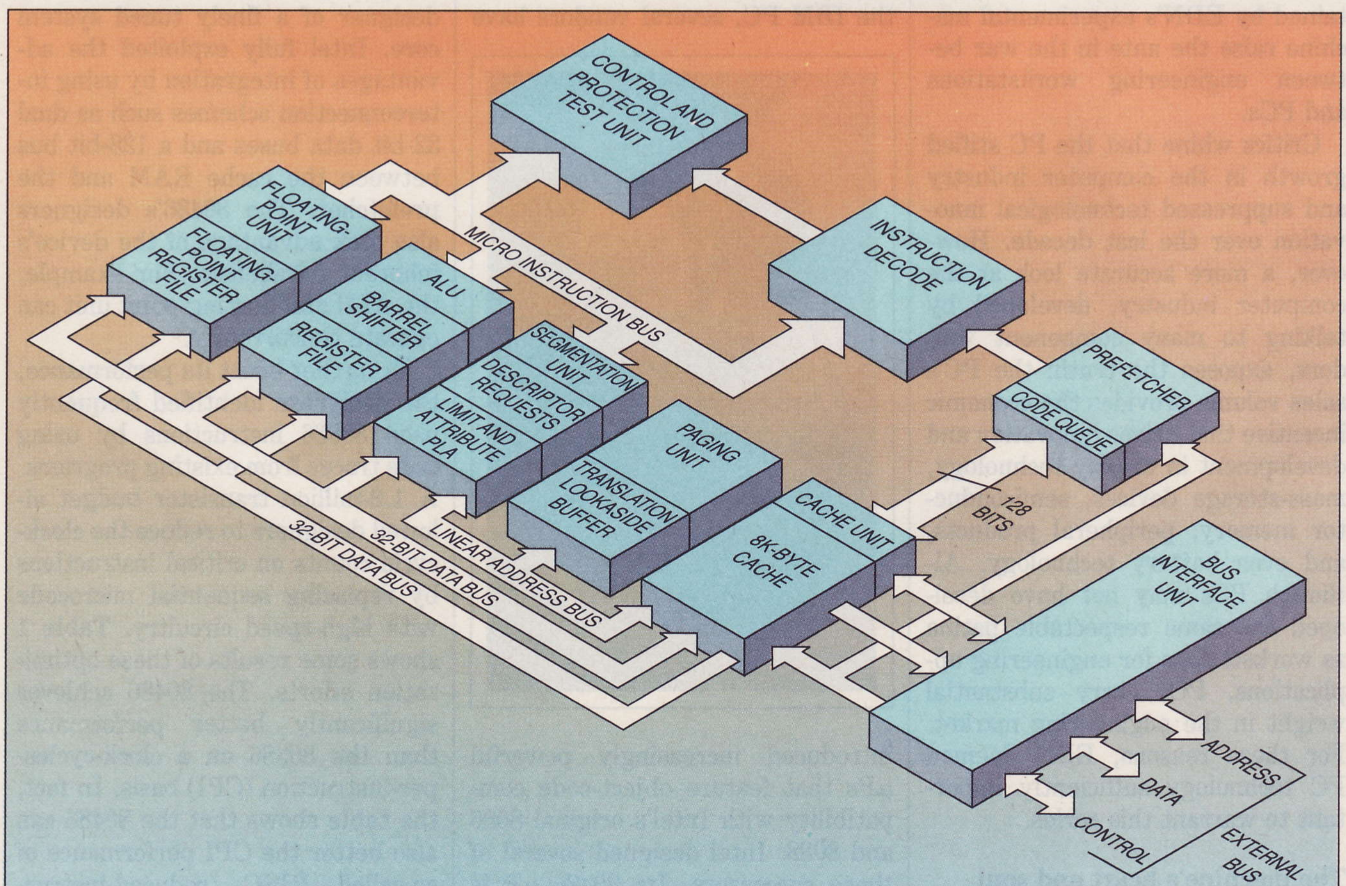
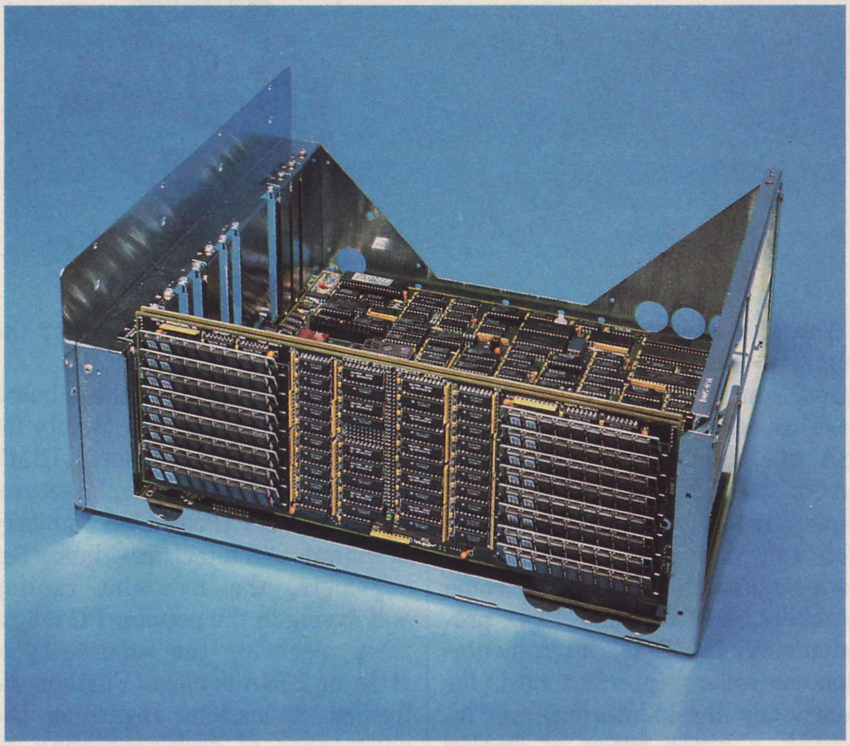


Fig 1—An integral floating-point unit and on-chip cache RAM help drive the performance of Intel's 80486 µP sky high. Massive busing moves data to the various on-chip elements quickly.

like the 80486 isn't of much use; it has to be packaged into a system. For PCs, the key component of such a system is the mother board. Many companies make mother boards for PC systems using a variety of design philosophies. I selected the Cheetah Gold 425 mother board, from Cheetah International Inc, for the All-Star PC after several discussions with Ron Sartore, the company's president. Sartore's design strategy boils down to using the most flexible components available and wringing the last nanosecond from them without relying on "typical" specifications. That's a design philosophy I can easily accept.



A removable card cage eases assembly and servicing of EDN's All-Star PC and provides a good display frame for the 16M bytes of RAM on the Cheetah Gold 425 daughter card.

As a consequence of Sartore's approach, the Cheetah Gold 425 sports PC/AT expansion slots. It doesn't incorporate any of the mother-board chip sets offered by many semiconductor vendors. Instead, Cheetah's mother board employs the same LSI peripheral devices that the PC/AT uses, glued together with PLDs. The flexibility that the mother-board PLDs provide allows Cheetah to tackle the inevitable compatibility problems that arise when plugging in various expansion cards designed for IBM's astoundingly ambiguous PC and PC/AT buses (recently misnamed the "Industry Standard Architecture" or ISA bus).

Unfortunately, IBM's entire documentation for its PC and PC/AT buses consists of a few paragraphs of text and the schematics for the IBM PC, PC/XT, and PC/AT computers. As a result of this sparse documentation, every company's implementation of these buses is somewhat different. Yet, these poorly specified, uncontrolled buses have become de facto industry standards, and as such have attracted the attention of board designers. You can't fault IBM, however. The company never proposed its PC buses as standards.

Changing processors in midstream

Cheetah's Gold 425 mother board began its existence as the Cheetah Gold/33, a design based on Intel's 33-MHz 80386 μP. I saw the board in this configuration during my first meeting with Cheetah's president, Ron Sartore. The 80386-based design placed the processor on the mother board and used a proprietary memory card plugged into a slot that was not part of the conventional expansion-slot arrangement. Because the 80386 doesn't support burst-mode transfers directly, the memory design included a burst-mode controller built from PLDs. However, by our second meeting, Sartore had converted one of the Cheetah Gold/33 memory boards into a memory- and processor-board unit based on the 80486. By pulling the 80386 from its socket on the mother board and plugging in the 80486-based daughter card, Sartore transformed his 80386-based design into the Cheetah Gold 425 in only a day or two.

Even at 25 MHz (a 25% reduction in clock rate), the 80486-based design outperformed the 33-MHz 80386-based design by a factor of two or three. The time required to remove hidden lines and regenerate a drawing of London's St Paul's Cathedral using Autodesk's popular AutoCAD program dropped from seven minutes using the 80386 to two minutes using the 80486. Clearly, the 80486's internal cache memory provides much of that performance boost (Cheetah's 80386 design employed no cache RAM), but the 80486's streamlined instructions also contribute to its speed. After Sartore's demonstration, I conscripted the 80486 onto EDN's All-Star PC Project.

The ISA bus now boasts the industry's widest range of plug-in cards. Among PC users, engineers have especially benefited from the ISA bus, because many manufacturers offer ISA boards designed especially for engineering needs. You can buy analog and digital data-acquisition cards, video frame grabbers, EPROM and PLD programmers, IEEE-488 instrumentation controllers, interface cards for nearly any digital interface ever invented, a broad range of display cards, industrial and commercial network controllers, peripheral controllers for the biggest menagerie of devices on earth, and nearly any other type of expansion card that you could possibly imagine for the ISA bus.

It will take years for these board vendors to replicate this variety for the ISA bus's successors: IBM's MCA (Micro Channel Architecture) and the EISA (Extended Industry Standard Architecture) bus. For engineers, the incessant ranting and raving in the popular PC magazines regarding the superiority of MCA or EISA is moot. Further, informed discussions regarding the advantages of multiprocessing on the MCA and EISA buses await software to exploit this capability. DOS doesn't handle multiprocessing configurations well. So until the board vendors can provide the same wide range of expansion card functions for the newer buses, I believe that the ISA bus remains the right choice for a PC-based engineering workstation. That's why Cheetah's mother board (and EDN's All-Star PC) employs PC/AT slots.

A potential flaw looms in my argument, however. If the ISA bus proves to be the limiting performance factor and actually throttles the PC's throughput, then it loses much of its attractiveness. Major consumers of bus bandwidth include the main memory, disk and network controllers, and the display adapter. Cheetah's design avoids many potential bus-bandwidth problems by separating the

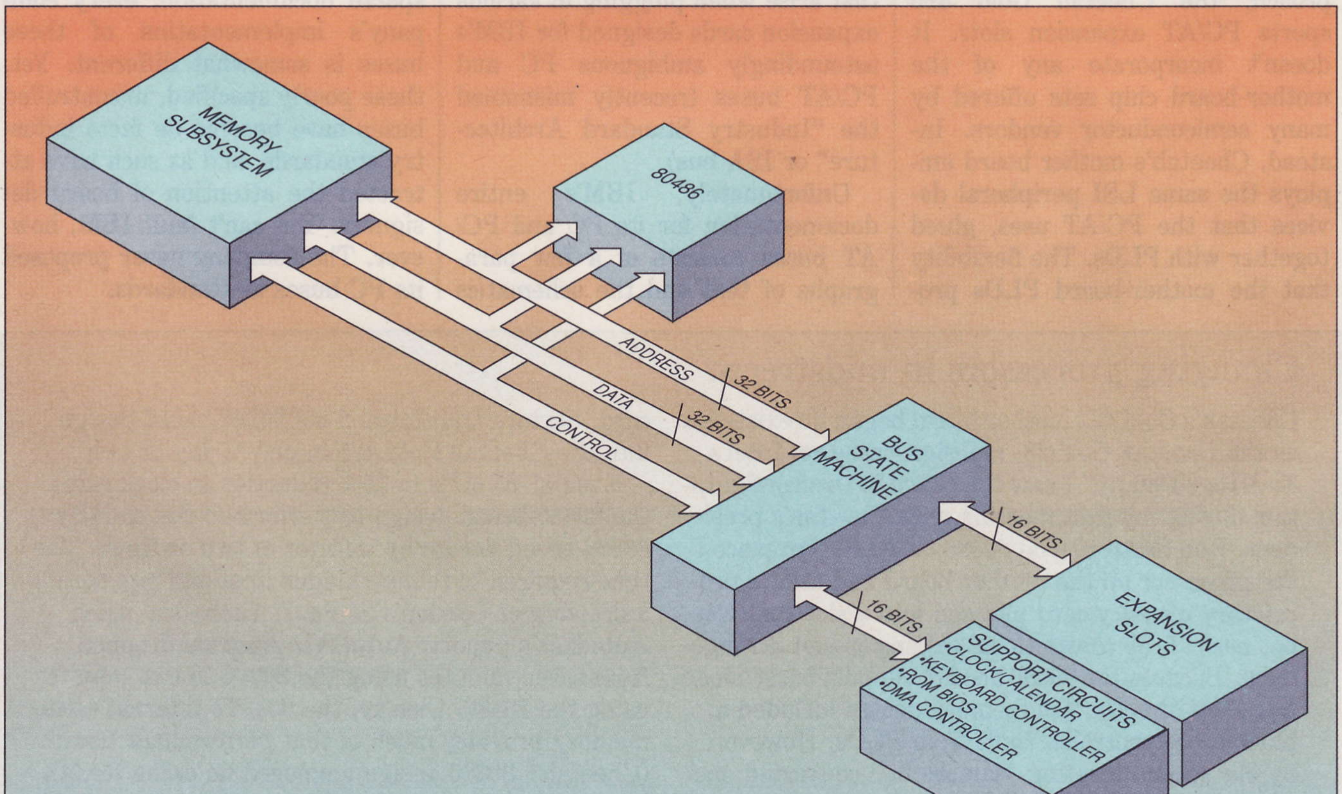


Fig 2—By separating the memory and I/O subsystems on its Gold 425 mother board, Cheetah International achieves an extra degree of parallel operation beyond that provided by the onboard 80486 μP.

main system memory and the I/O circuitry on the mother board (**Fig 2**). Both the memory subsystem and the I/O subsystem have independent, state-machine controllers that optimize the subsystems' interfaces to the 80486.

The processor/memory interface

Cheetah's memory-subsystem and processor boards snap together to create a single unit, which plugs into a proprietary expansion slot on the mother board. The processor card holds the 80486 and sufficient circuitry to drive the memory controller and bus state machine. The memory card holds the entire memory subsystem, including 16M bytes of RAM, organized as four 4M-byte blocks (**Fig 3**). Cheetah's processor/memory design superficially resembles the approach taken by other vendors who build ISA mother boards for 32-bit μPs. The ISA bus doesn't support 32-bit memory, so a proprietary memory slot is required. Cheetah's approach differs by placing both the processor and the RAM on one plug-in daughter card, thereby permitting an optimized connection between the processor and memory, and removing memory cycles from the expansion bus. This approach also allows the company to migrate its design to the next μP in the PC's evolution by redesigning only the daughter card.

Because it is so closely coupled with the μP, the 425 mother board's memory subsystem achieves nearly optimum performance. With zero-wait-state RAM, the 80486 can transfer four 32-bit double words in five clock cycles. But several megabytes of zero-wait-state memory costs too much to be practical. Using fast-page-mode DRAMs, Cheetah's design can perform the burst-mode operation in six clock cycles. When loaded with 8M or 16M bytes of RAM, the memory subsystem interleaves 4M-byte memory banks and can sustain the 6-clock-cycle burst rate indefinitely if the processor continues to read memory sequentially. Without interleaving, DRAM precharge requirements

Table 1—Enhanced execution of frequent instructions

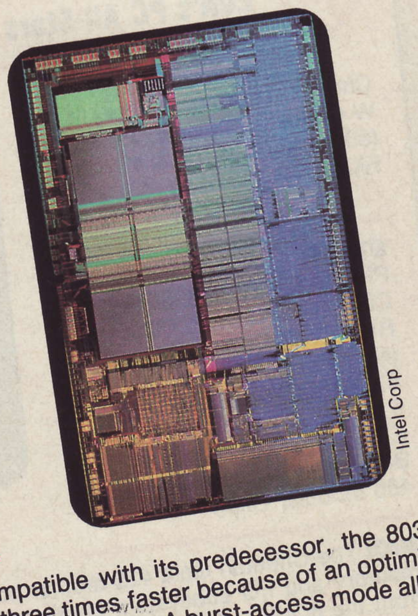
Instruction	Clock Counts			
	Intel 80386	Intel 80486	Sun SPARC	Motorola 88000
Load	4	1	2	1-3
Store	2	1	3	1
Register-to-Register	2	1	1	1
Jump (Taken/Not Taken)	9/3	3/1	1/2	1
Call	9	3	3	1

Source: Intel Corp

80486 μP

EDN's PC All-Stars

Intel Corp, 3065 Bowers Ave, Santa Clara, CA 95051. (408) 987-8080. **Circle No. 666**



STATS:
ALU: Optimized integer processor
FLOATING-POINT PROCESSOR: Compatible with the 80387
CLOCK RATE: 25 MHz
ON-CHIP CACHE RAM: 8k bytes
MEMORY MANAGEMENT: Page and segment units
CODE-COMPATIBLE WITH: 8086, 8088, 80286, 80386

BIO: The 80486 μP is code-compatible with its predecessor, the 80386, but runs the same code two to three times faster because of an optimized execution unit and the on-chip cache memory. A burst-access mode allows the μP to feed its prefetch unit data at 80M bytes/sec.

force the DRAM controller to insert additional wait states. EDN's All-Star PC incorporates 16 Toshiba THM91000AS-70 SIMMs (single in-line memory modules), for a total memory capacity of 16M bytes. You can also place memory in the mother board's expansion slots, but that data path runs slower because of the expansion bus's speed and 16-bit width.

Cheetah's bus state machine also attempts to minimize the consumption of bus bandwidth. All I/O devices on the mother board and all expansion cards plugged into the mother board's expansion slots transfer data in 8- or 16-bit chunks, but the 80486 has a 32-bit data bus. Intel solved this data-bus mismatch by providing the 80486 with dynamic bus sizing. For each bus cycle, the 80486 first attempts to perform the transfer using the entire 32-bit data bus. Devices that can't

Nine million transistors require very little room when packaged as a 1M×9-bit SIMM (single in-line memory module). The All-Star PC uses 16 of these 70-nsec THM91000AS-70 SIMMs from Toshiba America Electronic Components Inc.

accommodate 32-bit bus cycles drive one of two processor pins to signal that they only support 8- or 16-bit transfers. Asserting either signal forces the 80486 to run additional bus cycles until the transfer is completed. For devices limited to 16-bit transfers, the 80486 runs two bus cycles, unless the data is not word-aligned, in which case it runs three cycles. For byte-sized devices, the processor runs four bus cycles to complete the transfer.

The 80486 wastes bus bandwidth when it executes additional bus cycles to accommodate devices smaller than 32 bits. Slow I/O devices that require the insertion of wait states during a bus cycle merely compound the problem. Cheetah's bus state machine provides a partial solution to this problem by diverting write cycles into a 32-bit holding register. This register is a fast device, so it invokes no wait states. Thus, all write cycles directed at the mother board or an expansion card require only one processor bus cycle. Once the transfer between the 80486 and the holding register is completed, the processor's bus is no longer busy. Therefore, the 80486 can use the memory subsystem while the I/O controller completes the execution of the bus cycle initiated by the processor. Meanwhile, the I/O controller moves the 32 data bits from its holding register to the intended recipient of the write cycle in appropriately sized chunks using two or four transfer cycles for 16- or 8-bit devices, respectively.

Unfortunately, this clever technique doesn't work for read cycles, so the processor must throttle down to read data from devices on the mother board or from boards plugged into the expansion slots. However, the architecture must be effective for the 80486 because the Cheetah Gold 425 mother board

EDN's PC All-Stars

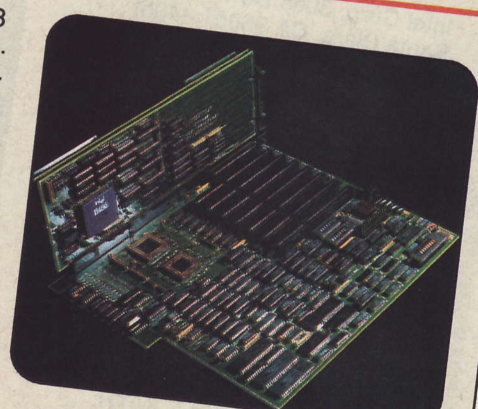
Cheetah Gold 425

Cheetah International Inc, 1003 W Cotton, Longview, TX 75604. (800) 243-3824. (214) 757-3001. FAX (214) 753-0589.

Circle No. 667

STATS:

PROCESSOR: Intel 80486
CLOCK SPEED: 25 MHz
RAM CAPACITY: 16M bytes (4M-byte increments)
EXPANSION-BUS SPEED: 6 MHz
EXPANSION-BUS SLOTS: 7
BIOS ROM: Award Software's 486 Modular BIOS



Cheetah International Inc

BIO: The Cheetah Gold 425 mother board employs state machines for its memory and I/O subsystem controllers, eking every iota of performance from the 80486 μP. It maintains compatibility with a large number of ISA expansion cards through the use of PLDs, which also allow the company to tailor the board's expansion-bus timing for special needs.

consistently outperforms other 80486-based PC mother-board designs in benchmark tests conducted by computer magazines such as *Byte* and *Personal Workstation*, formerly *MIPS* (**Refs 1** and **2**).

Cheetah's bus state machine also disassociates the mother board's expansion-bus speed from the processor's clock rate. IBM's original PCs merely extended the μP's bus signals to the expansion bus through some simple buffers. The first PC ran at 4.77 MHz; the first PC/AT ran at 6 MHz. The expansion buses in these machines consequently ran at a leisurely pace. As processor speeds rose, so did the expansion-bus speeds of the PC clones. By the time the expansion buses started running at 10 MHz, some real timing problems appeared, once again because of the undocumented and uncontrolled nature of the ISA bus. The Cheetah Gold 425's bus state machine runs the expansion bus at 6 MHz and avoids many of the timing problems that sometimes crop up between fast PCs and expansion cards.

Cheetah uses Award Software Inc's 486 Modular BIOS (basic I/O system) firmware on its mother board. Award developed its 80486 BIOS code in conjunction with Cheetah. A BIOS serves as the glue between the operating system and the hardware. It translates operating system function calls into ma-

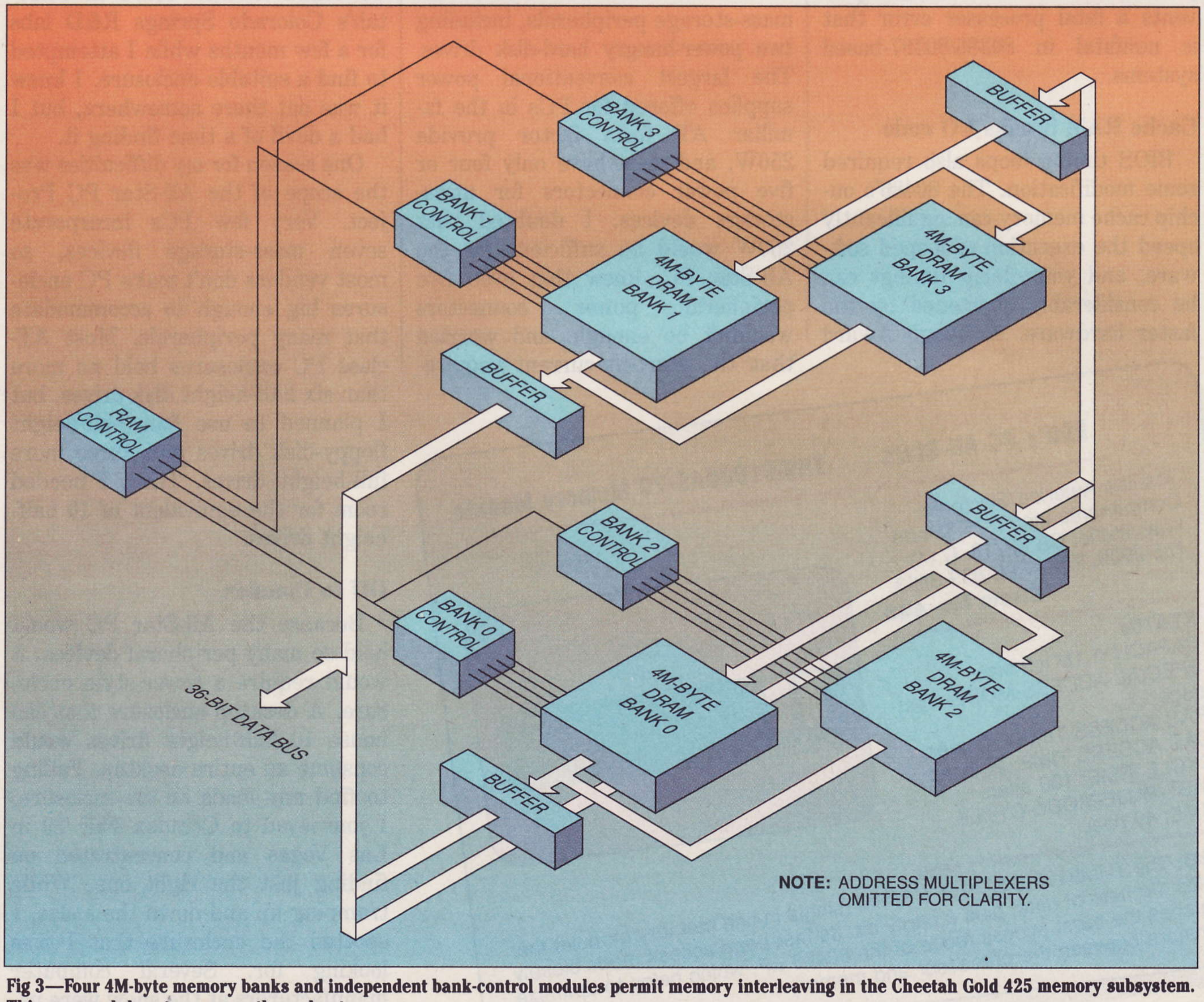


Fig 3—Four 4M-byte memory banks and independent bank-control modules permit memory interleaving in the Cheetah Gold 425 memory subsystem. This approach boosts memory throughput.

chine instructions that interact directly with the hardware. BIOS vendors must rewrite their firmware for each new µP to make the best use of the processor's new features. An 80386 BIOS will work in 80486-based systems, but it won't be able to test or use the on-chip cache memory. Because of changes made to the 80486's floating-point processor, Award modified the way in which its 486 Modular BIOS initializes the 80486's floating-point processor. The modification prevents a fatal processor error that is nonfatal in 80386/80387-based systems.

Cache RAM breaks I/O code

BIOS timing loops also required some modification. The 80486's on-chip cache memory can significantly speed the execution of looped software, and your delay timings can be considerably shortened by the faster hardware. Although Award discovered that it didn't need to make many changes to its delay code, the 80486's faster execution speed definitely caused problems later in the project.

With the mother board and processor selected, only two more components were required to complete the All-Star PC's foundation: the power supply and the enclosure for the CPU. I knew from early inquiries that I'd require a substantial power supply. My plans called for a total of seven 5¼- and 3½-in. mass-storage peripherals, including two power-hungry hard-disk drives. The largest conventional power supplies offered for PCs in the familiar AT form factor provide 250W, and most have only four or five power connectors for mass-storage devices. I doubted that 250W would be sufficient for the All-Star PC, knew that even five peripheral power connectors wouldn't be enough, and worried that the start-up-current requirements of the hard-disk drives would overload a 250W power supply's 12V output.

Fortunately, PC Power & Cooling Inc anticipated the development of large PC-based computer systems like EDN's All-Star PC and developed a 420W power supply: the Turbo 450. It supplies ample power and provides eight power connectors for mass-storage devices—perfect for the All-Star PC project. The Turbo 450 powered Cheetah's mother board in Cheetah's Colorado Springs R&D labs for a few months while I attempted to find a suitable enclosure. I knew it was out there somewhere, but I had a devil of a time finding it.

One reason for my difficulties was the scope of the All-Star PC Project. Very few PCs incorporate seven mass-storage devices, so most vendors don't make PC enclosures big enough to accommodate that many peripherals. Most AT-class PC enclosures hold no more than six half-height disk drives, but I planned to use four half-height floppy-disk drives plus three more full-height drives. Thus, I needed room for the equivalent of 10 half-height drives.

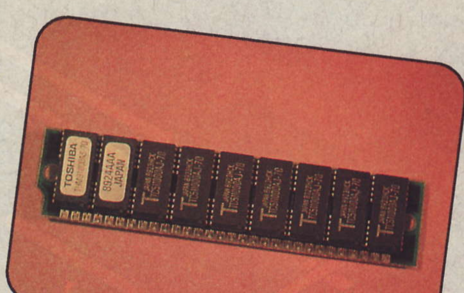
Off to Comdex

Because the All-Star PC would hold so many peripheral devices, it would require a tower-style enclosure. A desktop enclosure that can house 10 half-height drives would consume an entire desktop. Failing to find any leads on an enclosure, I journeyed to Comdex Fall '89 in Las Vegas and concentrated on finding just the right one. While tramping up and down the aisles, I spotted the enclosure that I was looking for. Several computer manufacturers at the show were us-

EDN's PC All-Stars — **THM91000AS-70 Memory Module**

Toshiba America Electonic Components Inc, 9775 Toledo Way, Irvine, CA 92718. (714) 455-2000. FAX (714) 859-3963.

Circle No. 668



STATS:

CAPACITY: 1M × 9 bits
SPECIAL ACCESS MODE: Fast page
RAS ACCESS TIME: 70 nsec
CAS ACCESS TIME: 20 nsec
CYCLE TIME: 130 nsec
FAST-PAGE-MODE CYCLE TIME: 40 nsec

BIO: The THM91000AS-70 is a SIMM (single in-line memory module) that holds 1M byte of data, plus a parity bit. Its fast-page access mode closely matches the burst access mode of the 80486 µP, which helps to optimize transfers between the processor and memory.

ing what was obviously the same enclosure; I even saw a gold-plated version. Most of these computers were file and network servers that incorporated several disk drives installed in the enclosure's drive cage. That cavernous cage had space for 10 half-height drives. But finding the right enclosure isn't the same as finding its vendor. The companies showing computers based on this enclosure either didn't know or wouldn't tell me who the vendor was.

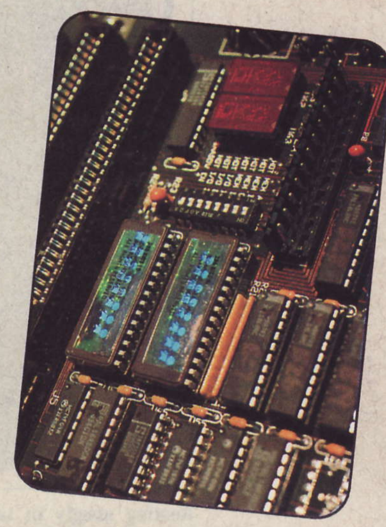
Finally, at one booth, I asked the wrong person: someone who worked for the enclosure vendor instead of the booth's owner. That's how I found Interface Electronics Inc. The All-Star PC uses the company's painted (not gold-plated) VES 1000 enclosure system. The enclosure has several outstanding features. In addition to the 10 drive bays, it has a removable card cage that is mounted vertically so that all of the PC's cabling exits from the top. If you've ever hooked a PC up to a few external peripherals such as printers, plotters, and displays, you know what a benefit it is to have the I/O connectors accessible from the top of the machine instead of the back, where most computer manufacturers put them. Once you've completed the connections, a steel cap slides over the cables making everything look neat and tidy.

The entire enclosure is made of steel, blocking those pesky EMI emissions that beckon the regulatory agencies. Hinged front and side doors provide easy access to the drive bays and the inside of the machine. Both doors lift off their hinges so that you can move them out of the way when assembling the system or during extended service

EDN's PC All-Stars

486 Modular BIOS

Award Software Inc, 130 Knowles Dr, Los Gatos, CA 95030. (408) 370-7979. FAX (408) 370-3399. TWX 510-601-0414.
Circle No. 669



STATS:
PROCESSOR SPEEDS HANDLED: 6-33 MHz, 0-2 wait states
MAXIMUM MEMORY SIZE MANAGED: 4G bytes
KEYBOARD COMPATIBILITY: 84, 101, and 102 keys
FLOPPY-DISK-DRIVE COMPATIBILITY: 5¼ and 3½ in.
HARD-DISK-DRIVE COMPATIBILITY: 40 drive types
CODE SIZE: 32k bytes

BIO: Derived from a long line of IBM-compatible BIOS ROMs, the 486 Modular BIOS supports the special features of the 80486 µP such as the on-chip cache and floating-point unit. Optional extensions include shadow RAM support and disk caching.

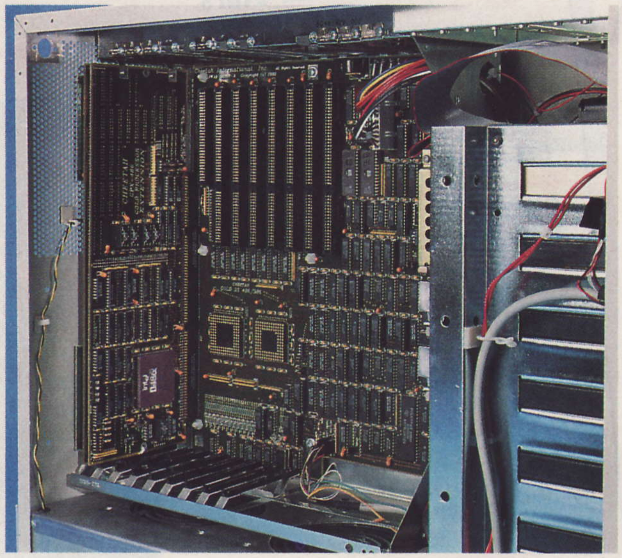
EDN's PC All-Stars

VES 1000 Enclosure System

Interface Electronics Inc, 2217 Claxter Rd NE, Salem, OR 97303. (503) 393-2838. FAX (503) 393-1709.
Circle No. 670

STATS:
SIZE: 24.5 × 9 × 23 in. (height, width, depth)
CARD-CAGE CAPACITY: 8-14 slots
DRIVE-BAY CAPACITY: 10 half-height drives
CABLE ACCESS: From the top
FRONT AND SIDE DOORS: Hinged and easily removable
UL recognized

BIO: Designed for high-end PCs such as file servers, the VES 1000 enclosure system can hold a large number of disk and tape drives and accommodates PC/AT-style and oversized mother boards. The steel construction helps reduce EMI emissions.



Resting snugly in the removable card cage, the Cheetah Gold 425 mother board and processor/memory daughter card await the expansion boards that will complete the foundation of the All-Star PC Project.

procedures. Even small features make the VES 1000 an attractive choice. For example, it uses the same-sized screw for all removable fasteners, so you don't need to keep track of different types of screws. The enclosure has many such well-thought-out features, including a slide-out air filter that keeps dust and dirt from entering the machine through the air inlet. Though perfect for the All-Star PC Project, the VES 1000 won't satisfy the requirements of every PC-based design, so Interface Electronics will customize the VES 1000 enclosure or develop new designs for other OEM requirements.

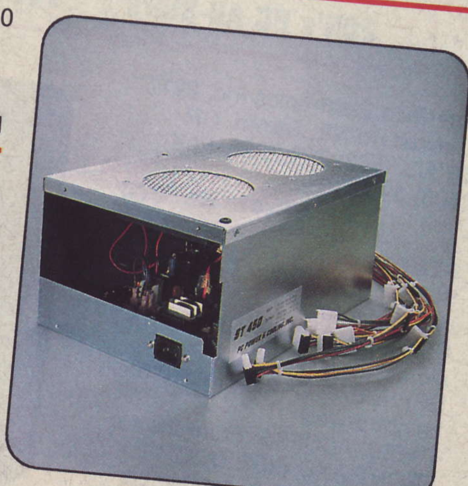
Only one problem remained. The VES 1000 doesn't accept AT-sized power supplies. Instead, it uses a 420W power supply that was custom designed and built by PC Power & Cooling. How's that for coincidence? I quickly exchanged the All-Star PC's Turbo 450 power supply for the company's ST450. The ST450 employs the Turbo 450's circuit board but has a larger housing so that it can accommodate two thermally controlled, variable-speed fans. The fans draw air through the power supply's enclosure and blow it over the VES 1000's card cage. This scheme provides significantly better cooling than the conventional PC/AT layout, a feature that high-end PCs like EDN's All-Star PC, which contain many high-power components, require. The ST450 thus matched the design of the VES 1000 and the requirements of this project perfectly. As I installed PC Power & Cooling's ST450 into the VES 1000, the last piece of the All-Star PC's foundation finally fell into place.

EDN

EDN's PC All-Stars — **ST450 Custom Power Supply**

PC Power & Cooling Inc, 31510 Mountain Way, Bonsall, CA 92003. (619) 723-9513. FAX (619) 723-0075.

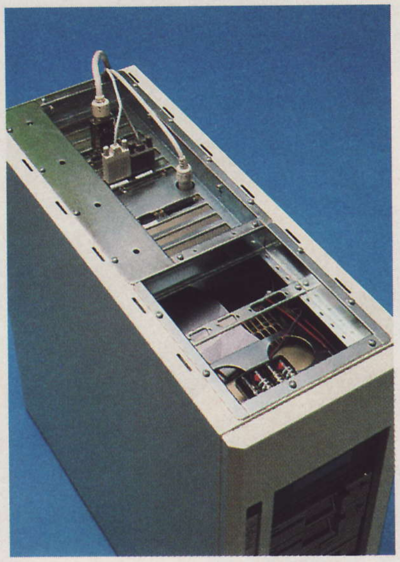
Circle No. 671



PC Power & Cooling Inc

STATS:
POWER OUTPUT: 420W (480W peak)
OUTPUTS: 5V@45A, 12V@15A (20A peak), −5V@0.5A, −12V@1A
OPERATING RANGE: 85-135V ac, 170-270V ac
PROTECTION: Spike, surge, brownout, overvoltage, overcurrent
COOLING: Two temperature-controlled, variable-speed fans
MTBF: 50,000 hours

BIO: The ST450 power supply operates from 110 and 220V mains and automatically chooses the proper input-voltage range. It has EMI filters on the ac inputs as well as independently regulated dc outputs with 3-stage output filters. The power supply meets UL, CSA, and TUV specs.



Putting the I/O cables at the top of the PC's enclosure simplifies making connections to external peripheral devices.

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